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Impact of Internet Access on Peru's Economic Growth: An ARDL Approach

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Summary

This research aims to estimate the impact of internet access on the economic growth of Peru, period 2011-2019. The model considered quarterly information on the GDP variables, percentage of households with internet access at home, and macroeconomic factors (gross fixed capital formation and labor force). Likewise, a Cobb-Douglas function and the ARDL model were used to assess whether there is a long-term relationship between the variables.

The results indicate that there is a long-term relationship between internet access and economic growth, while the short-term dynamic model reveals that the speed of convergence to equilibrium is moderate, implying that there is also a short-term relationship between them. variables. Therefore, investments aimed at improving internet access can create a stimulus to reactivate the Peruvian economy.

Keywords: Economic growth, internet access, ARDL model.

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Chapter 1. Introduction

Explaining causes of economic growth has been one of the most important topics economists have investigated. Initially, Solow's (1956) neoclassical growth model considered an aggregate production function and exogenous technical changes. This changed with the work of Romer (1986) who focused on the endogeneity of growth processes. The wide spread of the internet and broadband networks have become one of the basic pillars of modern society. Increasingly, the use of the internet is important for various activities, both work and daily.

In general terms, Internet access is considered as one more capital that directly affects growth, so it is included in terms of production as one more factor, such as human capital. According to the perspective of the World Economic Forum, it is considered that the greater the use of broadband (and telecommunications services in general), the greater the competitiveness of the countries, and therefore, it will generate a greater impact on economic growth. For some years, Peru has shown an increase in telecommunications infrastructure capacity and an increase in broadband networks to benefit from the contribution of ICT.

For some years, Peru has shown an increase in the capacity of its telecommunications infrastructure and broadband networks to benefit from the contribution of Information and Communication Technology (ICT)[1] Considering the significant expansion of infrastructure in Peru, there is a lack of empirical studies on its impact and causal relationship with economic growth. However, two questions arise: Does the development of internet access lead to economic growth in Peru? Is there a short-term and long-term relationship between the development of internet expansion and Peru's economic growth?

The purpose of this working document is to investigate the development of internet access and how this development affects economic growth in Peru. This issue is important and receives considerable attention in the current situation due to the need to carry out public investment projects and their potential impacts on the economy. This research provides empirical evidence on the main theoretical debates between the links of internet development and economic growth. Although many international researchers have provided empirical evidence of the correlation between investment in ICT and economic growth, the study of the impact of Internet development on economic growth in Peru is still an unexplored area. Therefore, this working paper tries to close something, that void in empirical literature.

[1] ICT is defined as the set of networks, devices, tools and technological resources necessary to access, create, process, store, transmit, exchange, receive information and access digital services. This set of networks, devices, tools and technological resources includes the technologies of live transmission (radio, television and web transmission), the development of telecommunications networks, computers, fixed and mobile telephony and the Internet that allows connectivity of people and things.

Chapter 2 develops stylized facts and connectivity in Peru. Chapter 3 presents a review of the literature on the impact of the internet on economic growth in different economies. Chapter 4 shows the discussion of data. In chapter 5 the development of the methodology used is found, and in chapter 6 the main results found are shown. Finally, the conclusions and recommendations derived from this research are presented.

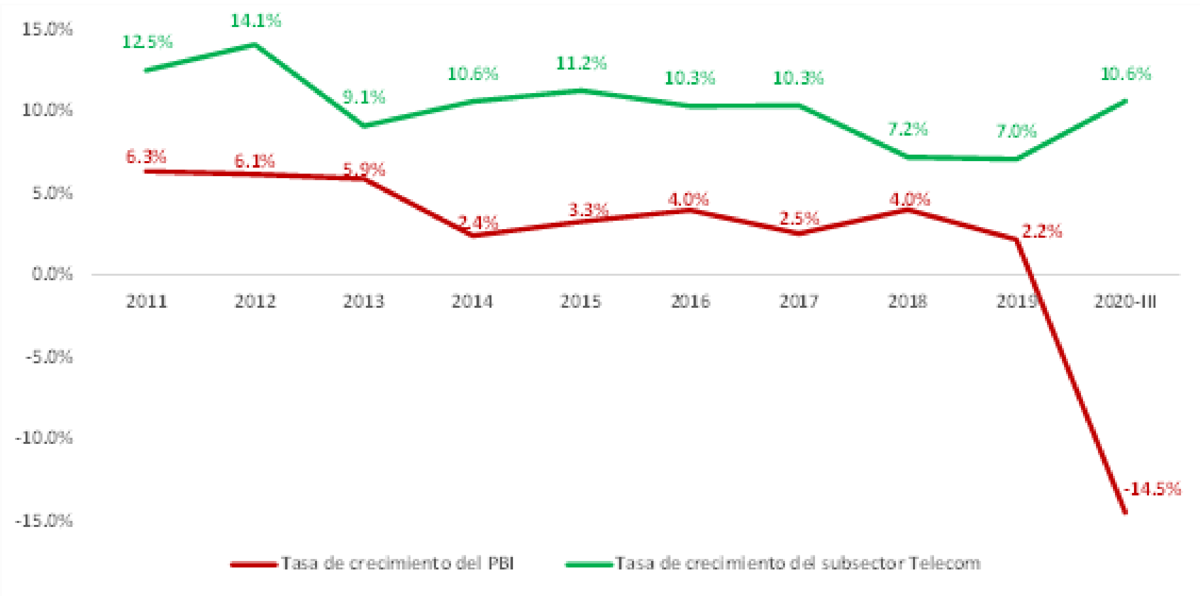
Chapter 2. Stylized facts and connectivity in Peru

1. Stylized facts

1.1 Evolution of the National and Sectoral GDP in Peru.

During the period 2011 to 2019, the GDP of the Telecommunications subsector grew by an average of 10.3%, presenting a greater dynamism than the growth of the national GDP, which was 4.1[2]. Likewise, in 2020, the health emergency situation has important consequences, not only on people's health and lives, but also on the economy, since mitigating the ongoing spread requires social isolation measures that involve necessarily reducing production. Thus, in the third quarter of 2020, the national GDP suffered a fall of -14.5%, while the GDP growth of the subsector grew by 10.6% (see graph 1).

Graph 1. GDP growth in Peru and the Telecommunications subsector



Note: The Communications sector is made up of: the Telecommunications subsector, which includes fixed telephony services, mobile telephony, internet service, subscription television, data transmission and other telecommunications services; and the subsector of other information services.
Source: INEI. Prepared by: DGPRC-MTC.

The dynamism of the Telecommunications sector, between 2011 and 2019, is associated with the reception of investments, the entry of new operators and the increase in penetration of services; Consequently, the sector's participation in national GDP (percentage structure of constant values) went from 3.3% to 5.8% in the period 2011 to the third quarter of 2020, becoming one of the fundamental pillars of the economy (see graph 2).

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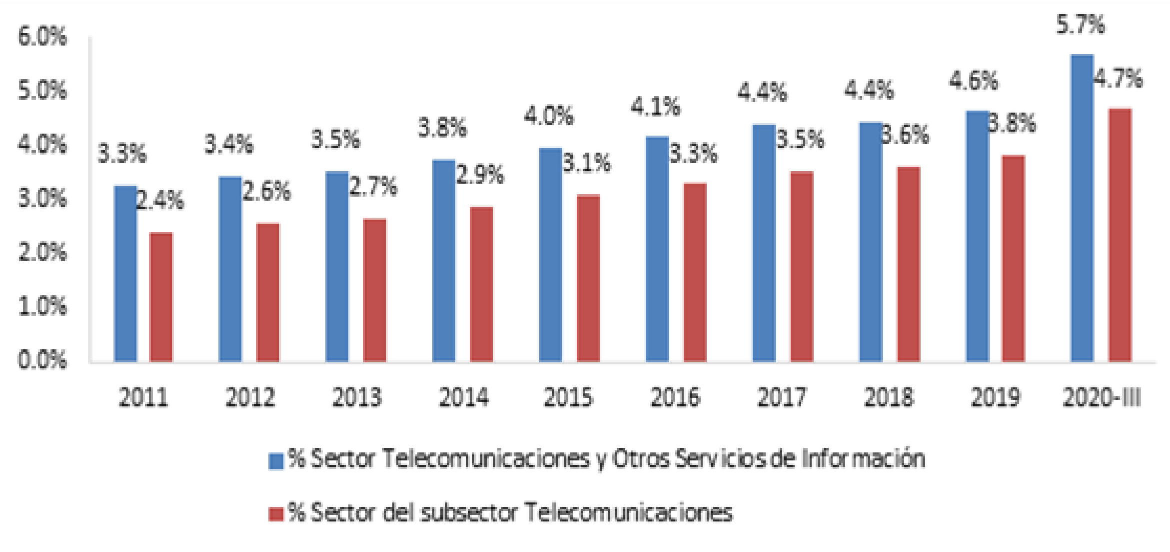
2 According to **Central Reserve Bank** of **Peru** (**BCRP**) (2019), the downward trend of GDP in this period was mainly due to the external context of slowing world growth and reduction in terms of trade.

Graph 2. Participation of telecommunications services and other information services in GDP.

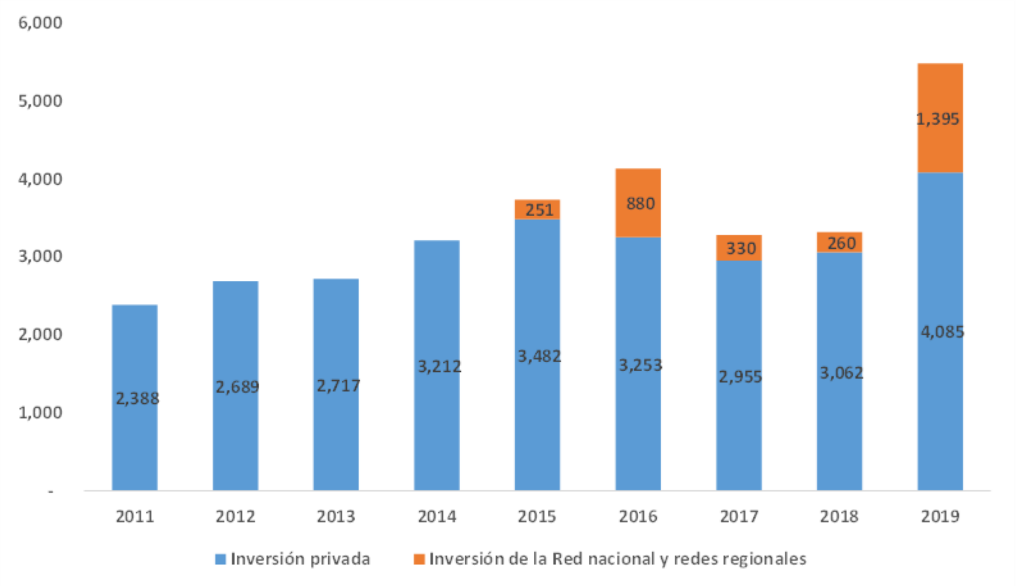


Source: INEI. Elaborated by: DGPRC-MTC.

1.2 Evolution of private and public investment

During the period 2011 to 2019, the accumulated investment in the Telecommunications sector was S / 34,720 million (does not include the investment amounts resulting from the spectrum tenders that amounted to S / 3,761 million), proving to be a sector that attracts strong investments. This level of investment is mainly explained by technological evolution, competitive intensity, increased penetration of services, regulatory mechanisms and policies to promote private investment implemented by the State, as well as the investment made in the national network. and regional networks. Regarding public investment, this was S / 251 and S / 880 million in the national network in 2015 and 2016, respectively. In addition to S / 330, S / 260 and S / 1,395 million in regional broadband networks in the years 2017, 2018 and 2019, respectively (See graph 3).

Graph 3. Investment in the Telecommunications sector (millions of S /)



Note: The information does not include the investment of USD 259 million for the 4G public tender in 2013 and the investment of S / 3.061 million for the public tender of the 700 Mhz Band: Telefónica (S /. 1,058 million), Claro (S /. 1,028 million) and Entel (S / 975 million), in 2016.
Source: OSIPTEL. Prepared by: DGPRC-MTC.

Regarding investment projects, as detailed in the National Infrastructure Plan for Competitiveness (PNIC), approved by Supreme Decree No. 238-2019-EF, which indicates the need to promote the permanent deployment of the different entities of the State, because it is necessary to design projects that serve the greatest number of citizens, especially, that are executed within the established deadlines and with the greatest transparency. In this context, it is important to highlight that, of the 52 projects included in the PNIC, the MTC is responsible for 31, which will contribute significantly to closing gaps to strengthen national development. Likewise, according to Emergency Decree No. 018-2019, extraordinary measures were established for the promotion and implementation of the projects prioritized in this National Plan to boost the growth of the economy.

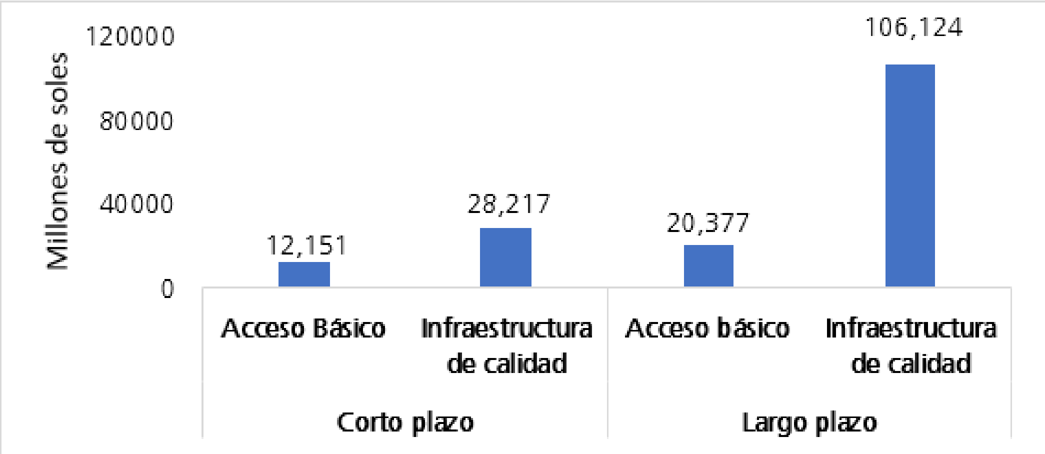
Under this scenario, in which, on the one hand, the demand for public transport and communications services increases more and more and, on the other, that the gap in access and quality of infrastructure is still considerable, it is necessary to adopt measures that guarantee access and continuity of public transport and communications services for the population, as well as allow the continued deployment of infrastructure necessary for the provision of public services, in order to bring connectivity and integration to the population that does not have those services or improve existing ones.

1.3 Investment gap in the sector

It is important to mention that in Peru there are still gaps in telecommunications infrastructure. According to a study prepared by the Universidad del Pacífico, in February 2019, at the request of the

Ministry of Economy and Finance, with the support of the IDB[3],, it was determined that the estimated investment gap to reach basic access levels of telecommunications infrastructure for the period 2019-2038 (long term - 20 years) it was S / 20,377 million[4];, while the gap for short term (five years) was S/. 12,151 million[5]. Likewise, it was identified that the quality gap of the telecommunications infrastructure, considering the infrastructure required to achieve mobile coverage with 4G technologies, at short term is S / 28,217 million; and at long term this gap amounts to S/. 106,124 million (See graph 4).

Graph 4. Investment gap in telecommunications infrastructure, 2019-2038 (millions of soles)



Source: Universidad del Pacífico

These estimated investment amounts may be insufficient, because of measures dictated by the Central Government to face the pandemic during 2020. In this context, there has been an increase in the demand for telecommunications services, it is estimated that the data traffic of the fixed network grew by 61% and the mobile network by 45%, between February and December 2020. Likewise, in this same period, the mobile applications that registered the highest growth rate on the mobile network[6]. were those related to streaming video communication, such as Zoom and Skype (4,385%), TikTok (421%) and Netflix (139%), according to the report of operator companies. On the other hand, it is important to mention that the increase in internet demand in other countries due to the pandemic has motivated the acceleration of construction of 5G network, as is being done by China, where demand has grown by 36%, according to with CNBC[7].

[3] National Infrastructure Plan for Competitiveness.

[4] This amount of investment is required to reach the basic access levels of telecommunications infrastructure, according to the group of more developed countries, such as those that are part of the OECD.

[5] This amount of investment is required to reach the levels of basic access to infrastructure that a country with our socio-economic and geographic characteristics should have.

[6] To obtain the traffic growth, the accumulated traffic for the month of February was considered, with respect to the accumulated traffic of December, according to the information reported by the companies to DGPRC-MTC.
Recovered from: https://expansion.mx/tecnologia/2020/03/03/el-coronavirus-retrasara-el-despliegue-de-5g-en-mexico-y-el-mundo

In 2019, the telecommunications sector attracted private investments for S / 4,085 million. During 2020, after reactivation of activities, it is estimated that at the end of the year, investments will be reduced between 10 to 30% compared to the previous year. This is due, although it was considered an essential activity, the deployment of telecommunications networks, or the installation of new infrastructure, was not allowed for several months. Likewise, the regional projects of the National Telecommunications Program (hereinafter, PRONATEL), were also paralyzed by several months.

Therefore, it is necessary to adopt measures that guarantee the continuity of public telecommunications services. This is due to the current situation due to the demand for public telecommunications services that increases more and more, as new interfaces are implemented for remote work, tele-education and telehealth. On the other hand, the gap in access and quality of telecommunications infrastructure is still considerable and it is necessary to promote the deployment of the necessary infrastructure to provide public telecommunications services to the population that lacks these services. Finally, investments should continue to be made in the national network and regional networks to contribute to closing gaps.

2. Connectivity in Peru

2.1 National Fiber Optic Backbone Network and regional projects.

In 2012 and 2013, the Broadband Law and its Regulations were approved[8]. These standards established –among others– the following parameters for construction, operation and maintenance of transport networks, necessary for promoting the development of broadband in the country:

- It is declared of public necessity and national interest, the construction of a National Fiber Optic Backbone Network (RDNFO) that integrates all the provincial capitals and the deployment of high-capacity networks to integrate all the districts (understood as networks regional transport).
- It is established that regional networks are an integral part of the RDNFO.
- It is defined that the RDNFO and regional networks are owned by the State, specifying that the RDNFO is a high-speed, availability and reliability transport network, to be designed on the basis of fiber optic laying, with schemes of redundancy and points of presence in the provincial capitals, should preferably be implemented with equipment that supports the IP protocol and multimedia applications.
- The MTC is attributed the power to define the technical, economic and legal conditions of the design, construction, concession, operation and financing of the RDNFO, and to the Telecommunications Investment Fund - FITEL (currently, PRONATEL) the development and financing of projects for the deployment of regional networks.

[8] Law No. 29904, Law for the Promotion of Broadband and Construction of the National Fiber Optic Backbone Network and its Regulations approved by Supreme Decree No. 014-2013-MTC.

- It is provided that the RDNFO may be given in concession to one or more operators, with the Private Investment Promotion Agency - Proinversión responsible for conducting the concession process.
- The subsidiary intervention of the State is defined in areas where there is no private investment.
- It is established that the RDNFO operator is a neutral operator, defining it as a concessionaire of public telecommunications services that provides carrier services only to other concessionaires and has no end users.

Considering this legal framework, in May 2013, Proinversión called the Comprehensive Projects Public Tender for the concession of the Project "National Backbone Fiber Optic Network: Universal North Coverage, Universal South Coverage and Universal Central Coverage".

As a result of the process of promoting private investment, on June 17, 2014, the MTC, on behalf of the Peruvian State, and the company Azteca signed the concession contract, which has a single addendum, signed on November 17 2014, regarding the "bankability" of the project.

The project design and the concession contract have the following main conditions:

- Its purpose is the construction, operation and maintenance of the RDNFO.
- The term of the concession is 20 years, with the possibility of renewal for a similar period.
- It contemplates the payment of a Remuneration for Investment (RPI), which consists of the quarterly payment that the concessionaire receives to reward the investment in which it has incurred; as well as a Remuneration for Operation and Maintenance (RPMO), as payment made by the grantor (MTC) to the concessionaire for the operation and maintenance of the RDNFO.
- Provides a unique national rate of USD 23.00 (without VAT) for one (1) Mbps, applicable during first five years of operation, subject to rate review.
- Possibility of making discounts of any kind is not considered.

The RDNFO was progressively deployed, through 6 deliveries, forming a transport network of approximately 13,500 km of fiber optic, connecting 22 regional capitals, 180 provincial capitals and 136 localities. It has 8 Core nodes, 22 aggregation nodes, 180 distribution nodes and 136 connection nodes.

In 2016, the construction of the RDNFO was completed and it entered into operation in its entirety, for the provision of carrier service (See graph 5).

Graph 5. RDNFO coverage map

Source: MTC institutional portal

On the other hand, the Technical Secretariat of FITEL (today PRONATEL) created a portfolio of 21 projects of regional scope, called “Broadband Installation for Integral Connectivity and Social Development”, which aim to increase access to telecommunications services in districts and localities of the beneficiary regions. These projects include the construction of broadband transport networks with scope at the district capital level, starting from the distribution nodes to be installed by the RDNFO, as well as the implementation of a wireless access network for access to public transport services. broadband to rural locations.

The projects are designed to allow 1,136 district capitals to be connected through the deployment of more than 30,000 kilometers of fiber optics, which in turn will mean that 21 regions of the country have high-capacity and high-speed networks, connecting approximately 12,000 to the internet. public institutions and benefiting 3.4 million inhabitants, to which is added the possibility of deploying tools and technological applications, such as telehealth programs, tele-education, among others, through a broadband network, made up of a transport network fiber optic (RT) and a terrestrial wireless access (RA) network.

In this regard, according to the information reported by PRONATEL, it should be noted that, of the twenty-one (21) regional projects, eighteen (18) projects have current contracts and three (03) projects with terminated contracts and are being reformulated. In relation to the three (03) resolved projects, it should be noted that on April 24, 2019, the contracts for the regional projects of Cajamarca, Piura and Tumbes were resolved due to the difficulty of the operator to comply with the provisions of the financing contracts.

• Regional projects in reformulation

The regional projects of Cajamarca, Piura and Tumbes are currently in the process of reformulation for their subsequent implementation. The aforementioned projects have a proposed investment schedule where the completion of the work is set for 2022 and the following results are expected regarding connectivity improvements:

• The Cajamarca regional project will provide internet service to 1,210 localities and a total of 2,168 public institutions, including schools, health centers and police agencies, which will be the beneficiary institutions of the project.

• The Piura regional project will provide internet service to 522 towns and a total of 799 public institutions, including school premises, health centers and police agencies, which will be the beneficiary institutions of the project.

• The Tumbes regional project will provide internet service to 62 localities and a total of 112 public institutions, including school premises, health centers and police units, which will be the beneficiary institutions.

It should be noted that the regional projects under reformulation have a list of beneficiary localities and public institutions; however, this list could vary according to the field evaluation that is being carried out in order to validate the final list of beneficiaries.

• Regional projects in investment period

On the other hand, currently, there are fourteen (14) regional projects in the investment period. These projects will benefit approximately 4,000 localities and 7,000 public institutions, including schools, health centers and police units, which will be the beneficiary institutions of the project. It also includes the installation of internet (WiFi) in 3,531 places in the region's towns and the installation of 438 Digital Access Centers.

Of which the Cusco and Lima Projects are reaching 100% progress of their access and transportation network; meanwhile, the state of progress of almost all the other Regional Projects is well advanced in its transport network but starting the construction of its access network. Finally, the Ancash, Arequipa, La Libertad and San Martín Projects are starting. All Projects will provide internet services once the installation of the infrastructure and equipment has been completed.

Table 1. Regional projects in investment period

Nº	Region	Localities	School premises	Health establishment	Police Stations	Nº Squares with WiFi	Digital Access Center
1	Cusco	371	424	147	44	71	-
2	Lima	291	255	201	21	291	-
3	Puno	471	635	285	38	471	-
4	Junín	353	325	221	12	353	-
5	Moquegua	66	69	29	9	66	-
6	Tacna	52	68	24	11	52	-
7	Ica	81	50	58	8	30	-
8	Amazonas	268	256	218	42	110	-
9	Huánuco	348	341	161	14	315	59
10	Pasco	264	375	155	15	223	37
11	Ancash	481	520	269	28	460	118
12	Arequipa	252	268	121	53	226	92
13	La Libertad	730	743	186	30	694	71
14	San Martín	220	215	139	17	169	61

Source: Directorate of Engineering and Operations of PRONATEL

Likewise, regional projects in the investment period have the following estimated dates for their start-up:

Table 2. Start of operation of regional projects in investment period

N°	Regional Project	Company	Estimated date[9]
1	Installation of broadband for comprehensive connectivity and social development in Cusco region	GILAT NETWORKS PERÚ S.A.	2021
2	Installation of broadband for comprehensive connectivity and social development in Ica region	GILAT NETWORKS PERÚ S.A.	2021
3	Installation of broadband for comprehensive connectivity and social development in Lima region	AMÉRICA MÓVIL PERÚ SAC	2021
4	Installation of broadband for comprehensive connectivity and social development in Amazonas region	GILAT NETWORKS PERÚ S.A.	2022
5	Installation of broadband for comprehensive connectivity and social development in Junin region	OROCOM S.A.C.	2021
6	Installation of broadband for comprehensive connectivity and social development in Puno region	OROCOM S.A.C.	2021
7	Installation of broadband for comprehensive connectivity and social development in Tacna region	OROCOM S.A.C.	2021

9 Information on the date of possible start-up. The start of works will depend on the measures that are available regarding the health emergency.

8	Installation of broadband for comprehensive connectivity and social development in Moquegua region	OROCOM S.A.C.	2021
9	Installation of broadband for comprehensive connectivity and social development in Ancash region	YOFC PERÚ S.A.C.	2021
10	Instalación de banda ancha para la conectividad integral y desarrollo social de la región Arequipa	YOFC PERÚ S.A.C.	2021
11	Creation of broadband for comprehensive connectivity and social development in Huánuco region	BANDTEL S.A.C	2021
12	Creation of broadband for comprehensive connectivity and social development in La Libertad region	YOFC PERÚ S.A.C.	2021
13	Creation of broadband for comprehensive connectivity and social development in Pasco region.	BANDTEL S.A.C	2021
14	Creation of broadband for comprehensive connectivity and social development in San Martin region.	YOFC PERÚ S.A.C.	2021

Source: Directorate of Engineering and Operations of PRONATEL

It should be noted that, as of the start date of commissioning, the ten (10) year term would begin for the operation period of each regional project. However, the estimated date of operation could be modified by recent events (global pandemic due to COVID-19 and declaration of a State of National Health Emergency).

• Regional projects in operation period

There are four regional projects that are in the period of operation, that is, that are providing internet services to their respective beneficiary towns, which correspond to the regions of: Huancavelica, Apurímac, Ayacucho and Lambayeque.

i. The Project "Creation of Broadband for the Integral Connectivity and Social Development of the Huancavelica Region": The financing contract was signed on May 27, 2015, with the project operator being the company GILAT NETWORKS PERÚ S.A.C. The project provides internet service to 354 localities and a total of 710 beneficiary public institutions made up of schools, health centers and police agencies. It should be noted that the Apurímac Regional Project does not contemplate the installation of internet (WiFi) in the squares of the localities of the region nor the installation of Digital Access Centers.

ii. The Project "Creation of Broadband for Integral Connectivity and Social Development of the Apurímac Region": The financing contract was signed on May 27, 2015, the project operator being the company GILAT NETWORKS PERÚ S.A.C. The project provides internet service to 285 localities and a total of 668 beneficiary public institutions made up of schools, health centers and police units. It should be noted that the Apurímac regional project does not contemplate the installation of internet (WiFi) in the squares of the localities of the region nor the installation of Digital Access Centers.

iii. The Project “Broadband Installation for Integral Connectivity and Social Development of the Ayacucho Region”: The financing contract was signed on May 27, 2015, with the project operator being the company GILAT NETWORKS PERÚ S.A.C. The project provides internet service to 350 localities and a total of 731 beneficiary public institutions made up of schools, health centers and police units. It should be noted that the Ayacucho regional project does not contemplate the installation of internet (WiFi) in the squares of the localities of the region nor the installation of Digital Access Centers.

iv. The Project "Creation of Broadband for Integral Connectivity and Social Development of the Lambayeque Region": The financing contract was signed on May 27, 2015, the operator of the project being the company TELEFÓNICA DEL PERÚ S.A.A. The project provides internet service to 357 localities and a total of 500 beneficiary public institutions made up of schools, health centers and police units. It should be noted that the Lambayeque Regional Project does not contemplate the installation of internet (WiFi) in the squares of the localities of the region nor the installation of Digital Access Centers.

The start of the operation period of the Regional Projects of Huancavelica, Apurímac, Ayacucho and Lambayeque is detailed below:

Table 3. Period of operation of regional projects of Huancavelica, Apurímac, Ayacucho and Lambayeque.

Regional Project	Operator	Start of operation period	End of operation period.
Broadband installation for comprehensive connectivity and social development of the Huancavelica region	GILAT NET-WORKS PERÚ S.A.	06/18/2019	06/18/2029
Broadband Installation for the integral con-nectivity and social development of the Apurímac region	GILAT NET-WORKS PERÚ S.A.	06/28/2019	06/28/2029
Broadband Installation for the integral con-nectivity and social development of the Ayacucho region	GILAT NET-WORKS PERÚ S.A.	07/17/2019	07/17/2029
Broadband Installation for the integral con-nectivity and social development of Lam-bayeque region	TELEFÓNICA DEL PERÚ S.A.A.	12/31/2020	12/31/2030

Source: Directorate of Engineering and Operations of PRONATEL

In summary, implementation of 21 regional projects will connect approximately 12,000 public institutions to internet and benefit 3.4 million inhabitants so they have the possibility of obtain internet service. In this regard, it is necessary that internet offers the possibility of carrying out new transactions, because it reduces the costs of acquiring information and makes more information available in a transparent manner and considerably increases the economic efficiency of companies, workers and the State, among others. other benefits that positively impact economic growth.

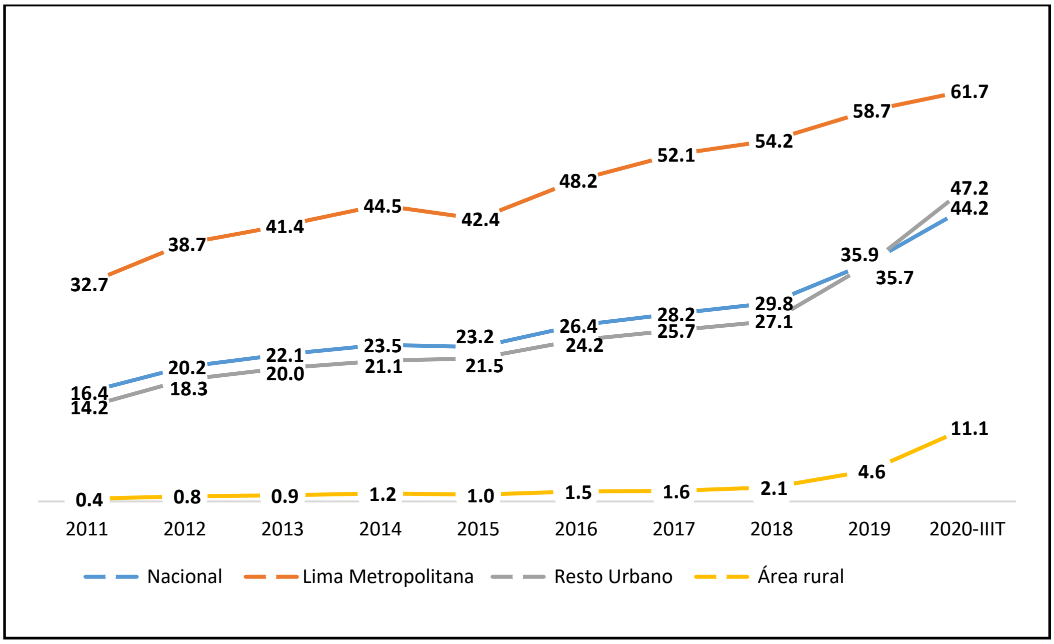
Regarding the implementation of policies that promoted the deployment of fiber optic networks (RDNFO and regional projects), according to More and Argandoña (2020), the probability of obtain 4G mobile coverage increases due to presence of fiber optic networks nearby.

2.2 Internet access, use and speed

Regarding access to internet service at the household level, according to data from the Enaho, in recent years Peru has shown an accelerated growth in internet access. In this regard, in 2011, 16.4% of Peruvian households have access to the Internet service, reaching 44.2% of Peruvian households with Internet access in 2020. However, despite the increase in access to households, still There are gaps in access to this service[10], because 55.8% of Peruvian households do not access the internet service.

Although the data shown is at the national level, due to the geographical conditions of the country, there are differences in the level of access when the information is disaggregated by area of residence. Metropolitan Lima has the highest level of households with internet access with 61.7%, followed by the rest of the urban area with 47.2% of households and the rural area, with the lowest percentage: 11.1% of households. It should be noted that, in recent years, households with access to internet service in rural areas show a significant increase (See graph 6).

Graph 6. Households with internet access (%) 2011-2020

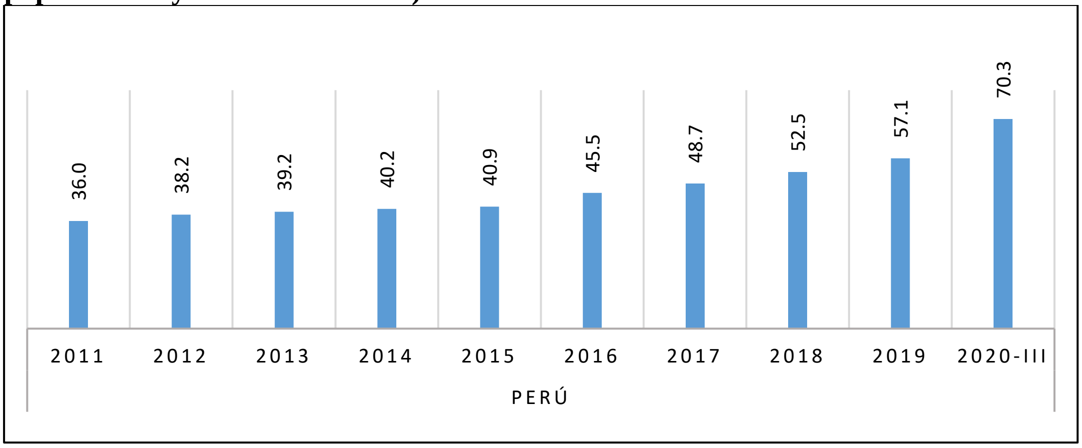


Source: National Institute of Statistics and Informatics - National Household Survey.
Elaborated by: DGPRC – MTC

[10] Description of differences between people or households that can and cannot access.

Regarding the use of internet service, for third quarter of 2020, 70.3% of Peruvians (6-years old and more) use internet, compared to 2011, a growth of 34.3 percentage points is observed (See graph 7).

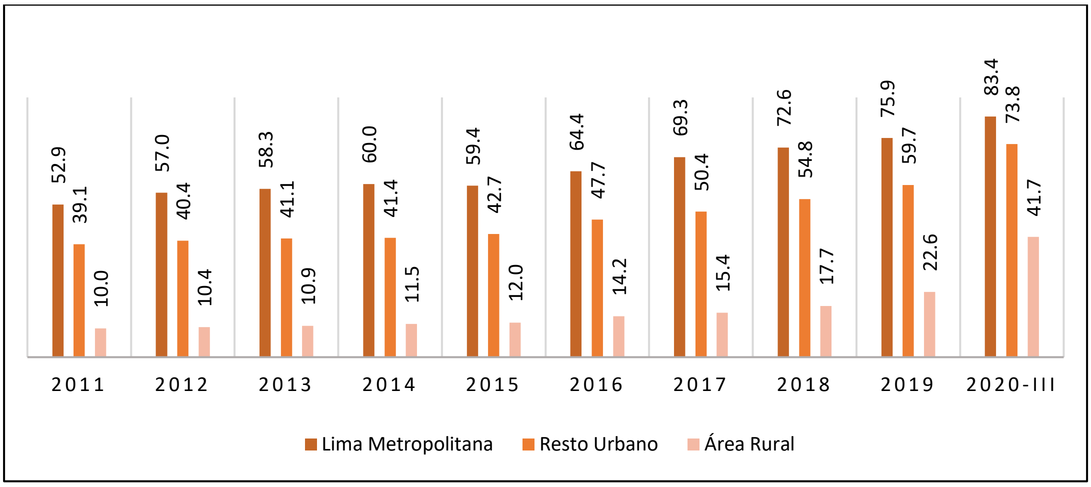
Graph 7. Peru: People 6-years old and more, which use the Internet (Percentage of total population 6-years old and more).



Source: Enaho-INEI (2020). Prepared by: DGPRC - MTC.

According to area of residence, in Metropolitan Lima, the Internet user population represented 83.4%, in the rest urban 73.8% of people and in rural area 41.7%. Compared to 2011, it represented an increase of 30.5, 34.7 and 31.7 percentage points, respectively (See Graph 8).

Graph 8. Peru: People 6-years old and more, which use internet by residence area (Percentage of total population 6-years old and more).



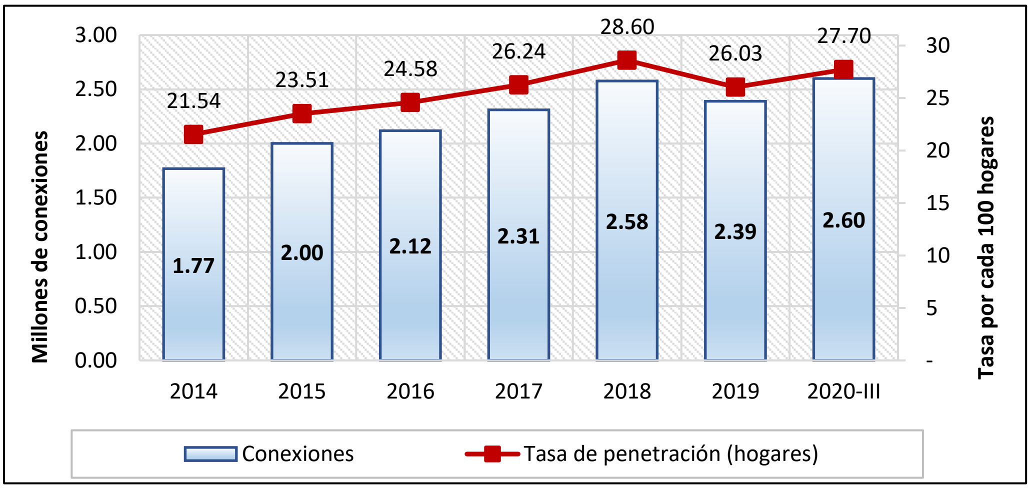
Source: Enaho-INEI (2020). Prepared by: DGPRC - MTC.

On the other hand, the previously described analysis corresponds to information based on INEI surveys. However, there is also information reported by internet access[11], providers, which is used to analyze the characteristics of connections. Likewise, the analysis will be carried out for the fixed internet service

11 You must have the corresponding registry to provide the value-added public service of packet data switching (Internet).

and its speed ranges. In the first case, it is observed that fixed internet connections had an increase of 47%, going from 1.77 to 2.6 million during 2014, to the third quarter of 2020. Likewise, 27.70 of every 100 households have internet. Compared to 2014, a growth of 6.16 percentage points is observed (See Graph 9).

Graph 9. Fixed internet connections (millions) and household penetration 2014-2020



Source: Report of operators companies to the MTC[12].
Elaborated by: DGPRC-MTC

Regarding the contracted speed of the fixed internet service, according to the figures reported by the telecommunications operators[13], as of September 2020, most of the fixed internet connections correspond to a contracted speed greater than or equal to 16 Mbps (69.6% of the connections), unlike in 2016, where most of the fixed internet connections corresponded to a contracted speed between 2 and less than 8 Mbps (64.7%). As can be seen, fixed internet connections have had improvements in the contracted speeds (See graph 10).

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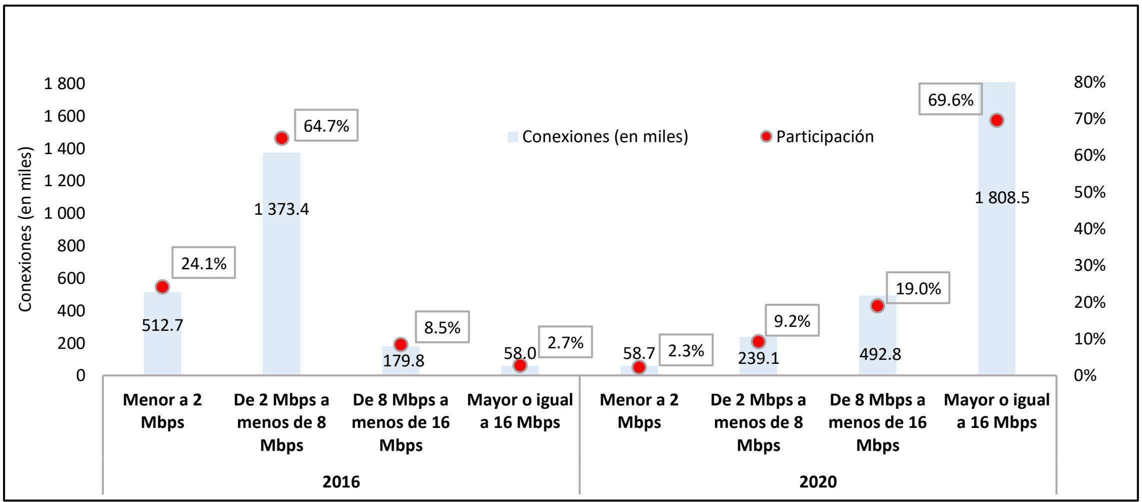
[12] According to the MTC database.
[13] It has a concession or registration to provide one or more public telecommunications services.

Graph 10. Fixed internet connections according to contracted speed ranges, 2016 and 2020.



Source: Report of the operator companies to the MTC. The information for 2020 corresponds to the third quarter.
Elaborated by: DGPRC-MTC

According to ECLAC[14], (2020), closing broadband download speed gaps is very important because it effectively provides the ability to make use of digital solutions. Consequently, there are low speeds of 5Mbps, average of 18 Mbps and the highest of 25 Mbps, this means in the current demand, that those who are on a low-speed connection, can only do email, basic video and streaming of audio, but they cannot telework or tele-education. In medium speed, it is possible to perform two basic functions plus a simultaneous high-demand online activity, teleworking or tele-education and, finally, in high speed, basic functions plus high-demand functions are allowed simultaneously, which would allow the teleworking and tele-education.

Finally, according to the information reviewed, we can account for the growing trend of internet access and use, however, there are gaps at the level of residence area, since there is low access, especially in use in rural areas, therefore that there is ample room for improvement. On the other hand, the improvements in terms of download speeds of fixed internet connections are recognized

2.3 Broadband Development Index (BDI 2018).

The Broadband Development Index (IDBA by its initial in spanish) is a socioeconomic instrument that allows to easily measure the current status and development of broadband in the region. One of its objectives is to help identify the main obstacles to broadband development in IDB borrowing member countries. Likewise, it helps to measure the success of the implementation of projects aimed at the development of the sector through the degree of fulfillment of the objectives set. This index was published for the first time in 2012 by the IDB, also calculating values for the two previous years (2010 and 2011). However, for the values of the year 2018 a new methodology was applied that implies the

[14] https://www.cepal.org/sites/default/files/presentation/files/final_final_covid19_digital_26_agosto.pdf

inclusion of new variables and the suppression of others.

BDI sets itself apart from other indicators by focusing on broadband development in order to measure a very specific element of the information society. This index is made up of sub-indices of the following subjects: i) public policies and strategic vision, ii) strategic regulation, iii) infrastructures and iv) applications and training, which in turn are constructed from the aggregation of 37 variables, through the assignments of weights that have been set (See Table 8).

Table 8. Pillars of IDBA

Public Policies and Strategic Vision	•Describes the importance given by governments to ICT development policy, laws and measures aimed at promoting penetration and competition in the sector. •Evaluates public policy measures and strategic vision: development of broadband plans, government involvement in ICT, digitization strategies, as well as their quality, etc.
Strategic Regulation	•Analyze the development of strategic regulation in the country. •Evaluates indicators that describe the current state of development plans, as well as their effectiveness, through, for example, degree of concentration of the fixed and mobile broadband market in terms of competition.
Infraestructure	•It refers to the state of digital infrastructures and the development of public-private agreements. •It evaluates the existence of homes with adequate infrastructure, the average speeds achieved, the number of lines of the different services or investment in telecommunications with private participation.
Applications and Training	•It measures the level of training in ICT as well as in applications and content. •It evaluates ICT training through statistics of the level of education, being an important indicator within the potential development of the sector. •It analyzes the use of ICT by the population, through a series of indicators, such as those related to the use of social networks or the internet.

Source: IDB (2019); Elaborated by: DGPRC-MTC.

There are 65 countries analyzed by the IDB (26 from LAC, 34 members of the OECD, and the others are countries that collaborate with the IDB) based on the Broadband Development Index, Peru is ranked 51 (BDI value is 4.62), compared to 2016, the country increased one place in the ranking. Likewise, is in a better position than countries such as Bolivia (position 55), Venezuela (position 60) and Paraguay (position 58); very close to countries such as Ecuador (position 49), Uruguay (position 48), Argentina (position 47) and Mexico (position 46); and below countries such as Colombia (position 44) and Chile (position 28).

Table 9. Ranking of the Broadband Development Index 2016 and 2018

	BDI 2016	BDI 2018	BDI Subíndex 2018			
			Public Policies and Strategic Vision	Strategic Regulación	Infraestructure	Aplications and training
Peru Ranking	52	51	53	44	48	51
Peru Value	4.43	4.62	3.89	5.91	4.25	4.43
ALyC /1 Value	4.28	4.64	3.88	5.54	4.33	4.72
OCDE /2 Value	6.12	6.27	5.65	6.71	6.13	6.46

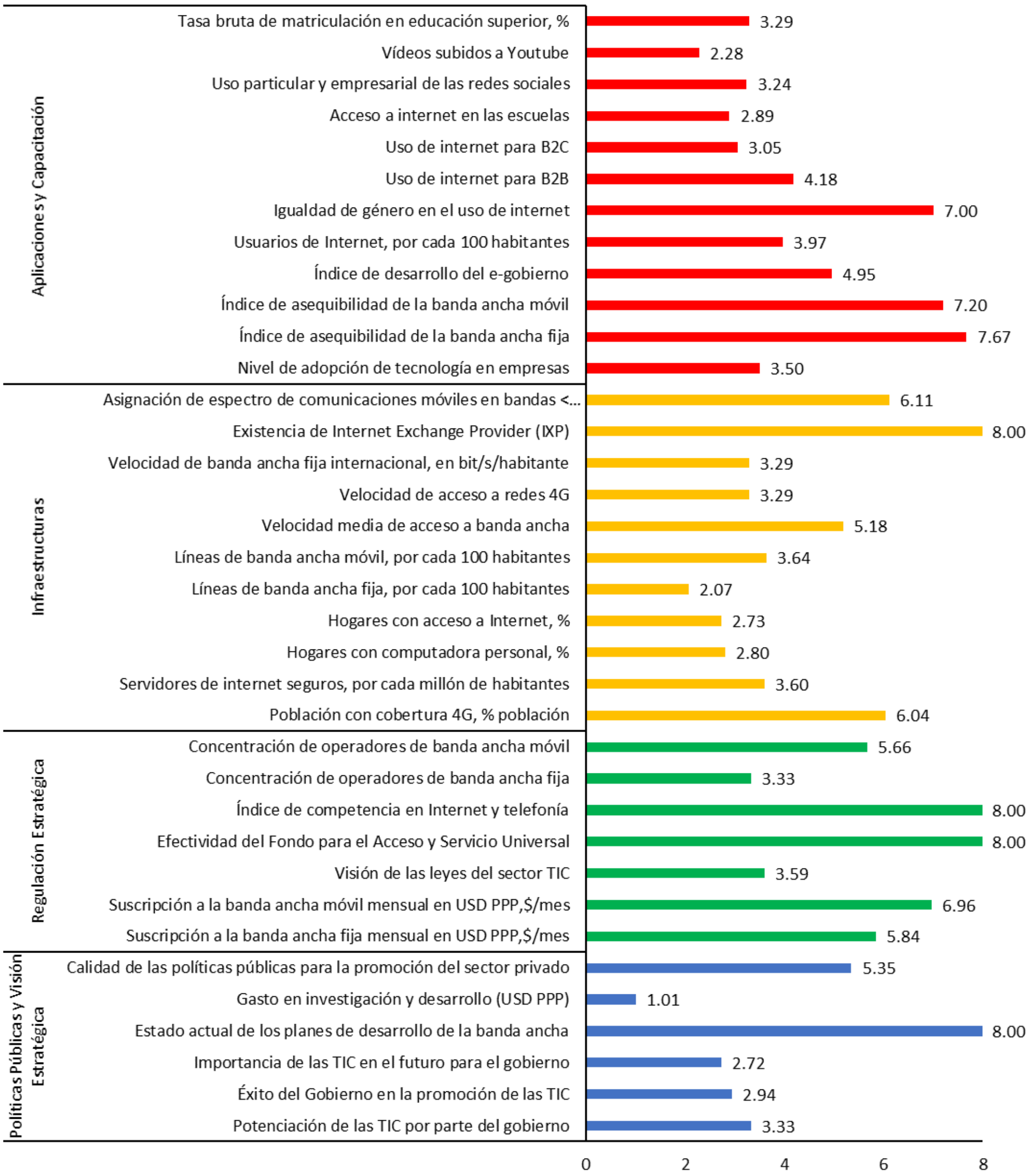
Note: 1 / Includes 26 Latin American and Caribbean countries borrowing from the IDB.
2 / They include 34 member countries of the Organization for Economic Cooperation and Development.
Source: IDB; Prepared by: DGPRC-MTC.

The values of the IDBA for countries that belong to the OECD exceed those of the IDB borrowing countries of Latin America and the Caribbean (LA&C). Likewise, it should be noted that in the sub-indices of Strategic Regulation, Infrastructure, Applications and training, Peru reaches values above half the possible value, with 5.91 (position 44), 4.25 (position 48) and 4.43 (position 51) respectively. It should be noted that the IDBA gives a range of values between 1 and 8, where 1 is the rating for the worst case and 8 for the best (see Table 9).

If the sub-indices are disaggregated into the variables that comprise it, we will identify that in the Applications and Training pillar, the variables that have obtained the highest values are the variable of gender equality in internet use, the affordability index of the band mobile broadband and fixed broadband affordability index. In the case of the Infrastructure sub-index, the variables that have had a good result are those referring to the population with 4G coverage, allocation of mobile communications spectrum and the existence of Internet Exchange Provider (IXP).

Regarding the Strategic Regulation sub-index, Peru exceeds the average for the region, and there are two variables that reach the maximum possible value: Internet and telephony competition index and the effectiveness of the Fund for Universal Access and Service. Finally, in the Public Policies and Strategic Vision pillar, it is important to improve in the variable Research and development expenditure. It should be noted that the variable Current status of broadband development plans has a maximum score (See Graph No. 11).

Graph 11. Value of variables that define the IDBA 2018 for Peru



Source: BID (2019); Prepared by: DGPRC-MTC

Due to the analysis carried out, according to the BDI it is important to focus on the variables that have shown poor performance, such as spending on research and development. Likewise, close the gaps in access and use of internet service, for which, the role played by regional projects and the RDNFO is important to bring infrastructure to the most remote places of the country.

Chapter 3. Literature review

Studies on the impact of the internet on the economy have largely focused on macroeconomic analysis, where there are clear transmission mechanisms and evidence of the impact on economic growth (ITU, 2018; Minges, 2016; Atif et al., 2012) . These are mainly based on endogenous growth models, which involve the importance of the accumulation of human capital, endogeneity of technical progress, relevance of investment in research and development, among others (Romer, 1986; Barro, 1991). In this context, it is considered that broadband facilitates the generation and distribution of information and ideas, which promote innovation and productivity and consequently, economic growth.

Studies on the impact of the Internet have largely focused on its contribution to economic growth, that is, broadband as a driver of economic growth (GDP). In this context, international studies have provided various econometric analyzes to measure the effects of the internet on the economy as a whole.

First, in the study: The Economic Impact of Broadband on Growth: A Simultaneous Approach (Koutroumpis, 2009) investigates how broadband penetration affects economic growth for 22 OECD countries during the period 2002-2007.
To do this, a macroeconomic production function with a broadband investment micro-model is used to estimate the impact of broadband infrastructure and growth.

The results indicate a significant positive causal link, especially when there is a critical mass of infrastructure. In addition, an increase in broadband penetration of 1% causes an increase of 0.025% in economic growth in countries of the sample.
The first analysis of the economic impact of broadband in Latin America (Katz, 2010) was based on a cross-sample of countries. In the absence of time series, the analysis used the ordinary least squares (OLS) method, using a sample of data pooled in the period between 2004 and 2009. Despite the lack of panel data, the study was able to demonstrate a positive impact of broadband in the economic growth of Latin America and the Caribbean. Regarding education and GDP per capita, a 10% increase in broadband penetration raised GDP by 0.158%.

In 2011, greater availability of disaggregated data allowed for studies at the national level. The first was carried out in Colombia, with data corresponding to the period between 2006 and 2010 (Katz and Callorda, 2011). In this study, the impact of fixed broadband on GDP growth was analyzed, controlling for the initial level of economic development for population growth and human capital (represented as average years of education). In this case, the study showed that the increase in broadband connections in Colombia had a positive effect on GDP growth. An increase in connections of 10% generated a GDP growth of 0.037%.

Also, in the study: The Impact of Broadband on the Economy: Research to Date and Policy Issues (ITU, 2012), two studies are compiled that investigated the impact of fixed broadband in Brazil[15] and Chile[16]. The model built to calculate the impact of broadband on Brazilian GDP growth was based on a database of 27 Brazilian states that included data on regional GDP per capita, literacy rate, costs of interstate commerce, costs creation of a new company, average GINI coefficient and broadband penetration. Recognizing the limitations of the model, in terms of the number of observations, the evidence pointed directly to the fact that a 10% increase in fixed broadband penetration could contribute 0.08 percentage points to GDP growth.

Likewise, to calculate the impact of broadband on Chilean GDP growth, the model was based on quarterly data for each administrative region, which included regional GDP growth, percentage of population with some level of tertiary education, population (size and growth), urbanization rate, contribution of the agricultural and commercial sectors, and broadband penetration. Broadband penetration was found to be statistically significant and with the expected sign in terms of contribution to GDP growth. According to coefficient of this variable, a 10% increase in penetration translated into an increase of 0.09 percentage points in Chile's regional GDP.

On the other hand, Katz and Koutroumpis (2012) conducted a study using a structural model to measure the economic contribution of fixed broadband in Panama. Based on this model, it was determined that fixed broadband had a significant impact on economic growth between 2000 and 2010. Its average annual contribution to GDP growth was estimated to be 0.45% for every 10% increase penetration.

Katz and Callorda (2013), continuing with the use of structural models, analyzed the economic contribution of fixed broadband to the economic growth of Ecuador. According to this study, fixed broadband contributed significantly to the growth of Ecuador's GDP between 2008 and 2012. For every 10% increase in penetration, the average annual contribution to GDP growth was estimated to be 0.52%.

On the other hand, the study Broadband access in the EU: An assessment of future economic benefits (H. Gruber, J. Hätönen, P. Koutroumpis, 2014), shows that there are good economic reasons to expand the high-speed broadband infrastructure. speed in Europe, using econometric estimates of the impact of broadband diffusion on economic growth. These data are contrasted with cost estimates for the construction of broadband infrastructure. A structural model with simultaneous equations was developed to measure the contribution of broadband to the GDP of 27 countries members of European

15 This analysis builds on previous research contained in Katz, R. L. (2010b). Broadband: an inalienable goal for Brazil presented at the 54th Telebrasil Panel. Guaruja, on August 18, 2010.

16. This analysis was originally published in Katz, R.L. "The contribution of broadband to economic development", in Jordan, V., Galperin, H. and Peres, W. (2010). Accelerating the digital revolution: Broadband for Latin America and the Caribbean, published by the Economic Commission for Latin America and the Caribbean (ECLAC) and DIRSI.

Union[17], during the period between 2005 y 2011.

Based on this model, it was determined that broadband penetration contributed annually to 1.36% of the GDP of the countries in the sample between the years 2005 and 2011.
Furthermore, the study suggests that for the European Union as a whole, the economic benefits of investing in broadband outweigh its costs.

Gilchrist (2015), for his part, conducted a study for the Caribbean[18], ECTEL member states, applying an ordinary least squares (OLS) model with a solid error model. The author concluded that, in the case of the ECTEL States, an increase in the broadband penetration rate of 10% would lead to an increase in real economic growth of 0.76%.

Recently, in the study Economic contribution of broadband, digitization and ICT regulation: Econometric modeling for the Americas region (ITU, 2018), structural econometric models are used to measure the contribution of broadband to the economy. Based on these models, it was determined that fixed broadband has had a significant impact on the world economy between 2010 and 2017, as a 1% increase in fixed broadband penetration produces an increase in the 0.08% in GDP. Mobile broadband has a greater impact on the world economy than fixed broadband, as a 1% increase in mobile broadband penetration led to a 0.15% increase in GDP. Furthermore, it was determined that the economic impact of fixed broadband is guided by a return-to-scale effect, according to which the economic impact of fixed broadband is greater in more developed countries than in less developed ones. For its part, the economic impact of mobile broadband presents a saturation effect, according to which its contribution is greater in less developed countries than in more developed countries.

The previous results allowed studies that deepen these effects, focusing on specific regions of the world, in this regard, in the study: The economic contribution of broadband, digitalization and ICT regulation: Econometric modeling for the Americas (ITU, 2019)[19] and the same methodologies and models are used to assess global effects and measure the contribution of broadband to the economy of the Americas region. Based on these models, it was determined that fixed broadband had a significant impact on the economy of the Americas between 2005 and 2017, because a 10% increase in fixed broadband penetration produces an increase 1.9% in GDP. Mobile broadband has a lesser impact on the economy of the Americas than fixed broadband, because a 10% increase in mobile broadband penetration led to a 1.2% increase in PBI.

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[17] The countries are: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal , Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

[18] The Commonwealth of Dominica, Grenada, the Federation of St. Christopher (St. Kitts) and Nevis, St. Lucia, St. Vincent and the Grena-dines.

[19] The study compiles the research bibliography on the economic contribution of broadband in the Americas region, which has also been compiled in this working paper.

Finally, the study: The Cointegration Relationship and Causal Link of Internet Penetration and Broadband Subscription on Economic Growth: Evidence from ASEAN Countries (Cambas & Cambas, 2020) explores the cointegration relationship and the causal link between Internet penetration and Broadband subscription to the economic growth of the 10 countries of the Association of Southeast Asian Nations (ASEAN), for the period between 2000 and 2016. A multiple regression model was developed grouped with GDP growth as a function of penetration Internet and broadband subscription. The Johansen-Fisher panel cointegration was applied to determine the presence of a long-term equilibrium relationship between the three variables, also, the direction of causality was identified by estimating the vector error correction model, based on panel (VECM).

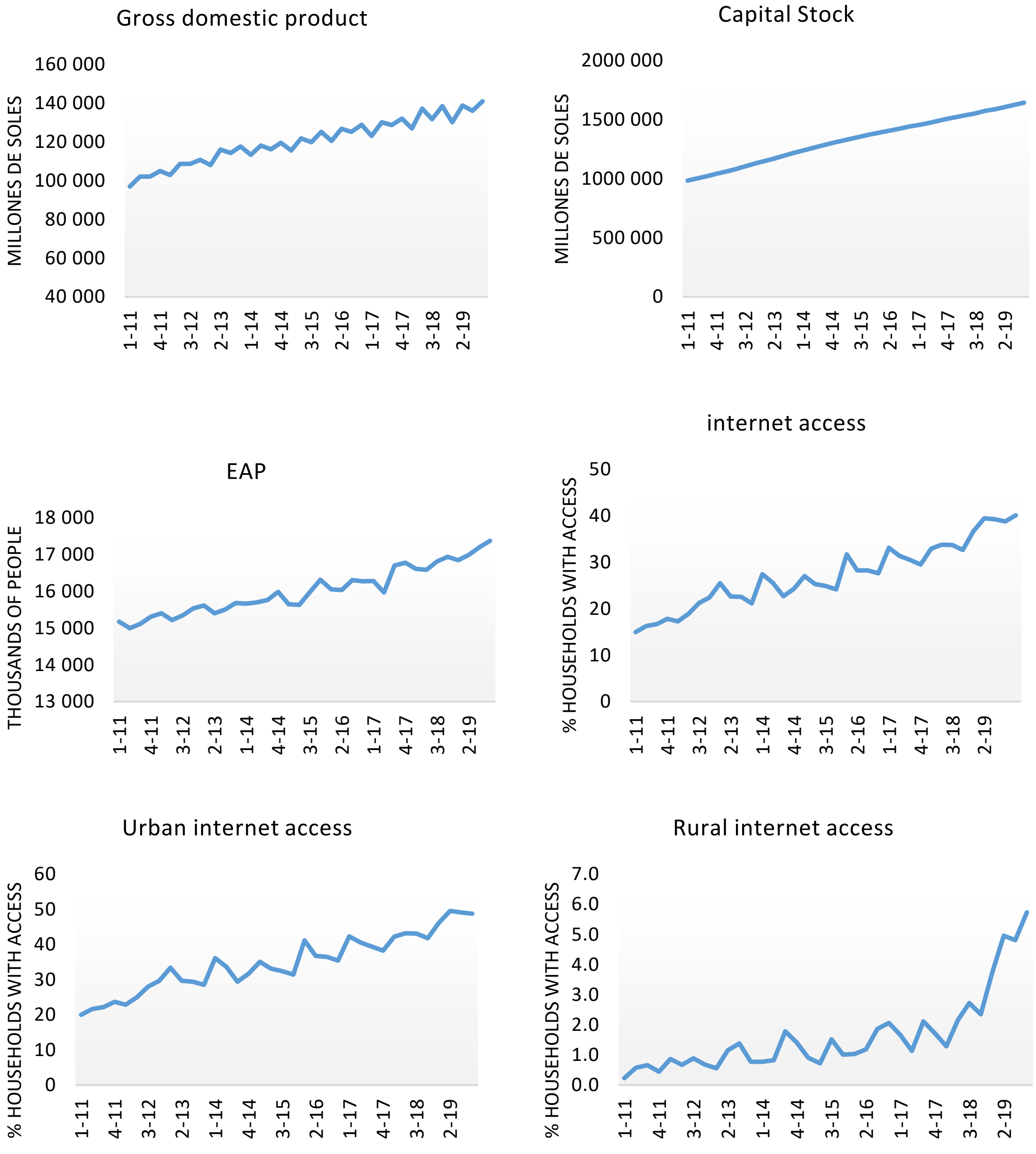
Based on this model, it was determined that Internet penetration and broadband subscription collectively influenced the economic growth of ASEAN countries between 2000 and 2016. The findings indicate that there is a long-term equilibrium relationship time between economic growth and each of the independent variables, Internet penetration and broadband subscription, in ASEAN countries. In addition, the study suggests that there is a long-term causality ranging from Internet penetration and broadband subscription to economic growth.

In summary, there is evidence from various transmission channels that indicate that there is a positive effect of internet access on the country's economic growth.

Chapter 4. Data Discussion

To estimate the impact of internet access on the production level of the economy, time series will be used on a quarterly basis between the first quarter of 2011 and the fourth quarter of 2019.

Graph 12. Graph of the variables used, 2011 IT - 2019 IVT



Source: INEI

In this sense, a Cobb Douglas-type production function is modeled, where Table 1 summarizes the variables used, the treatment received and the sources for obtaining the data.

Table 10. Description of Variables

Variable	Description	Treatment	Source
GDP	Real Gross Domestic Product, in millions of soles in 2007	• The series with Tramo-Seats was seasonally adjusted	• GDP: INEI
K	Stock of physical capital, in millions of soles of 2007	• The series was obtained by the perpetual inventory method (Nehru and Dareshwar, 1993), $K_t = (1 - d)K_{t-1} + I_t$. Where $K_0 = \frac{I_1}{g+d}$, I_t is the gross formation of fixed capital, d the rate of depreciation and g the growth rate of GDP.	• I: INEI • g: average GDP growth rate be-tween 1950-1980, 5% per year. • d= 3.3% per year: MEF (2020).
L*h	Human capital, in thousands of people	• The series with Tramo-Seats was seasonally adjusted. Where L is the employed economically active pop-ulation and h is a human capital index, given by $h_t = \exp\,[\left(\frac{\theta}{1-\psi}\right) s_t^{1-\psi}]$	• L: INEI • s: ENAHO • $\Psi = 0{,}58$, $\theta = 0{,}32$: Klenow and Bils (2000)
ptot	% of households with internet access at home	• The series with Tramo-Seats was seasonally adjusted	ENAHO - INEI
purb	% of households with internet access at home, in urban areas	• The series with Tramo-Seats was seasonally adjusted	ENAHO - INEI
purb	% of households with internet access at home, in rural areas	• The series with Tramo-Seats was seasonally adjusted	ENAHO - INEI

Source: Elaborated by the authors

Meanwhile, Table 11 shows the main statistics of the variables used:

Table 11: Descriptive statistics

Variable	Unit of measure	N° de Obs.	Maximum	Minimum	Average	Median	Dev. Standard
Gdp	in millions of soles	36	141029.0	97016.0	120564.6	120275.0	11709.1
L	in millions of soles	36	17.4	15.0	16.0	16.0	0.6
K	in millions of soles	36	1644584.0	984798.5	1330295.0	1347501.0	198679.7
ptot	percentage	36	39.5	15.0	26.8	26.3	6.7
prur	percentage	36	49.5	20.0	34.8	34.4	8.1
purb	percentage	36	5.7	0.2	1.6	1.2	1.3

Source: Elaborated by the authors

Chapter 5. Methodology

It is usual to estimate Vector Error Correction Models (VECM), to determine the short- and long-term relationships between certain variables. The VECM model, however, tends to have some limitations, for example, it can only be used as long as all the variables are first order integrated (I (1)), and these types of models are sensitive to the number of lags to include. In this sense, the ARDL models represent a good alternative regarding the VECM model, since they allow the use of variables I (0) and I (1), likewise, the number of optimal lags is chosen according to each variable, which allows to obtain more strong results when applied to small samples (Pesaran and Shin, 1999).

Considering the above, it is pertinent to evaluate the order of integration of the series in order to choose the appropriate model. The Augmented Dickey Fuller-ADF test will be used (Dickey and Fuller, 1979, 1981). This raises an autoregressive difference model, which is shown in equation (1). Where the null hypothesis that the series, y_t, presents unit root ($H_0: \delta = 0$), is contrasted, for which the critical values proposed by MacKinnon (1996) are used.

$$\Delta y_t = \alpha y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + \delta x_t' + \varepsilon_t \qquad (1)$$

The operator Δ denotes first differences, x_t' represents the exogenous variables and ε_t is the error term. The ADF test includes lags (p), which are determined by some information criterion.

Likewise, the Phillip Perron-PP test (Phillip and Perron, 1988) will be used, which is based on an AR (1) model (equation (2)). This test contrasts the null hypothesis that the series y_t is first order integrated by a non-parametric method.

$$\Delta y_t = \alpha_0 + \delta y_{t-1} + \varepsilon_t \qquad (2)$$

The choice of the appropriate model will depend on the order of integration of the series, in that sense, if all the series are integrated in the same order, the VECM models are the most appropriate (Aparco and Flores, 2019), while if the variables are integrated of order zero $I(0)$ and order one $I(1)$, it is convenient to use the ARDL models (Pesaran & Pesaran, 1997).

In this study, the $ARDL\ (p, q, r, s)$ models will be estimated, which represents the model in the form of error correction, as detailed in equation (3), in which the respective error correction model (ECM) can be estimated and determine the existence of a long-term relationship between the variables.

$$\Delta lnGDP_t = a_0 + \sum_{j=1}^{p} \alpha_j \Delta lnGDP_{t-j} + \sum_{j=0}^{q} \beta_{1j} \Delta lnK_{t-j} + \sum_{j=0}^{r} \beta_{2j} \Delta Lh_{t-j} + \sum_{j=0}^{s} \beta_{3j} \Delta INT_{t-j} + \lambda ECM_{t-1} + \delta_i D_i + \varepsilon_t \quad (3)$$

The operator Δ is the first difference operator, a is the independent term, the parameters α and β_i are associated with short-term effects; while λ is the vector associated with the error correction term (ECM_{t-1}), and δ_i represents the effects of the dummy variables. Finally, ε_t is an identical and independently distributed variable. The number of lags for each variable included in the model is represented by $p,\ q,\ r$ y s. Furthermore, INT is the internet access variable, which can take the value of ptot (Model 1), purb (Model 2) and prur (Model 3).

Pesaran et al. (2001) proposes an approach to test which variables in levels cointegrate, regardless of whether they are $I(0)$ o $I(1)$ using the F test to test the significance of the cointegration parameters in the error correction model. The limits test consists of comparing whether the asymptotic critical values corresponding to the extreme cases in which all variables are zero-order integrated, $I(0)$, or that all variables are first order integrated, $I(1)$. These values are calculated using specific stochastic simulations according to the sample size.

The null hypothesis of the limits test is of no long-term relationship between the variables; therefore, if the calculated F statistic falls above the critical value of the upper limit, it is said that there is statistical evidence to reject the hypothesis of no relationship in the long term. On the contrary, if the calculated statistic is below the lower critical value, the null hypothesis cannot be rejected, concluding that there is no cointegration relationship. Finally, if the value of the calculated statistic is between the critical values, then the test will not be conclusive.

Chapter 6. Results

Identifying the degree of integration of the series is a necessary step in obtaining the ARDL model, since it is necessary that the variables be at the most integrated of the first order for the F test to be valid.

Table No. 12 shows the ADF and Phillips Perron tests. The results of these tests show that the null hypothesis that the series have unit root at the usual significance levels in the variables of lnpbi, ptot, purb and prur in levels cannot be rejected, but that this is rejected when the variables are in differences, so it can be concluded that they are first order integrated. Similarly, unit root tests for ADF and PP show that the variables lnK and lnLh are zero-order integrated.

Table 12. Unit Root Tests

Variables	ADF Test			Phillips – Perron Test			Order
	Intercept	Intercept and trend		Intercept	Intercept and trend		
ln(gdp)	-2.624*	-2.999		-3.409**	-2.376		I(1)
lnLh	0.852	-0.983		0.965	-2.610		I(1)
lnK	-5.051***	-6.334***		-8.085***	-1.089		I(0)
ptot	0.560	-1.232		0.108	-2.023		I(1)
prur	0.202	-1.615		-0.046	-2.356		I(1)
purb	3.693	2.719		1.763	-0.986		I(1)
Δ ln(pbi)	-3.395**	-2.659		-3.275**	-4.199**		I(0)
Δ ln(Lh)	-10.934***	-10.978***		-10.437***	-11.472***		I(0)
Δ ln(K)	-	-	-	-	-		-
Δ ptot	-7.305***	-7.301***		-7.305***	-7.301***		I(0)
Δ prur	-7.385***	-7.309***		-7.373***	-7.300***		I(0)
Δ purb	-1.880	-2.622		-6.851***	-7.194***		I(0)

Note: Δ is the first difference operator. * Significance at 10%, ** Significance at 5% and *** Significance at 1%. Values calculated by MacKinnon (1996). Source: Own Elaboration.

Given that the variables analyzed have an integration order of less than two, it is feasible to estimate equation (3), for which it is necessary to determine the number of lags that should be included. In this sense, Table N ° 13 shows the number of optimal lags that will be used in each model based on the Schwarz information criterion.

Table 13. Top 10 best models based on Schwarz criteria (SIC)

Model 1 (ptot)		Model 2 (purb)		Model 3 (prur)	
Models	**SCI**	**Models**	**SCI**	**Models**	**SCI**
ARDL(4, 3, 4, 5)	-10.338	ARDL(4, 3, 4, 5)	-10.339	ARDL(3, 0, 2, 3)	-8.254
ARDL(4, 4, 4, 5)	-10.266	ARDL(5, 3, 4, 5)	-10.250	ARDL(4, 0, 2, 0)	-8.208
ARDL(4, 3, 5, 5)	-10.231	ARDL(4, 4, 4, 5)	-10.244	ARDL(4, 0, 2, 3)	-8.198
ARDL(5, 3, 4, 5)	-10.228	ARDL(4, 3, 5, 5)	-10.229	ARDL(2, 0, 2, 3)	-8.190
ARDL(4, 5, 4, 5)	-10.171	ARDL(4, 5, 4, 5)	-10.167	ARDL(4, 0, 1, 0)	-8.170
ARDL(4, 4, 5, 5)	-10.169	ARDL(5, 3, 5, 5)	-10.164	ARDL(2, 0, 2, 4)	-8.166
ARDL(5, 4, 4, 5)	-10.156	ARDL(5, 4, 4, 5)	-10.163	ARDL(3, 0, 2, 4)	-8.163
ARDL(5, 3, 5, 5)	-10.122	ARDL(4, 4, 5, 5)	-10.135	ARDL(2, 0, 4, 3)	-8.161
ARDL(4, 5, 5, 5)	-10.097	ARDL(5, 4, 5, 5)	-10.133	ARDL(4, 0, 4, 0)	-8.160
ARDL(5, 4, 5, 5)	-10.084	ARDL(4, 5, 5, 5)	-10.077	ARDL(3, 0, 1, 3)	-8.151

Source: Elaborated by the authors

Next, the existence of a long-term relationship is verified by the limits test (or F-test). As shown in Table N ° 14, according to this test, at the usual significance levels (1%, 5% and 10%) the existence of a cointegration relationship is evidenced in models 1 and 2, since the The calculated F value is greater than the upper limit (I (1)), but in model 3 the null hypothesis that there is no long-term relationship is not rejected. This means that there is no long-term relationship when the access variable is included in rural areas.

Table 14: Limits Test

Model	F-statistic	At 1%		At 5%		At 10%	
		I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Model 1 (ptot) ARDL (4, 3, 4, 5)	79.454***	4.30	5.23	3.38	4.23	2.97	3.74
Model 2 (purb) ARDL (4, 3, 4, 5)	82.443***	4.30	5.23	3.38	4.23	2.97	3.74
Model 3 (prur) ARDL (3, 0, 2, 3)	2.701	4.30	5.23	3.38	4.23	2.97	3.74

Note: Critical values calculated by Pesaran et al. (2001). Source: Own Elaboration.

Table N ° 15 shows the results of the estimates of the Error Correction Models (ECM). In both models it is observed that the error correction coefficients are negative and significant, so we can affirm that there is a long-term relationship between the variables analyzed.

The Jarque-Bera test indicates that the residues are normally distributed; In the Breusch-Godfrey serial non-autocorrelation test (LM test) and the Harvey non-heteroscedasticity test, the null hypothesis is not rejected at the usual significance levels (1%, 5% and 10%), with which the sphericity of the residues is verified.

Likewise, the coefficients shown correspond to the short-term elasticities. For example, the constant term has a negative and significant elasticity in both models. On the other hand, there is evidence of a positive impact of the capital stock on GDP in the short term, but that decreases as lags are added. In contrast, the stock of human capital has a negative impact on the economic level in the short term.

Regarding internet access, although this is negative in the first two periods, it tends to have a positive impact on GDP from the third lag, so the joint result is uncertain. This result is consistent with that found by Camba and Camba (2020), who did not find a causal relationship in the short term between internet penetration and economic growth.

On the other hand, it is inferred that the adjustment speed of the model is 129% (model 1) and 127% (model 2) for each period of time, that is, per quarter.

Table 15: Error Correction Model

Dependent variable: Δ ln(gdp)	Model 1	Model 2
	ARDL (4, 3, 4, 3)	ARDL (4, 3, 4, 3)
C	-3.933***	-2.154**
Δ ln(gdp (t-2))	0.683***	0.707***
Δ ln(gdp (t-3))	0.920***	0.937***
Δ ln(Lh)	-0.121***	-0.131***
Δ ln(Lh(t-1))	-0.492***	-0.422***
Δ ln(Lh(t-2))	-0.203***	-0.179***
Δ ln(Lk)	7.659***	7.316***
Δ ln(Lk(t-1))	2.468***	2.319**
Δ ln(Lk(t-2))	-0.243	0.368
Δ ln(Lk(t-3))	-6.977***	-6.606***
Δ ptot	0.0003	-
Δ ptot (t-1)	-0.002***	-
Δ ptot (t-2)	-0.001***	-
Δ ptot (t-3)	0.0003***	-
Δ ptot (t-4)	0.0007***	-
Δ purb	-	0.0003*
Δ purb (t-1)	-	-0.002***
Δ purb (t-2)	-	-0.001***
Δ purb (t-3)	-	0.0002
Δ purb (t-4)	-	0.001***
Du	0.002***	0.002***
EC (t-1)	-1.287***	-1.270***
Adjusted R-square	0.981	0.981
Schawarz information criteria	-10.782	-10.782
F Statistic	93.066	93.139
Prob.	0.000	0.000

Dependent variable: Δ ln(gdp)	Model 1	Model 2
	ARDL (4, 3, 4, 3)	ARDL (4, 3, 4, 3)
Normality (Jarque-Bera)	0.117	0.870
Prob.	0.943	0.647
No autocorrelation (Breusch-Godfrey, LM test)	3.289	3.076
Prob. (Statistical F(4,5))	0.112	0.125
Homoscedasticity (Harvey)	1.102	1.308
Prob. (Statistical F)	0.449	0.331

Note: * Significance at 10%, ** significance at 5% and *** significance at 10%. Source: Own Elaboration

Table No. 16 shows the long-term estimated coefficients. In model 1, which shows the impact of internet access at home, it shows that at a 10% variation in internet access, the level of economic activity would increase by 2.0%; while a 10% increase in internet access in urban areas would increase the level of economic activity by 1.8%.

These results are consistent with those found by Gruber (2014), Katz (2014) and Koutroumpis (2009) at the aggregate level. For the particular case of the impact at the rural level, although there is evidence of a positive impact on household income (Aguilar et al, 2020), no long-term relationship was found between internet access at the rural level and the level of economic production, which is explained by the small connection that exists between these economies and the rest of the market (CEPAL, 2018) and the still low rate of internet access in rural areas (at the fourth quarter of 2019, internet access at home was 5.9%).

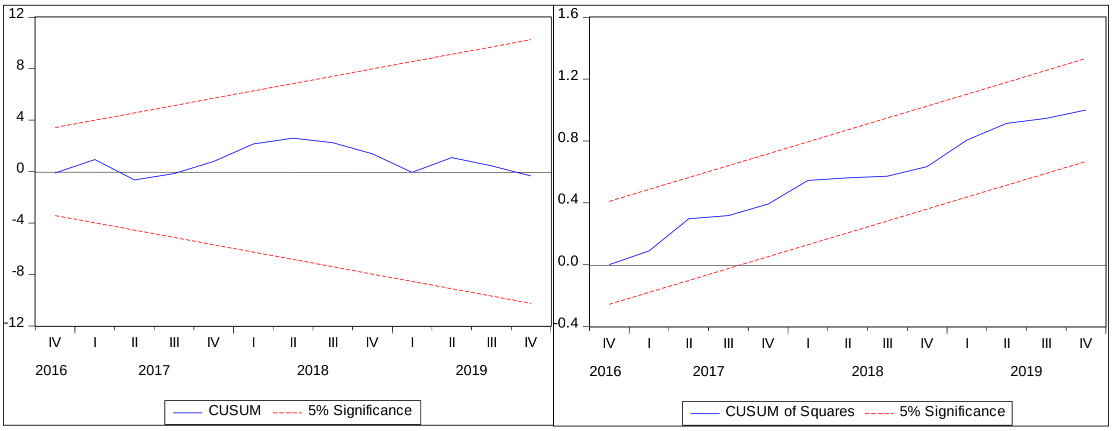
Table 16: Long-term elasticities

Dependent variable: ln(gdp)	Model 1	Model 2
ln(Lh)	0.285***	0.371***
ln(Lk)	0.951***	0.885***
ptot	0.0020***	-
purb	-	0.0018***

Note: * Significance at 10%, ** significance at 5% and *** significance at 1%. Source: Own Elaboration.

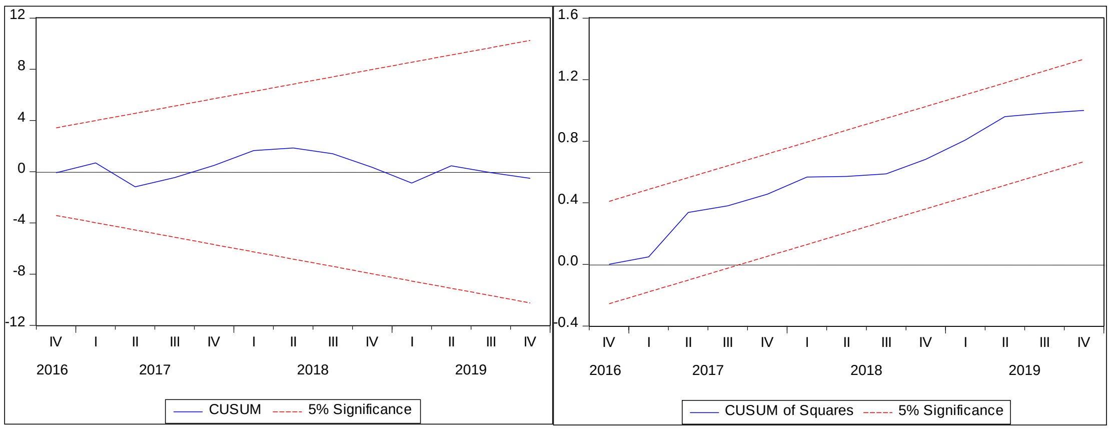
Finally, to provide robustness to the estimated models, graph 13 and graph 14 show the stability tests of the CUSUM and CUSUM-SQ parameters for models 1 and 2, respectively. These figures show that there is stability in the estimated parameters in both models, since the CUSUM and CUSUM-SQ do not exceed the significance bands at the 5% level.

Graph 13: CUSUM AND CUSUM-SQ of Model 1



Source: Elaborated by the authors

Graph 14: CUSUM AND CUSUM-SQ of Model 2



Source: Elaborated by the authors

Chapter 7. Conclusions and recommendations

During the period 2011 to 2019, the growth of the GDP of the telecommunications subsector has presented a greater dynamism than the national GDP, even in the year 2020. In the accumulated to the third quarter, the sector presented higher growth by 13.4%. Consequently, the Communications sector increased its participation in the national GDP from 3.3%, in 2011, to 5.8%, in the third quarter of 2020. In this same period of analysis, the telecommunications subsector captured more than S / 34,720 million, and only in 2019 it was S / 5,480 million.

The RDNFO infrastructure forms a transport network of around 13,500 km of fiber optics, which connects 22 regional capitals, 180 provincial capitals, and 136 localities. In 2016, its construction was completed, and it went into operation in its entirety, for the provision of the carrier service. Regarding the 21 regional projects, they include the construction of broadband transport networks with reach at the district capital level, from the RDNFO distribution nodes, as well as the implementation of a wireless access network to reach rural locations. . These projects are expected to provide internet service to 12,000 public institutions and benefit 3.4 million inhabitants.

This investment and infrastructure mentioned, has allowed to cover the growing demand for internet service reflected in the increase in access, use and speed of the service. In the current situation due to the pandemic, the internet service that allows activities such as: tele-education, telehealth, telework, among others, has been intensified in order to satisfy basic needs. However, the gaps in access and use at the level of residence area show us that these gaps are aggravated in rural areas, so they should be improved. In this sense, according to the IDB, it is important to focus on the variables that present low levels in its IDBA indicator, such as the access and use of the fixed internet service in homes and schools, for which, regional projects and the RDNFO They play an important role with an emphasis on rural areas.

The present study used a Cobb-Douglas production function and the ARDL econometric model to estimate the impact of internet access on households and economic growth in Peru. The results indicate that there is a long-term relationship between internet access and the level of production in the economy.

The ARDL model estimate shows that a 10% increase in internet access would increase the value of GDP by 2.0%, that is, if the percentage of households rose from 38.8% (at the fourth quarter of 2019 according to INEI) to 48.8%, the level of production (REAL OR NOMINAL) would increase by S / 10,923 million (2% of GDP in 2019). Likewise, considering internet access at the urban level, an increase in internet access by 10% in the urban area would increase the value of GDP by 1.8%, these estimates being consistent with several studies carried out as shown in Appendix No. 1.

On the other hand, although there is evidence that internet access in rural areas does generate a positive impact on household income (Aguilar et al, 2020), no long-term relationship was found between internet access at the rural level and the level of economic production, explained mainly by the little connection that exists between these economies and the rest of the market (Cepal, 2018) and the still low rate of internet access in rural areas.

Therefore, the implementation of public policies is recommended with the aim of reducing gaps in access, use and speed of internet service, in order to continue contributing to long-term economic growth. Likewise, special emphasis should be placed on rural areas, since it would allow an increase in connectivity, which generates business development and unites rural economies with urban ones. Likewise, it will allow increasing access and the quality of other public services such as health and education. Therefore, prioritizing investment projects in the sector will continue to generate competitive infrastructure (economic growth) and social (cover basic needs), this becomes more relevant considering that such effects would help reduce the negative effects caused by the COVID-19 pandemic.

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ANNEX

Annex 1. Impact of internet access on economic growth

An increase of 10% in the percentage of households that has internet access would increase the value of GDP by 2.0% in Peru. These results are consistent with those found at the international level, as detailed:

Author	Countries	Methodology	Dependent variable	Explanatory variable	Elasticity (anual average)
UIT (2019)	20 countries América	Simultaneous equations	Real GDP	Broadband penetration	1.9%
Arabi & Allah (2017)	Sudan (1980-2014)	ARDL	Real GDP	Fixed and mobile telephony	2.0%
Camba & Camba	10 Asian countries (2000-2016)	VECM	Real GDP	Broadband penetration	3.9%
Gruber (2014)	27 UE countries (2005-2011)	Simultaneous equations	Real GDP	Broadband penetration	8.3%
Koutroumpis (2009)	22 OECD countries (2002-2007)	Dynamic panel	Real GDP	Investment stock in telecommunications (MM USD)	2.4%
Czernich et al. (2009)	OECD countries (1996-2007)	Dynamic panel	GDP per capita	Broadband penetration	0.9-1.5%
Qiang et al. (2009)	119 countries	Cross-section	Real GDP	Broadband penetration	1.21% developed countries 1.38% developing countries

Source: Elaborated by the authors