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THE VALUE OF DIGITAL TRANSFORMATION THROUGH EXPANSIVE MOBILE IN LATIN AMERICA

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EXECUTIVE SUMMARY

The concept of expansive mobile represents a more advanced version of mobile services, offering much faster symmetrical speeds and minimal latency, without geographical limits. The services associated with expansive mobile offer greater coverage by providing consistent quality levels inside and outside of buildings, within populated and industrial areas, and along transportation corridors. Similarly, this service extends coverage to isolated and rural areas, providing ability to deliver signals to devices with very low energy consumption, such as Internet of Things devices. This extended version of mobile services is primarily aimed at enabling the full digital transformation of the economy. The following study is focused on assessing the economic impact of expansive mobile in Latin America and determining the public policy and public-private collaboration initiatives that are needed to make this concept a reality in the region.

The economic impact of expansive mobile in Latin America depends on its implementation, which could take place along the following four potential scenarios:

- Urban-Suburban scenario: expansive mobile is implemented only in first and second-tier metropolitan centers. This strategy is similar to 5G deployment plans in advanced economies. The service will offer uniform symmetric speed of 50 Mbps.
- National scenario I (2 Mbps in rural areas): the advanced service offered in urban-suburban areas is combined with lower service quality in rural areas.
- National scenario II (10 Mbps in rural areas): an advanced service is offered in urban-suburban areas combined with a less developed one in rural areas.
- National scenario III: the deployment in the urban-suburban scenario is extended to the entire country with consistent service features and quality levels (50 Mbps symmetric speed).

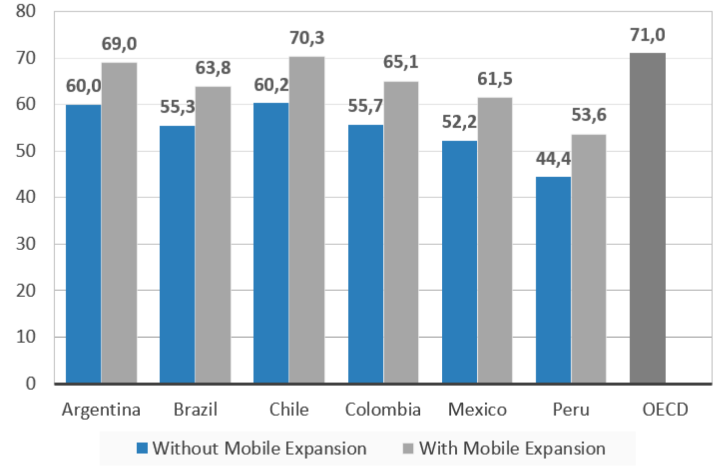
The capital required to deploy these networks in the six largest economies in Latin America (Argentina, Brazil, Chile, Colombia, Mexico and Peru) ranges between US$ 50.8 billion for the Urban-Suburban Scenario, and US$ 120.1 billion for the National Scenario III. It is estimated that, considering the non-discretional CAPEX needs, operators would face an increase of annual capital spending between 15% and 20%, depending on the country and deployment scenario.

The economic and social impact resulting from the implementation of expansive mobile has been estimated in the following three areas:

- **Impact on digital transformation**: expansive mobile will generate benefits in connectivity, household digitization, the digitization of production, as well as providing an incentive for the growth of digital industries.
- **Impact on the growth of the Gross Domestic Product (GDP)**: the increase in the level of digitization will contribute to the GDP due to the investment in network deployment, but even more importantly, as a result of the spillover effects on the whole economy.
- **Impact on the contribution to GDP of certain industrial sectors**: the spillover effects result from an increase in operational efficiency as well as an improvement in the productivity of key regional industries, such as agriculture and food processing.

In 2018, the Digital Ecosystem Development Index that measures the level of digitization of the economy of the six countries under study ranges between 60.24 for Chile and 44.35 for Peru (based on a scale from 0 to 100). The six Latin American countries that were studied in detail lag the prorated average index for OECD countries by between ten and twenty-five points. The implementation of technologies associated with expansive mobile leads to significant growth in the Latin American Digital Ecosystem Development Index, closing the gap with the OECD (see Graphic A).

Graphic A. Latin America versus OECD: CAF Digital Ecosystem Development Index (without and with the effect of expansive mobile - national scenario III)



Source: Telecom Advisory Services analysis

The advance in digitization as a result of expansive mobile occurs in six areas: digital infrastructure, connectivity, household digitization, digitization of production, the growth of digital industries and the improvement of factors of digital production (such as human capital). The implementation of expansive mobile according to the national scenario III generates a GDP contribution ranging between US$104 billion for Brazil and US$15 billion for Peru. If the National Scenario III is deployed, the GDP will grow by US$249.8 billion for the six countries under study, once roll-out is completed and adoption of services is generalized. By extrapolating the effect to the rest of Latin America, expansive mobile will contribute between US$ 292.88 billion (under the urban-suburban scenario) and US$ 292.88 billion (under the national scenario III) to the Latin American GDP. This implies an annual contribution to the GDP of US$ 29.28 billion, resulting from a time horizon for deployment and service adoption of ten years. Under this scenario, the increase in annual GDP for the whole region that is attributed to expansive mobile would be an average of 0.54%[1]. This value has been disaggregated by country (see table B).

Table B. Annual GDP impact by country (in percentage)

	Urban-Suburban	National Scenario I	National Scenario II	National Scenario III
Argentina	0.40%	0.46%	0.47%	0.48%
Brazil	0.40%	0.45%	0.47%	0.49%
Chile	0.44%	0.50%	0.51%	0.53%
Colombia	0.42%	0.48%	0.51%	0.53%
Mexico	0.40%	0.50%	0.53%	0.56%
Peru	0.46%	0.58%	0.61%	0.67%
Rest of LATAM	0.41%	0.47%	0.50%	0.52%

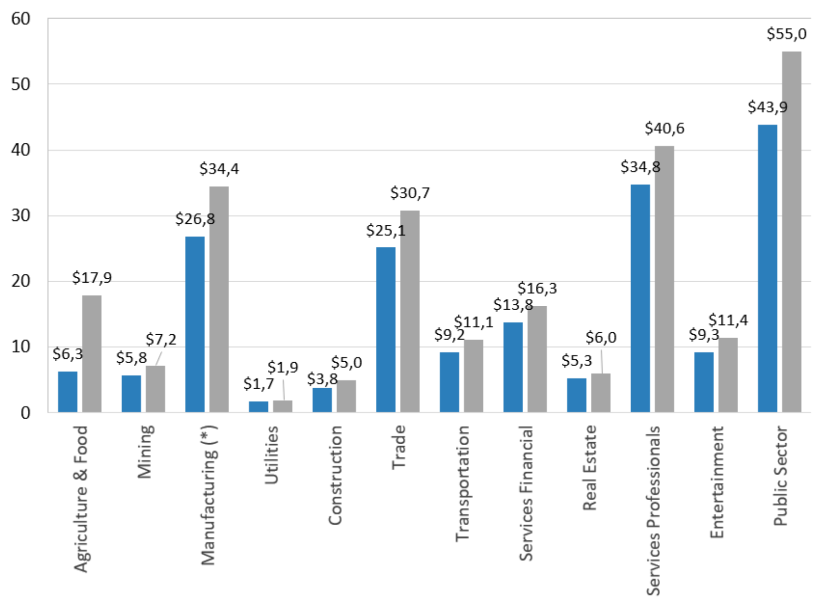
Source: Telecom Advisory Services analysis

Beyond the macroeconomic effect, the impact of expansive mobile can also be estimated at the microeconomic level since the adoption of use cases facilitated by the implementation of expansive mobile reduces an enterprise cost structure (better efficiency) while increasing its market scope and

[1] These values reflect the cumulative growth of GDP once the expansive mobile infrastructure is deployed and services offered have been adopted. The number of years that this process will require increases or decreases the annual impact. For example, if deployment begins in 2022 and adoption has been generalized ten years later, the annual impact on the Latin American GDP for the national scenario III would be 292.8 billion/10 = $ 29.28 billion.

coverage (by deployment of new distribution channels). The sectors that receive the most important benefits are the public sector, professional services, manufacturing, and agriculture (see Graphic C).

Graphic C. Latin America: Economic Impact per Industrial Sector (urban-suburban versus national scenario III) (in millions of US$)

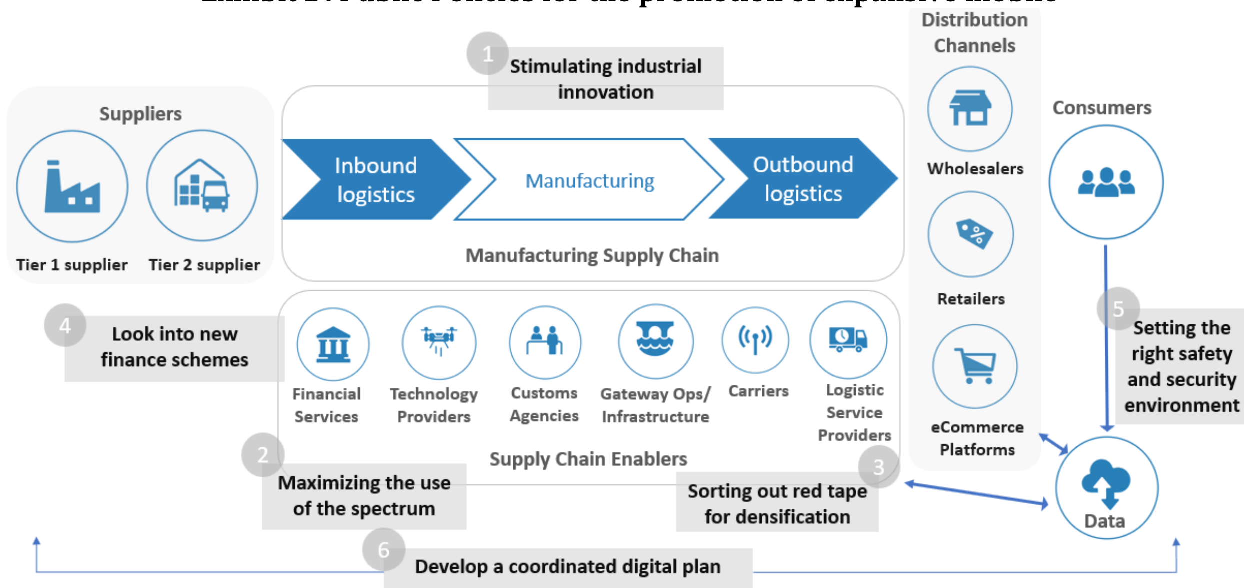


(*) Includes all manufacturing sub-sectors except for food processing.
Sources: Global Trade Analysis Project; Telecom Advisory Services analysis

This conclusion is of the utmost importance. First, the impact on the public sector highlights the importance that expansive mobile will have on the quality and efficiency in the delivery of public services (including health, education and safety). Second, as expected, professional services, as an information intensive sector will be a natural beneficiary of expansive mobile. Third, the impact of technology on manufacturing, commerce and agriculture demonstrates the central premise of expansive mobile, as a primary vehicle for the digital transformation of Latin American economies. For example, in the case of the agricultural and food processing sectors (representing 15% of Latin American GDP), the use cases facilitated by expansive mobile generate a 2.47% increase in productivity. In the case of the automotive industry, the increase is even greater: 4.02% of the sector's gross product. From a general standpoint, expansive mobile is an essential component in the diffusion and adoption of the 4.0 industry framework in the region.

For this to happen, expansive mobile should not be conceived as a gradual improvement on the wireless telecommunications services that are being offered in the market today, but as representing a quantum leap in the future value of connectivity. The implementation of expansive mobile needs to be promoted and enabled using the leverage of public policy in order to provide resources (such as spectrum, infrastructure, capital and security) and to create incentives for innovation regarding the deployment of use cases in different sectors. Enabled by expansive mobile, value chains in each industry will be stimulated, enabled and/or conditioned by such use cases. This type of development requires vision, institutional framework and a very special coordination and cooperation effort because its global nature makes it enormously challenging (see Exhibit D).

Exhibit D: Public Policies for the promotion of expansive mobile



Source: Telecom Advisory Services analysis

First, innovation must be stimulated through policies that focus on responding to the specific digital transformation needs of the varied industrial and economic sectors. In this context, the current institutional framework for the regulation and formulation of public policies in the digital ecosystem is no longer appropriate. In fact, the actions taken by telecommunications regulators today represent only a small part of the relevant aspects of expansive mobile, which include competition, data protection and coordination with sectoral authorities and local governments. To resolve these limitations, it is necessary to experiment in controlled environments ("regulatory sandboxes[2]") and test new, more flexible regulatory frameworks that encourage risk investment and the development of new services (see Table E).

Table E: Coordination between public policies and agencies is essential to promote the innovation that is required for digital transformation

	National Digital Development Plan			
Gov Levels	Telecom Regulator	Data Protection /Security Agency	Agriculture, Health, Education, Finance, Industry, Energy	Local Government
Policy enablers	• Spectrum roadmap allocation. Flexible allocations (QoS, coverage, use) • Promote network investment, 2G/3G shutdown plan, infrastructure sharing, one window, new infra only players (TowerCos), facilitate use of national buildings • Universal Service Funds and use of national backbone networks • Open standards/technology neutrality. • Flexibilize net neutrality to allow full slicing and virtualization.	• Strengthen privacy and security policy • Big Data and open data access, encryption, annonymization • Cybersecuity protocols • Private encrypted networks • Enforcement, security monitoring	• Tax incentives, subsidies, innovation funds • Drone/Air/terrestrial traffic control • Labor training programs, university syllabus coordination, policymakers capacity building • SMEs creation facilitation, access to Venture Capital. • Use of electricity posts, meters • Facilitate eCommerce, ePayments • Cloud services, patient records. Use of Big Data for public health policies	• Secure national backbone access • Promote use/share of all local infrastructure, ducts and give access to public infrastructure • Positive silence policies, quicker permits for small cells, greater transparency, allow E2E fiber rollout • Invest in sensors/meters, adopt open scalable tech • Local SMEs tax incentives, local OTTs • Training programs, skills development • Promote local content

Source: Telecom Advisory Services analysis

[2] The *sandbox* or "regulatory sandbox" is a method based on pilot studies where experimentation with different levels of regulation can be carried out in a controlled environment to test their impact.

Second, administration of the radio spectrum with a forward-looking vision will be essential in implementing expansive mobile. Regarding this matter, it is clear that Latin America has not initiated the transition path between 4G and 5G and will therefore need to plan how to use the following entire spectrum: low bands such as the second digital dividend of 600 MHz, are very useful for reaching maximum coverage; mid bands are important for providing capacity with a greater amount of contiguous and harmonized spectrum for 5G, as in the case of the 3.5GHz spectrum; high bands are important where millimeter frequencies will enable low latency and high reliability services. The high future demand for spectrum will force Latin American countries to explore alternative mechanisms and flexible allocation methods, such as shared use and the secondary market. This requires clarity so that governments do not simply seek to maximize revenue through auctions, but rather that they promote the dedication of resources for implementation and innovation.

The third area of leverage refers to the need to implement a model to reduce local administrative barriers to infrastructure deployment. The use of small cells in urban areas will be a huge challenge to achieving the densification that is needed for the implementation of new services and expansive mobile use cases. It is estimated that by 2030 three times more sites than what are currently being used will be needed, along with 4 to 5 times more radio base stations. It is therefore important to take into account the experience obtained from facilitation measures that have already been partially implemented, but that unfortunately have not succeeded in overcoming difficulties that are due to municipal constitutional autonomy regarding the granting of road permits and the installation of antennas (see Table F). In this area, it would be preferable to introduce a system with a single point of contact with positive administrative silence, making the enabling process more transparent and predictable. This must necessarily be complemented by the effective and expedited facilitation of the use of public buildings and the provision of all kinds of incentives for sharing both infrastructure assets themselves and their management.

Table F: Types and Examples of Initiatives to Reduce Implementation Barriers Infrastructure at the Local Level in Latin America (Not comprehensive)

Initiative	Countries	Characteristics
Laws regarding antennas/infrastructure	Peru, Brazil	These promote the principle of "positive administrative silence" and later denial by the municipality in the case of non-compliance with any regulations.
National Infrastructure and Connectivity Plans	Argentina, Colombia, Costa Rica, Brazil	National Executive plans focused on reducing barriers, promoting the installation of fiber (backbone and building networks) and establishing rules or incentives (such as being included in the "obligation to act" for operators)[3] so that municipalities will enable/facilitate new infrastructure. It has been difficult to carry out mandates at the local level.
Single point of contact	Colombia, Argentina	In Colombia, follow-up of the online procedure is offered, but only some municipalities report consistent information. In Argentina this has been approved but not implemented.
Facilitating the use of federal buildings	Mexico, Chile, Costa Rica, Brazil, Argentina	If technically possible, regulate the use of public buildings or land owned by the Federal Government (Argentina, Mexico) or by state and/or private companies that provide public services such as roofs, pipelines and towers (Colombia, Chile).
Ranking of friendly cities	Argentina, Brazil, Peru	Classify (for example, OSIPTEL in Peru), reward and/or promote good practices in some cities (ENACOM/Argentina "Friendly Cities")

[3] See, for example, the 2018-2022 National Development Plan of Colombia, Article 309 of Law 1955 from 2019.

Initiative	Countries	Characteristics
Good practice standards	Argentina, Colombia	Provide a model ordinance for voluntary adoption that aligns local regulations. A lack of incentives for municipalities to adhere to has been observed.
Educational campaigns regarding antennas and radiation.	Peru, Colombia, Bolivia, Argentina	Sometimes promoted by private sector lobbying groups, such as "More Antennas, Better Communication" in Peru, or in conjunction with the Ministry as in Colombia's case, or by regulating agencies, such as "Friendly Antennas" in Argentina, or even bit the mobile operators themselves.
Radiation Level Maps	Colombia, Argentina	Maps showing measurements made by the regulating agency are available but are seldom consulted. Continuous measurements have been proposed and even standardized, but they are expensive, seldom consulted in practice and have not been implemented.

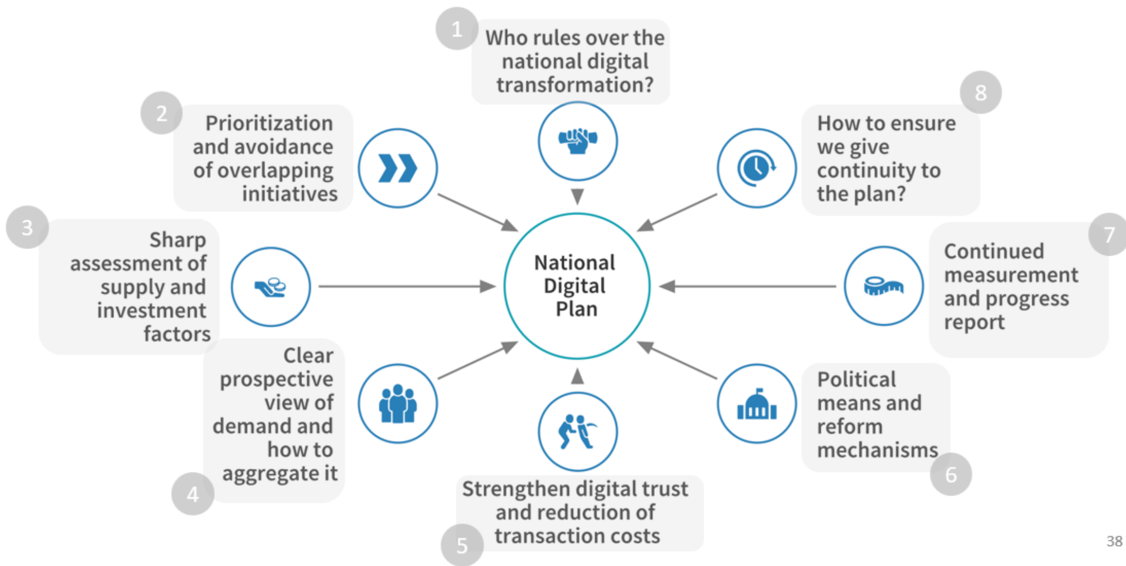
Source: Telecom Advisory Services compilation

The fourth area of leverage is oriented to take on the shortage of capital or the lack of incentives to invest in new businesses whose profitability and business model have not been proven. While the urban-suburban implementation scenario for expansive mobile is within historical CAPEX ranges for mobile operators, the deployment of infrastructure in national settings (especially infrastructure that provides uniform high-quality services throughout the entire area) represents a significant increase in capital investment. In this case, it is important to explore alternatives for combined or mixed financial structuring *(blended finance*) based on public-private cooperation. This can help mobilize private capital within the framework of more intense participation from the public and from multilateral organizations. An example of this leverage can be found in the "Internet for all" project that was developed in Peru and created a new rural operator using public-private investment that will help expand coverage in that country.

Finally, the fifth area of leverage is aimed at providing a safe and reliable digital environment with a prevailing trust for users and devices. There should be a proportional balance between the protection of privacy and confidentiality in transactions and the factors that promote new data economies, such as data collection and portability as well as cross-border flow. Additionally, countries and telecommunication operators will need cybersecurity strategies that offer a framework so that, for example, the internet of things does not end up creating yet another socio-economic vulnerability.

To conclude, the expansive mobile that drives digital transformation brings with it additional implementation challenges that require the following fundamental and foundational reforms: creation of an institutional framework, coordination, diagnosis and prospective analysis of demand, ensuring confidence and lower transaction costs, guaranteeing the political means to carry out reform processes, measuring and enabling continuous reporting and emphasizing that all these changes will continue beyond a particular government. In summary, it is necessary to define a comprehensive digital development plan that is effective in coordinating the mainstreaming of public policies, and that allows for overcoming the uncertainty of new innovative and highly productive use cases whose profitability or sustainability is still unclear. In short, the national scenario for expansive mobile implementation can only be made possible with cooperation and socialization of the costs and benefits that digital transformation will bring.

Exhibit G: Key items to consider when putting together an effective digital plan



Source: Telecom Advisory Services

1. INTRODUCTION

The future vision of the wireless environment can be conceptualized around the idea of expansive mobile. This notion underlines the distinction that is already being proposed in the 5G arena, which differentiates a limited version of 5G, which is actually a mere upgrade of 4G in terms of speed and efficiency in order to offer better mobile broadband, from an expanded version of mobile services, which provides faster symmetric speeds and minimal latency without geographical limits. This extended version of mobile services is primarily intended to become an enabler of the digital transformation of the economy[4]. Along these lines, the objective of expansive mobile is to meet the needs of enterprises by providing advanced use cases, such as autonomous vehicles, smart manufacturing and telehealth services[5].

The following study takes into account work done for other geographies[6], but it is focused on assessing the economic impact of expansive mobile in Latin America. The analysis focuses in the assessment of the expansive mobile impact and its implications for Argentina, Brazil, Chile, Colombia, Mexico and Peru, the nations that together represent 85.34% of the region's GDP[7]. On this basis, the estimates of economic contribution for the six countries have been extrapolated to the region as a whole.

The starting hypothesis of the study suggests that expansive mobile should not be conceived as a gradual improvement of the mobile services that are already being offered in the market today. It represents a quantitative leap in the proposed value of connectivity. Since expansive mobile is an essential component of the digital transformation of Latin America and, its implementation cannot be the result of an incremental approach. The implementation of expansive mobile requires modifying the regulatory frameworks related to spectrum management, eliminating any existing barriers to network deployment, and creating incentives for telecommunications operators to experiment with new business models. These models should emphasize solutions and use cases in the enterprise market as opposed to offerings focused on the individual market. In fact, the economic impact of expansive mobile can only be achieved by developing incentives to accelerate innovation in the digital economy, allowing for the construction of new value propositions that are aimed at the productive sector of the economy.

The following document is organized into five chapters. Chapter 2 presents a definition of the concept of expansive mobile in terms of its features, service levels, and value proposition. Chapter 3 describes how expansive mobile could be implemented in Latin America, detailing the corresponding levels of investment and construction scenarios. Chapter 4 presents an analysis of the economic impact of expansive mobile, both at an aggregate macroeconomic level in terms of its contribution to the growth of gross domestic product (GDP), and its impact on efficiencies and output of specific industrial sectors. Chapter 5 reviews the changes that are needed in terms of the regulatory

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[4] The concept reestablishes, although with more advanced metrics, the following objectives defined by the European Union for the Gigabit Society: (1) All major socio-economic actors that depend on digital transformation must have access to ultra-high speed broadband; (2) All households must have access to at least 100 Mbps broadband; (3) All transportation routes must be covered by 5G service without interruption.

[5] See W Lemstra, 'Towards the successful deployment of 5G in Europe: What are the necessary policy and regulatory conditions?' *Telecommunications Policy* 2018

[6] Williamson, B. (2019) *Expansive mobile: Reaping the payoff from investment in mobile connected computing*. Communications Chambers; Salomon, G. (2019). *Policy pivot for expansive 5G*. Regarding the impact of 5G technology, see Campbell, K., Diifley, J., Flanagan, B., Morelli, B., O'Neil, B., Sideco, F. (2017). *The 5G economy: How 5G technology will contribute to the global economy.* HIS Economics; Australian Government: Department of Communications and the Arts (2018). *Impacts of 5G on productivity and economic growth. Canberra: April.*

[7] Source: World Bank.

framework, public policies and institutional mechanisms, so that expansive mobile can be deployed in the region. Finally, chapter 6 presents findings oriented towards the unavoidable need to deal with the implementation of expansive mobile, calling for coordinated action by the different actors involved in its implementation.

2. THE EXPANSIVE MOBILE CONCEPT

Expansive mobile is defined in terms of greater service functionality, an exponential increase in the quality of the proposed value of connectivity, and the consequent implementation of an advanced wireless network infrastructure.

The services associated with expansive mobile offer greater coverage by providing consistent quality levels inside and outside of buildings, in populated areas, industrial zones and along transportation corridors. Similarly, coverage is extended to isolated and rural areas, providing signal coverage for devices with very low energy consumption. This includes the ability to provide service for a high density of Internet of Things terminals. Furthermore, the unit cost of data traffic is significantly lower than that of 4G networks.

This functionality is offered at a high quality in different geographies, although the latency and speed of the services are adapted to particular applications, use cases and market segments.

These characteristics define an advanced network that is composed of a high density of access points[8] and that operates in high, mid and low bands, as well as millimeter wave bands and non-licensed spectrum. Download speeds can reach 300 Mbps in high density areas, and 1 Gbps inside buildings. Latency in high density areas will be 10 ms, although certain critical applications may receive 1 ms latency. The network will allow the joining of several different radio technologies that have the interoperability necessary to allow for uninterrupted communication sessions. This functionality includes interoperability with obsolete technologies using a compatible common infrastructure that minimizes the number of entities and functions. Finally, as is the case with 5G networks, the expansive mobile infrastructure will offer the ability to allocate portions of the network using the virtualization of network functions ("n*etwork slicing*") and *Software Defined Network*.

As a consequence of these characteristics and technical functionality, it is to be expected that the use cases for expansive mobile services are mainly focused on increasing efficiency in the production sector and on the provision of public services. Use cases can be grouped into three categories: 1) extended wireless mobile broadband, 2) Internet of Things, and 3) mission critical solutions. Each of these categories requires different functionalities (see Table 1).

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[8] In dense areas, the number of sites will range between 200 and 2,500 per km2, whereas in suburban spaces it will reach 400 sites per km2, and in rural areas it will be approximately 100 per km2.

Table 1. Expansive Mobile: Use cases and Service Requirements

	Use cases	Service requirements
Extended Wireless Mobile Broadband	• Extended wireless indoor connectivity • Extended wireless outdoor connectivity • Fixed wireless broadband • Inter-organization communications • Augmented and virtual reality	• All-terrain high quality wireless coverage • Ability to accommodate an increase in the number of high traffic devices • Low unit cost for data traffic
Internet of Things	• Asset traceability • Electrical energy network monitoring • Physical infrastructure monitoring • Sensors	• Ability to operate in licensed and unlicensed spectrum bands • Software Defined Networking and virtualization of network functions
Mission Critical Solutions	• Autonomous vehicles • Drones • Robotic systems • Telemedicine, virtual reality, augmented reality	• Facilitates high reliability, ultra-low latency and high level of security, resulting in 100% reliability

Source: Telecom Advisory Services

3. DEVELOPMENT SCENARIOS FOR EXPANSIVE MOBILE IN LATIN AMERICA

The economic impact of expansive mobile in Latin America depends on its implementation scenario. For this purpose, four possible scenarios have been defined:

- Urban-Suburban scenario: expansive mobile is implemented only in first and second-tier metropolitan centers. This strategy is similar to 5G deployment plans in advanced economies. The service will offer uniform symmetric speed of 50 Mbps.
- National scenario I (2 Mbps in rural areas): the advanced service offered in urban-suburban areas is combined with lower service quality in rural areas.
- National scenario II (10 Mbps in rural areas): an advanced service is offered in urban-suburban areas combined with a less developed one in rural areas.
- National scenario III: the deployment in the urban-suburban scenario is extended to the entire country with consistent service features and quality levels (50 Mbps symmetric speed).

Each scenario requires different levels of investment. These have been calculated using the estimates provided by studies carried out in advanced economies within the framework of the deployment of extended 5G service[9] (see Table 2).

Table 2. United Kingdom: 5G Cost

	Town/City (Million)	Population distribution	5G CAPEX ($ billion)	5G CAPEX (%)	CAPEX per POP
Urban (cities >1 million)	19.42	29%	$0.89	1.66%	$45.71
Suburban	36.16	54%	$7.13	13.37%	$197.16
Rural	11.38	17%	$45.32	84.97%	$3,981.22
Total	66.96	100%	$53.34	100%	$796.58

Source: Oughton and Frias (2017). Exploring the cost, coverage and rollout implications of 5G in Britain; Telecom Advisory Services analysis

Using capital investment per POP as a starting point (which does not include spectrum acquisition costs), deployment costs for networks aimed at providing services based on the concept of expansive mobile have been calculated[10]. They have been estimated for the four implementation scenarios detailed above. Estimated costs reflect the total capital spent in network roll-out (see Graphic 1).

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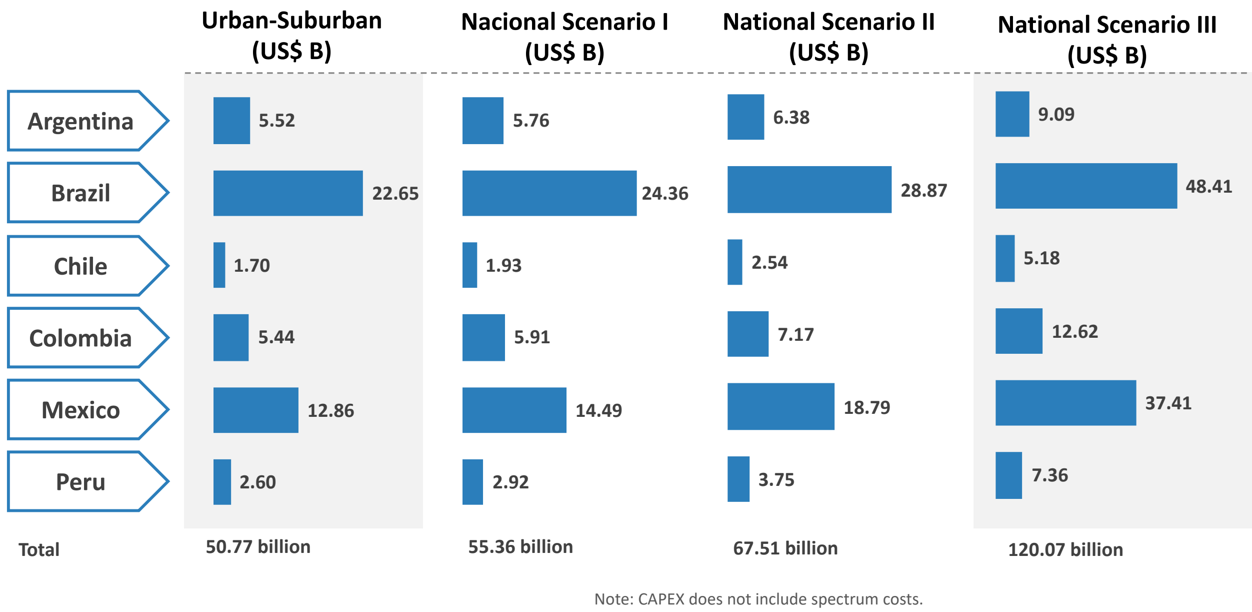
[9] Oughton and Frias (2017)."Exploring the cost, coverage and rollout implications of 5G in Britain," Nikolikj, V. & Janevski, T. (2014) "A cost modeling of high-capacity LTE-advanced and IEEE 802.11ac based heterogeneous networks, deployed in the 700MHz, 2.6GHz and 5GHz bands," Tech4i."Identification and quantification of key socio-economic data to support strategic planning for the introduction of 5G in Europe."

[10] The projected costs in this case are based on calculations for the deployment of the extended version of 5G networks. The required capital for rural deployment in Latin America was adjusted based on the difference in GDP between Latin American countries and the UIK.

Graphic 1. Cost for the Deployment of Expansive Mobile



Source: Telecom Advisory Services analysis

As presented in Graphic 1, the capital to be spent deploying expansive mobile networks in the six countries under study ranges between US$ 50.8 billion for the Urban-Suburban Scenario and US$ 120.07 billion for the National Scenario III. In light of this, the key question that needs to be addressed is whether these amounts can be handled by the ongoing annual CAPEX of operators in the region or if annual spending has to increase and by how much (in other words, we need to estimate whether regional telecommunications operators, mainly mobile, will have to increase their annual CAPEX from the current level). This analysis will require making some clarifications.

The capital investment of a telecommunications service provider is composed of (1) an amount targeted for network modernization (such as 5G or FTTH deployment) and (2) other non-discretionary expenditures (that is to say, investments that cannot be eliminated since they have an impact on the quality of service). Non-discretionary capital expenditures include replacement of legacy network equipment (such as a 3G base station) or the so-called "surgical" deployment of infrastructure aimed at addressing sudden non-forecast peaks in traffic. These non-discretionary components are generally labeled "maintenance CAPEX". When facing a big technological modernization wave such as the migration from 3G to 4G, telecommunications carriers begin gradually reducing their maintenance CAPEX and transferring investment capital to the deployment of new networks. In the case where modernization takes place within high capital efficient technology, the transition can be achieved within the ongoing CAPEX load, avoiding any increase. On the other hand, if the transition requires a higher rate of innovation, CAPEX will increase in relation to the sum assigned in previous years.

In order to determine how CAPEX will evolve to address the roll out of expansive mobile networks in Latin America, we begin by establishing the current capital spending of mobile operators in the six countries under study (see table 3).

Table 3. Latin America: yearly CAPEX (in US$ billion)

	2018	2019
Argentina	$ 0.85	$ 0.86
Brazil	$ 4.68	$ 4.17
Chile	$ 1.08	$ 1.12
Colombia	$ 1.04	$ 1.03
Mexico	$ 1.80	$ 2.07
Peru	$ 1.20	$ 1.08

Source: GSMA Intelligence

The next step is to determine if these amounts are enough to tackle the transition toward expansive mobile or if, alternatively, they would need to be increased. As mentioned above, the values presented in table 3 comprise investments that are not strictly assigned to network deployment (such as buildings, vehicles, capitalized software, and the like), for replacement of equipment in legacy networks, and infrastructure required to address unforeseen traffic peaks in selected areas of the network. More importantly, the capital investment presented in table 3 could also include sums for deployment of components that could become part of the expansive mobile network infrastructure (such as 4.5 sites or Wi-Fi hot-spots for traffic rerouting). We assume, for purposes of the analysis that maintenance CAPEX approximates 40% of total spending (this is based on a multiple of the depreciation rate for an enterprise that is growing relatively fast) while the sum assigned to deploying components of expansive mobile would amount to 20%.

Having established these baseline assumptions, we now calculate the amounts required yearly to fund the roll-out of expansive mobile networks. We assume that the values estimated in Graphic 1 will be spread along seven years (a reasonable rate of technological innovation in Latin America), beginning in 2021[11]. The following table presents the yearly investment required for deploying expansive mobile networks.

Table 4. Yearly investment required for expansive mobile deployment – under a seven-year timeline assumption (in US$ billion)

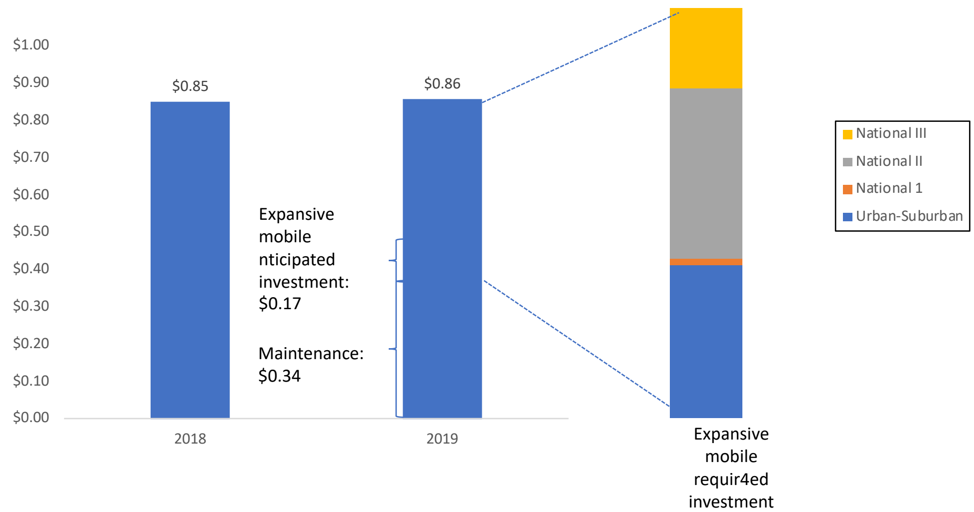
	Urban-suburban	National I	National II	National III
Argentina	$ 0.79	$ 0.82	$ 0.91	$ 1.30
Brazil	$ 3.24	$ 3.48	$ 4.12	$ 6.92
Chile	$ 0.24	$ 0.28	$ 0.36	$ 0.74
Colombia	$ 0.78	$ 0.84	$ 1.02	$ 1.80
Mexico	$ 1.84	$ 2.07	$ 2.68	$ 5.34
Peru	$ 0.37	$ 0.42	$ 0.54	$ 1.05

Source: Telecom Advisory Services analysis

These values can be plotted to conceptually present the relationship between the current CAPEX and the amount required to roll-out expansive mobile networks for Argentina (see Graphic 2).

[11] We acknowledge that these two variables can change by country and that yearly investment will not be uniform over the deployment timeline.

Graphic 2. Argentina: current CAPEX actual and annual investment required to deploy expansive mobile network



Sources: GSMA Intelligence; Telecom Advisory Service analysis

The values presented in graphic 2 can be used to estimate the evolution of CAPEX for Argentina according to the four deployment scenarios presented in graphic 1 (see table 5).

Table 5. Argentina: Impact of expansive mobile deployment on annual CAPEX (in US$ billion unless indicated)

	2019	Urban-suburban	National I	National II	National III
I. Maintenance	$ 0.34	$ 0.34	$ 0.34	$ 0.34	$ 0.34
II. Anticipated expansive mobile investment (4.5G)	$ 0.17	$ 0.17	$ 0.17	$ 0.17	$ 0.17
III. Amount available for expansive mobile deployment	$ 0.35	$ 0.35	$ 0.35	$ 0.35	$ 0.35
IV. CAPEX increase required to fund expansive mobile (required annual investment-II-III)		$ 0.27	$ 0.30	$ 0.39	$ 0.78
Total (I+II+III+IV)	$ 0.86	$ 1.13	$ 1.16	$ 1.25	$ 1.64
CAPEX increase (%)		32%	36%	46%	91%

Source: Telecom Advisory Services analysis

According to table 5, the deployment of expansive mobile under the urban-suburban scenario in Argentina would require a 32% increase over the 2019 CAPEX. It should be mentioned, however, that this estimate is sensitive to the amount of capital assigned to maintenance, the portion of current CAPEX already spent in 4.5G, and the number of years assumed to require the roll-out. For example, if the proportion of maintenance CAPEX is 30% rather than 40%, the percentage of capital already spent in 4.5G is 25%, and the number of years required for roll-out is eight rather than seven, the percentage increase from current CAPEX for the urban-suburban scenario in Argentina will be 10.2%.

Based on this methodology, we estimate the impact on CAPEX growth for each of the four expansive mobile deployment scenarios under an aggressive and more conservative set of assumptions (see table 6).

Table 6. Increase over current annual CAPEX (in percentage)

	CAPEX 2019 (US$ billion)	Urban-suburban		National I		National II		National III	
		Aggressive assumptions	Conservative assumptions	Aggressive assumptions	Conservative assumptions	Aggressive assumptions	Conservative assumptions	Aggressive assumptions	Conservative assumptions
Argentina	$ 0.86	31.7%	10.2%	35.7%	13.7%	46.0%	22.7%	91.0%	62.1%
Brazil	$ 4.17	17.6%	-2.1%	23.5%	3.0%	38.9%	16.5%	105.8%	75.1%
Chile	$ 1.12	-38.3%	-51.0%	-35.4%	-48.5%	-27.6%	-41.7%	6.1%	-12.2%
Colombia	$ 1.03	15.5%	-4.0%	22.0%	1.7%	39.4%	17.0%	115.0%	83.2%
Mexico	$ 2.07	28.8%	7.7%	40.0%	17.5%	69.7%	43.5%	198.2%	155.9%
Peru	$ 1.08	-25.6%	-39.9%	-21.4%	-36.2%	-10.4%	-26.6%	37.4%	15.2%

Aggressive assumptions: Maintenance CAPEX 40% of total; CAPEX already assigned to expansive mobile (4.5G): 20%; number of years for expansive mobile roll-out: 7
Conservative assumptions: Maintenance CAPEX: 30% of total; CAPEX already assigned to expansive mobile (4.5G): 25%; number of years for expansive mobile roll-out: 8
Source: Telecom Advisory Services analysis

Based on the values of table 6, the following conclusions can be drawn:

- Urban-suburban scenario: according to the more aggressive assumptions, Chilean and Peruvian carriers would be in a favorable position to tackle the deployment of expansive mobile technology since they would not need to increase their capital spending from the current yearly CAPEX levels. On the other hand, Brazilian operators would have to increase their capital spending by approximately 18% and Colombian service providers would have to do it by 16%. Finally, Argentine and Mexican telecommunications operators would need to increase their current CAPEX levels by 10.2% and Mexico by 7.7%, but they would also be compelled to extend their deployment timeline to eight years under the more conservative deployment assumptions,
- National Scenario I (which implies deployment of 50 Mbps symmetric service in urban and suburban geographies combined with a universal roll-out in rural areas with 2 Mbps speed): based on the more conservative roll-out assumptions, the increase of CAPEX over current levels is reasonable. The only two countries whose carriers would require an increase over current CAPEX levels would be Argentina (14%) and México (18%),
- National Scenario II (which implies deployment of 50 Mbps symmetric service in urban and suburban geographies and a universal roll-out in rural areas with 10 Mbps speed): when considering current CAPEX, the countries that can tackle deployment of expansive mobile technology within conservative roll-out assumptions are Brazil (requiring 17% of CAPEX increase), Colombia (17%), Chile and Peru (without need to increase their current capital spending). On the other hand, operators in Argentina and Mexico would face a significant increase in annual CAPEX (23% and 44% respectively).
- National Scenario III; with the exception of Chile, the remaining countries would face a financial challenge regarding their capital spending, even under the more conservative roll-put assumptions and an eight-year deployment timeline.

In summary, in light of the impact that expansive mobile network deployment will have on yearly CAPEX levels, it is likely that it will take place under the more conservative roll-out assumptions. This will allow Argentine operators to initially deploy in urban and suburban areas with a 13.7% increase in their current CAPEX, the Brazilian carriers to tackle the National Scenario II with a 16.5% increase and Mexico operators to the urban and suburban targets with 18% yearly capital increase. Over time expansive mobile network deployment will most probably occur in the region within the National Scenario I, with an aggregate total investment for the six countries under study of US$ 55.4 billion. This investment will yield significant economic gains as detailed in the analysis of the next chapter.

4. THE ECONOMIC IMPACT OF EXPANSIVE MOBILE IN LATIN AMERICA

The calculation of economic and social impacts as a result of the implementation of expansive mobile networks has been carried out in the following three areas:

- **Impact on digital transformation**: expansive mobile will generate benefits in connectivity, digitalization of homes and the productive system, as well as for the growth of digital industries.
- **Impact on GDP growth**: the increase in the level of digitalization will in turn generate an impact on the GDP due to the investment to be made in the deployment of networks, but especially as a result of the spillover effects in the whole economy.
- **Impact on the contribution to GDP of certain industrial sectors**: the spillover effects result from an increase in operational efficiency as well as an improvement in the productivity of certain industrial sectors.

The next chapter presents the results for each of these analyzes.

4.1. The impact of digital transformation

Digital transformation represents a fundamental socio-economic change resulting from massive adoption of digital information and communication technologies by individuals, companies and governments[12]. This phenomenon has been measured by analyzing the following eight pillars or components:

- Digital services infrastructure: fixed and mobile telecommunications networks that allow for the transmission of data traffic, enabling the functioning of the digital ecosystem;
- Digital services connectivity: adoption of terminals (smartphones, computers) and services (fixed and mobile broadband) that allow access to digital traffic infrastructure;
- Digitalization of households: use of Internet platforms and services by individual consumers (social networks, electronic commerce, electronic government);
- Production digitalization: adoption of digital technologies by companies in order to increase their productivity and competitiveness;
- Development of digital industries: companies that provide audiovisual content, social networks, search engines, telecommunications and the manufacture of equipment and terminals;
- Production factors in the digital ecosystem: human capital and investment necessary for the development of digital industries;
- Competitive intensity within the digital ecosystem: industrial organization and concentration levels within telecommunications markets and Internet platforms; and

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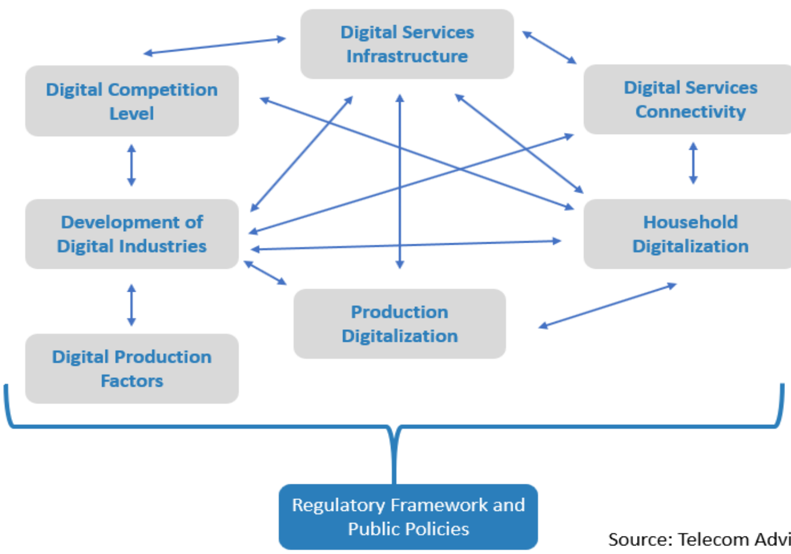
[12] Katz, R. and Koutroumpis, P. (2013).“Measuring digitalization: a growth and welfare multiplier,” *Technovation*, September 2013 33 (s 10–11): 314–319; Katz, R., Koutroumpis, P. and Callorda, F. “The Latin American path towards digitization,” *Info*, VOL. 15 NO. 3 2013, pp. 6-24; Sabbagh, K., Friedrich, R., El-Darwiche, B., Singh, M., Ganediwalla, S., and Katz, R. “Maximizing the impact of digitalization,” in Dutta, S., and Bilbao-Osorio, B. (ed.) *The Global Information Technology Report 2012*, Coligny: World Economic Forum; Katz, R., Koutroumpis, P., and Callorda, F. “Using the digitization index to measure the economic and social impact of digital agendas,” *Info*, Vol. 16, No. 1, 2014. Katz, R. and Callorda, F. (2018b) Accelerating the development of Latin American digital ecosystem and implications for broadband policy, *Telecommunications Policy* (42) 661–681.

- Regulatory framework and public policies: public policies and regulatory framework that stimulate the development of the digital ecosystem.

The digital transformation of a country has been measured based on the CAF Digital Ecosystem Development Index. This index is composed of 64 indicators, grouped into eight pillars[13] (see Exhibit 1).

Exhibit 1. Structure of the CAF Digital Ecosystem Development Index



Source: Telecom Advisory Services

In 2018, the Digital Ecosystem Development Index (measured on a scale from 0 to 100) for the six countries studied ranges between 60.24 for Chile and 44.35 for Peru (see Table 8).

Table 8. Latin America. CAF Digital Ecosystem Development Index (2018)

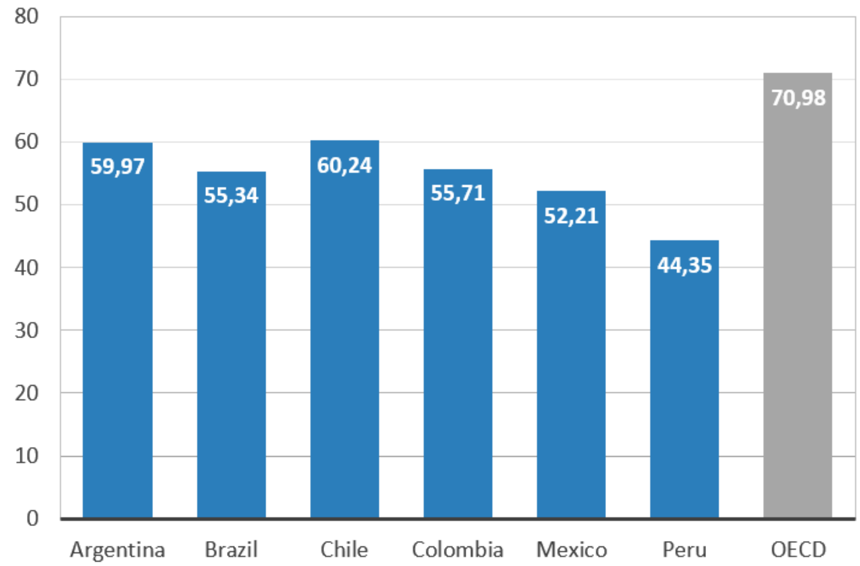
	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Infrastructure	49.73	44.12	59.60	45.53	44.45	42.65
Connectivity	82.82	67.65	78.75	64.56	68.66	59.43
Household digitalization	66.06	63.83	53.78	51.67	56.67	49.73
Production digitalization	56.63	65.35	73.82	78.37	46.15	47.98
Competition	88.75	66.30	70.85	92.59	80.02	48.02
Digital Industries	24.76	23.25	30.65	23.15	22.16	22.83
Production Factors	33.29	33.53	38.77	29.52	23.15	19.09
Institutional and Regulatory	70.05	68.93	63.23	51.68	72.85	53.83
Index	59.97	55.34	60.24	55.71	52.21	44.35

Source: Telecom Advisory Services analysis

As a reference, the six Latin American countries are distanced from the prorated index average for OECD countries by between ten and twenty-five points (see Graphic 3).

[13] To see the methodological details for the calculation of the CAF Digital Ecosystem Development Index, see Katz, R. and Callorda, F. (2017). *Toward the Digital Transformation of Latin America and the Caribbean: The CAF Observatory of the Digital Ecosystem*. CAF, at scioteca.caf.com.

Graphic 3. Latin America versus OECD: CAF Digital Ecosystem Development Index (2018)



Source: Telecom Advisory Services analysis

The calculation of the impact of expansive mobile on the digital ecosystem development index is based on the calculation of the change that will occur in each of the indicators that make up the index as a result of technology deployment[14]. Modifications to the index are calculated based on changes in each indicator. The most important factors in increasing the CAF Digital Ecosystem Development Index as a result of expansive mobile are the following:

Table 9. Key Factors of the Digital Ecosystem Influenced by Expansive Mobile

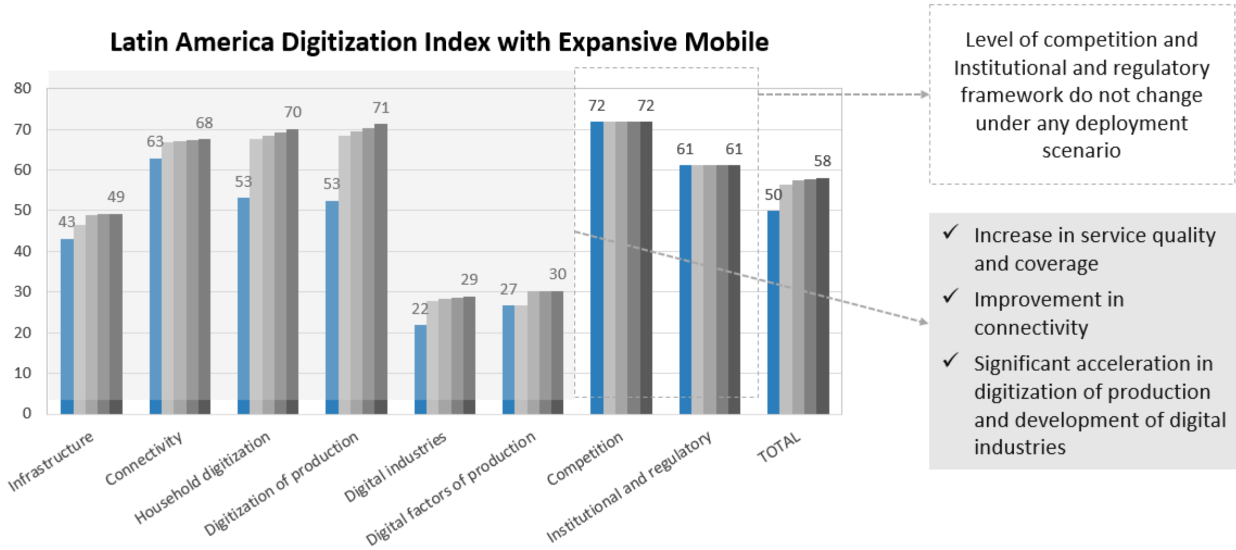
Pillar	Indicators
Infrastructure	• Mobile broadband download speed • 4G / 5G coverage
Connectivity	• Mobile broadband adoption
Household digitalization	• E-commerce applications • E-commerce volume • Telehealth • E-government applications
Production digitalization	• Supply chain digitalization • Distribution chain digitalization • IoT/M2M deployment
Growth in digital industries	• Production of local applications and content • Weight of the digital sector in GDP • Exports of ICT services
Innovative capacity	• Patents originated in the country • Income from use of intellectual property

Source: Telecom Advisory Services analysis

The result of the analysis shows significant growth in the CAF digital ecosystem development index for the entire continent as a result of expansive mobile. As expected, growth depends on the technology deployment scenario (see Graphic 4).

[14] See detailed analysis in Appendix A. Methodology.

Graphic 4. Latin America: Impact of Expansive Mobile on the CAF Digital Ecosystem Development Index



Source: Telecom Advisory Services analysis

As can be seen in Graph 4, the change in the index ranges from six to eight points depending on the deployment scenario. Advances occur in infrastructure pillars, connectivity, and digitalization of homes, digitalization of production, growth of digital industries and production digitalization factors. On the other hand, the level of competence and the institutional and regulatory framework do not undergo any changes.

Beyond the changes seen at the aggregate level, important advances are observed in the pillars of each of the Latin American countries that were studied in detail. Table 10 below should be examined in comparison to table 4 which records the current state of development in the digital ecosystem.

Table 10. Latin America. CAF Digital Ecosystem Development Index (based on National Scenario III)

	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Infrastructure	57.30	49.23	69.42	53.58	51.46	50.01
Connectivity	86.98	72.20	83.89	69.83	73.93	64.70
Household digitalization	84.23	81.99	78.61	76.50	74.84	67.90
Production digitalization	78.86	87.08	94.56	95.59	68.38	70.21
Competition	88.75	66.30	70.85	92.59	80.02	48.02
Digital Industries	32.22	30.62	38.40	30.62	29.56	30.32
Production Factors	38.31	35.95	40.27	32.43	29.67	24.89
Institutional and Regulatory	70.05	68.93	63.23	51.68	72.85	53.83
Index	69.04	63.83	70.25	65.06	61.50	53.63

Source: Telecom Advisory Services analysis

Upon deployment of the technologies associated with expansive mobile, the digitalization rate would increase by 15.12% in Argentina, 15.33% in Brazil, 16.61% in Chile, 16.77% in Colombia, 17.80% in Mexico and 20.93% in Peru. With these advances, this group of countries would be nearing the prorated average development of the OECD digital ecosystem.

4.2. Impact on GDP growth

The economic impact of expansive mobile will be based on two effects. First, expansive mobile will require significant deployment of radio base stations, a broadening of backbone networks and the incorporation of software engineering tools throughout the network. Based on this, the deployment of technologies related to this concept will have an impact on the gross product in terms of direct effects (investment in networks and their deployment), indirect effects (production of the supplies required by the telecommunications industry for the deployment of these networks), and induced effects (growth in the demand for goods and services caused by an increase in direct and indirect production). Once the networks are deployed, they generate a spillover effect on the economy as a whole as a result of an increase in business efficiency, the creation of new markets, and an increase in price realization.

These effects have already been measured empirically in numerous studies[15]. In particular, the contribution of digital transformation to GDP growth, labor productivity and multifactor productivity is highly significant, as evidenced by the results of econometric models produced by the authors of this study[16] (see Table 11).

Table 11. Result of econometric models regarding the impact of digitalization on GDP[17], labor productivity, multifactor productivity and the contribution of ICTs to labor productivity

Variable	(1) GDP	(2) Labor productivity	(3) Multifactor Productivity	(4) ICT contribution to (2)
Growth of CAF digitalization index	0.3169 (0.0735) ***	0.2622 (0.0683) ***	0.228 (0.0674) ***	0.0948 (0.0603) *
CAF digitalization index	0.0221 (0.0630)	0.0358 (0.0585)	0.0605 (0.0577)	0.0520 (0.0500)
Comments	201	201	201	180
R-Squared	0.7341	0.6914	0.5832	0.6111
Fixed effect per period	Yes	Yes	Yes	Yes
Fixed effect per country	Yes	Yes	Yes	Yes

*Note: All estimates factor in population and GDP. Asterisks represent the level of significance, * being 15%, ** being 5% and *** being 1%.*
Source: Telecom Advisory Services analysis

According to the models in Table 7, a 1% increase in the digitalization rate results in a 0.32% increase in gross domestic product, 0.26% in labor productivity, 0.23% in multifactor productivity and 0.09% in the contribution of ICT to labor productivity.

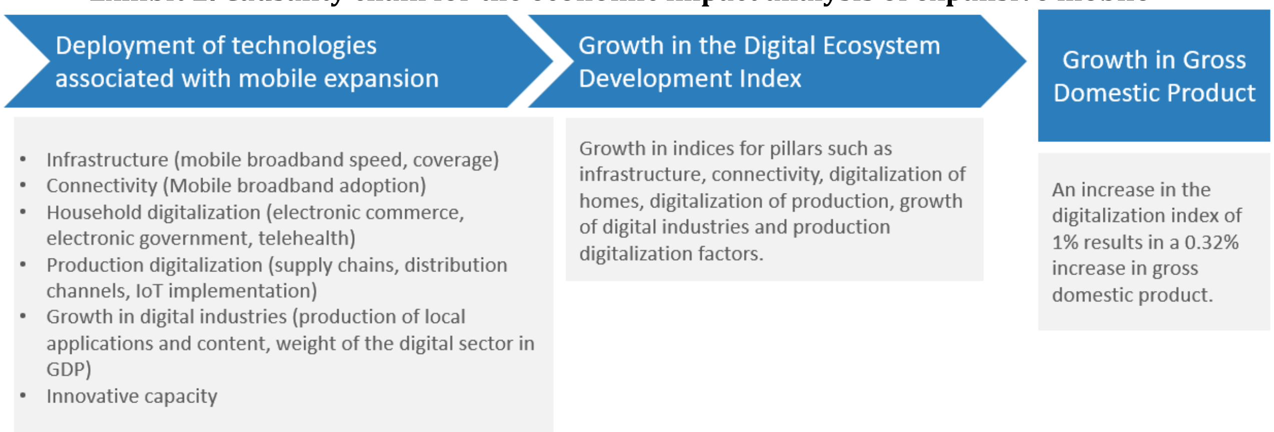
[15] See Katz, R. (2012). *The impact of broadband on the economy*. Geneva: International Telecommunications Union, April; Katz, R. and Callorda, F. (2018). *The economic value of Wi-Fi: A Global View (2018-2023).* Austin, TX: Wi-Fi Alliance, October; Katz, R. and Koutroumpis, P. (2012)."The economic impact of telecommunications in Senegal," *Communications and Strategies* No. 86, 2nd Q, June. Katz, R. and Callorda, F. (2018a) *The economic contribution of broadband, digitization and ICT regulation*. Geneva: International Telecommunications Union, September.

[16] Based on available data on GDP growth, labor productivity, multifactor productivity and ICT contribution to labor productivity between 2004 and 2015, the data was divided into 3 periods (2004-2008; 2008-2012; 2012-2015). With this information from 67 countries (60 in the case of the ICT contribution to labor productivity), regressions were run explaining the different variables from the growth of the CAF digitalization index, the initial level of the digitalization index, current GDP level and population. They included fixed effects by period and per country.

[17] This econometric model is different from the one published in Katz and Callorda (2018). In it, based on the classical role of production, physical capital as well as human capital is included as explanatory variables. What this structure does is capture the direct impact that digitalization has on GDP. However, it does not capture the impact that digitalization makes through changes in physical and human capital levels.

The analysis of the impact of expansive mobile is based on the coefficient that indicates that an increase in the digitalization rate of 1% results in a 0.32% increase in gross domestic product. This explains how the analysis is based on the following causality chain where expansive mobile generates an increase in digitalization, which in turn has an economic impact (see Exhibit 2).

Exhibit 2. Causality chain for the economic impact analysis of expansive mobile



Source: Telecom Advisory Services

Based on this causality, the coefficient is applied to the expected growth in the digitalization index of each country as a result of the implementation of expansive mobile in order to calculate its contribution to the gross product of the six countries studied (see Table 12).

Table 12. Latin America: Economic impact of expansive mobile implementation per country (National Scenario III)

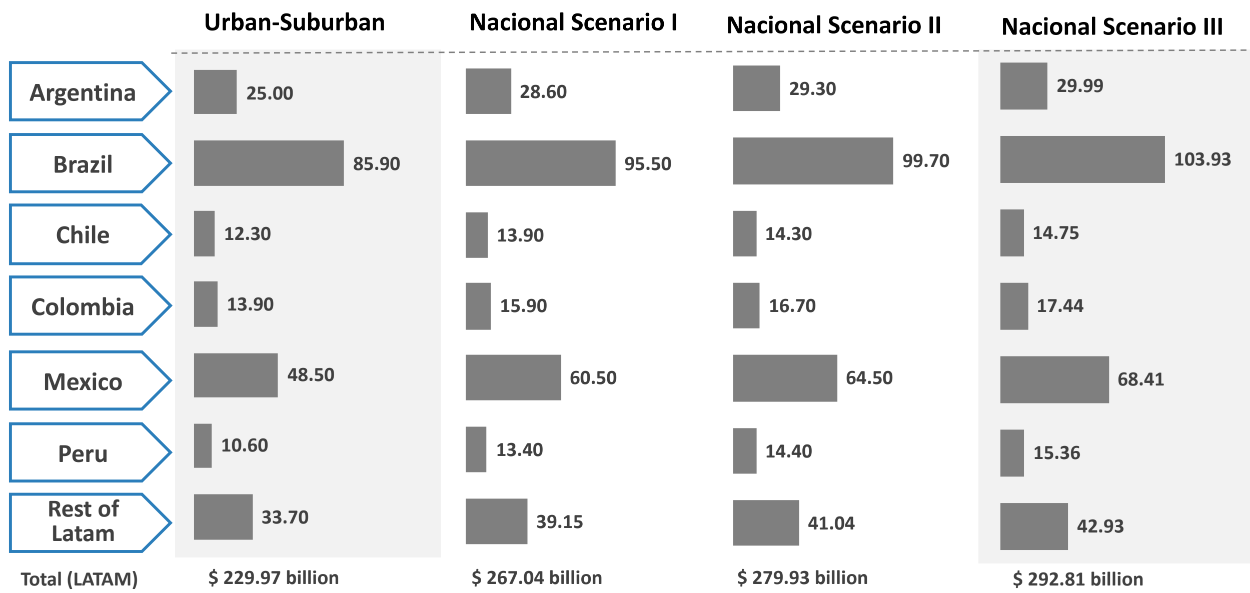
	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Current Index	59.97	55.34	60.24	55.71	52.21	44.35
Final Index	69.04	63.83	70.25	65.06	61.50	53.63
Index growth	15.12%	15.33%	16.61%	16.77%	17.80%	20.93%
Impact coefficient	0.3169	0.3169	0.3169	0.3169	0.3169	0.3169
Impact on GDP	4.79%	4.86%	5.26%	5.32%	5.64%	6.63%
Impact in millions of US$	29,995	103,933	14,751	17,433	68,413	15,361

Source: Telecom Advisory Services analysis

The impact on the gross domestic product of the six countries if expansive mobile is implemented under the national scenario III ranges between US$104 billion for Brazil and US$15 billion for Peru. Based on this, the contribution of the six countries studied is extrapolated to the region as a whole, assuming that the impact of expansive mobile in the rest of the countries in the region is equal to their weighted average[18]. By extrapolating the effect to the rest of Latin America, expansive mobile will contribute between US$ 229.97 billion (under the urban-suburban scenario) and US$ 292.88 billion (under the national scenario III) to the entire Latin American GDP (see Graphic 5).

[18] Considering that the six countries analyzed represent 85.34% of the region's GDP, their impact under the implementation of expansive mobile will also represent 85.34%.

Graphic 5. Latin America: Economic impact of Expansive Mobile implementation per country



Source: Telecom Advisory Services analysis

These values reflect the cumulative growth of GDP once the expansive mobile infrastructure is deployed and services offered have been adopted. The number of years that this process will require increases or decreases the annual impact. For example, if deployment begins in 2022 and adoption has been generalized ten years later, the annual impact on the Latin American GDP for the national scenario III would be 292.8 billion/10 = $ 29.28 billion. This value should be considered as the increase in the annual GDP for each country at current prices, which is equivalent to 0.54% of annual GDP growth for the entire region. This average impact estimate has also been calculated by country (see table 13).

Table 13. Annual GDP impact by country (in percentage)

	Urban-Suburban	National Scenario I	National Scenario II	National Scenario III
Argentina	0.40%	0.46%	0.47%	0.48%
Brazil	0.40%	0.45%	0.47%	0.49%
Chile	0.44%	0.50%	0.51%	0.53%
Colombia	0.42%	0.48%	0.51%	0.53%
México	0.40%	0.50%	0.53%	0.56%
Perú	0.46%	0.58%	0.61%	0.67%
Resto LATAM	0.41%	0.47%	0.50%	0.52%

Source: Telecom Advisory Services analysis

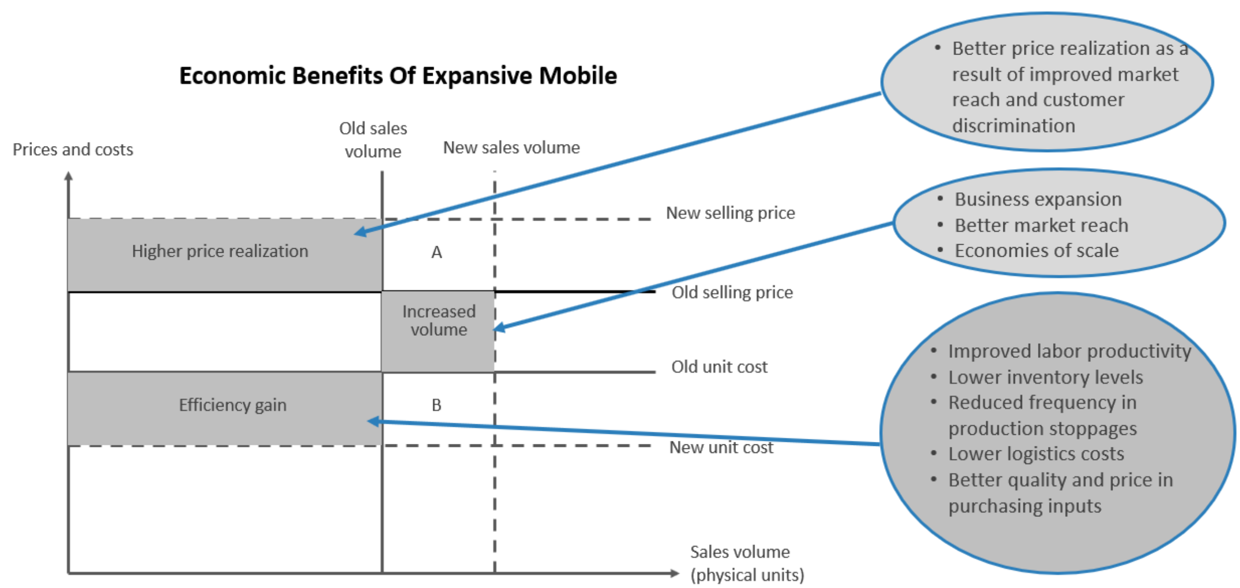
As expected, the contribution to GDP growth is lower under the urban-suburban implementation scenario. Having estimated the aggregate economic impact, how this effect comes about in each industry is calculated below.

4.3. Impact of expansive mobile by industry

In Section 4.2. the economic impact was estimated at the macroeconomic level resulting from the progress of digital transformation as a result of the implementation of expansive mobile. However, beyond the macroeconomic effect, it is important to mention that the impact of expansive mobile can also be estimated at the microeconomic level to specifically understand what mechanisms impact business productivity as a result of the adoption of digital technologies (Arrow, 1984). From the microeconomic point of view, the adoption of use cases facilitated by the implementation of expansive mobile results in a combined impact, both in the company's cost structure (better efficiency) and in the scope and coverage of its markets (deployment of distribution channels). Figure 3 conceptually presents the three microeconomic effects of expansive mobile in the company's performance.

As illustrated in Exhibit 3, the impact of expansive mobile within the company operates in three dimensions. First, the automation of processes and the efficiency of the supply chain can reduce the unit cost of a product, resulting in an increase in operating margins. Secondly, better market coverage from the deployment of new distribution channels allows for an increase in sales volume. Finally, expansive mobile allows for an increase in the proportion of value added to the product, which in turn generates an increase in prices. It is important to mention that this last factor depends on competitive dynamics that may erode its impact. For example, besides contributing to the creation of value, digitalization also reduces the barriers that competitors face when entering the market, and therefore competition can threaten the possibility of increasing prices.

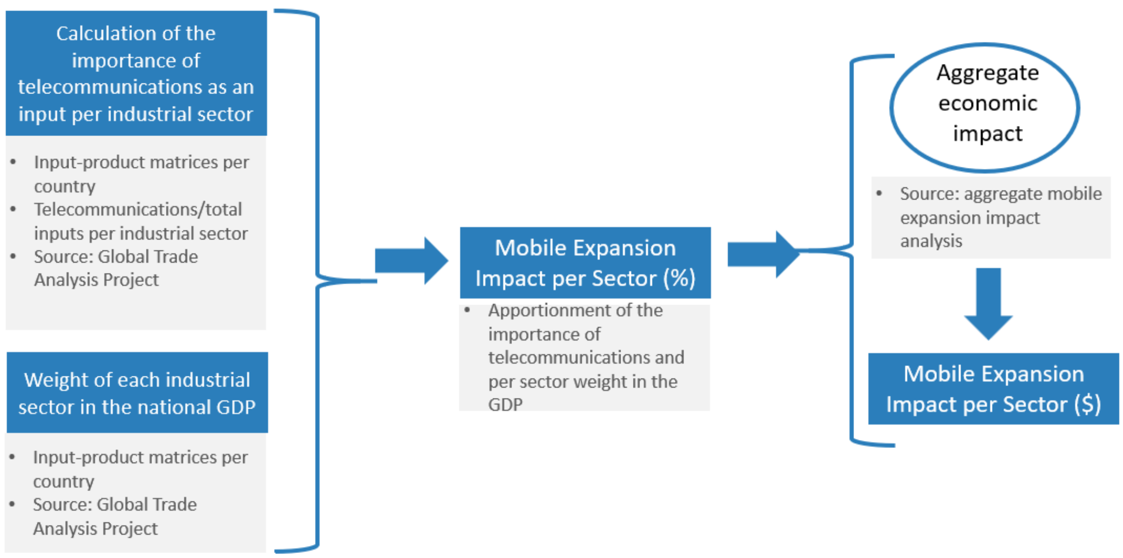
Exhibit 3. Economic Benefits of Expansive Mobile



Source: Adapted from Tyler, M. and Jonscher, Ch. (1983). The impact of Telecommunications on the performance of a sample of business enterprises in Kenya. Geneva: International Telecommunications Union.

The calculation of the sectoral impact of expansive mobile requires the use of information contained in national accounts and supply/product matrices in order to first understand the importance of communications for each sector's product (see Exhibit 4).

Exhibit 4. Methodology for estimating the sectoral impact of expansive mobile



Source: Telecom Advisory Services

To calculate the contribution of expansive mobile per industrial sector, we begin by calculating the importance of telecommunications as a supply for the production of each industrial sector's product. The premise in this case is that the more important telecommunications are as a supply in the production of an industrial sector, the greater the contribution of expansive mobile to the growth of that sector's product. For this reason, the supply-output matrices of each of the countries studied have been used[19] (see Table 14).

Table 14. Intensity in the use of telecommunications per industrial sector (Percentage of the value of all supplies per sector)

Sector	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Agriculture	0.92%	2.13%	1.05%	0.86%	0.93%	0.73%
Mining	1.56%	6.39%	1.05%	0.86%	1.10%	0.89%
Manufacturing	0.92%	2.13%	1.05%	0.86%	0.90%	0.55%
Electricity Supply, Water Supply	0.85%	3.99%	0.86%	1.02%	0.22%	0.31%
Construction	0.59%	0.42%	0.48%	0.18%	0.92%	1.05%
Trade	3.72%	3.95%	2.34%	3.73%	4.88%	3.60%
Transportation	4.09%	2.01%	1.27%	1.64%	1,82%	1.65%
Communications	21.83%	35.11%	47.10%	18.32%	16.68%	32.02%
Financial Services	10.37%	10.92%	2.19%	4.95%	9.74%	6.47%
Real Estate Services	6.94%	8.27%	2.13%	4.94%	2.00%	5.42%
Professional Services	4.11%	25.26%	4.47%	5.14%	7.48%	5.00%
Recreation and Entertainment	6.47%	7.78%	3.05%	5.92%	4.67%	3.13%
Public Services, Defense, Health, Education	5.19%	13.03%	4.33%	3.25%	7.41%	3.94%
TOTAL	2.62%	6.08%	3.00%	2.45%	2.57%	1.57%

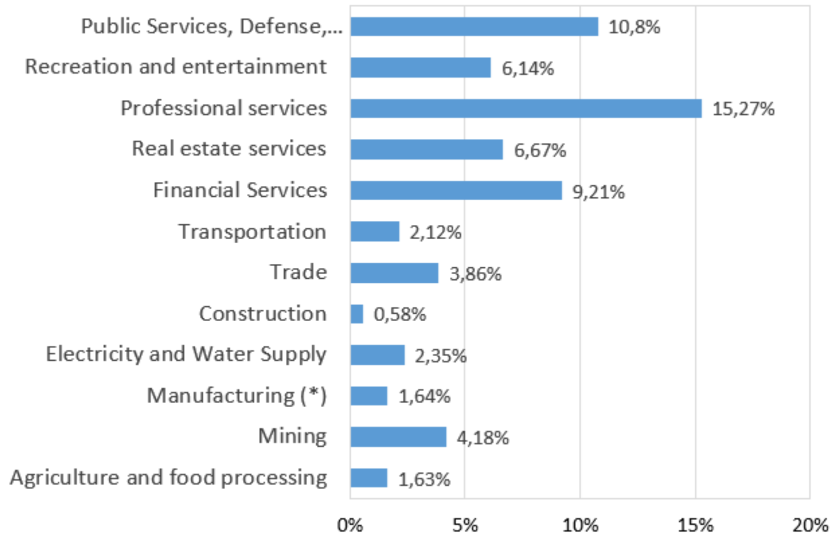
Sources: Global Trade Analysis Project; Telecom Advisory Services analysis

The analysis of intensity in the use of telecommunications requires an explanation. In the first place, assets in the communications sector must be excluded since they represent a direct expenditure for the sector (in other words, it is natural that the sector uses telecommunications intensively since this is its main product). Excluding communications, the mathematical average of the six countries

[19] See the methodology for calculating supply-product matrices per country in Appendix A.

studied indicates that the most important sectors in terms of the importance of telecommunications are professional services, financial services, and the public services sector. The extrapolation of results per country to the region as a whole allows the intensity of telecommunications to be visualized per industry (see Graphic 6).

Graphic 6. Latin America: Communications intensity per industry (percentage of supplies)



(*) Includes all manufacturing sub-sectors except for food processing.
Sources: Global Trade Analysis Project; Telecom Advisory Services analysis

Continuing with the analysis, in order to calculate the sectoral impact of expansive mobile, the intensity in the use of telecommunications per sector must be prorated by the weight that each industrial sector represents in the national gross product[20]. Again, based on the information provided by supply/product matrices per country, the weight of each industrial sector in GDP is estimated (see Table 15).

Table 15. Latin America: Weight of the industrial sector in the GDP of each country

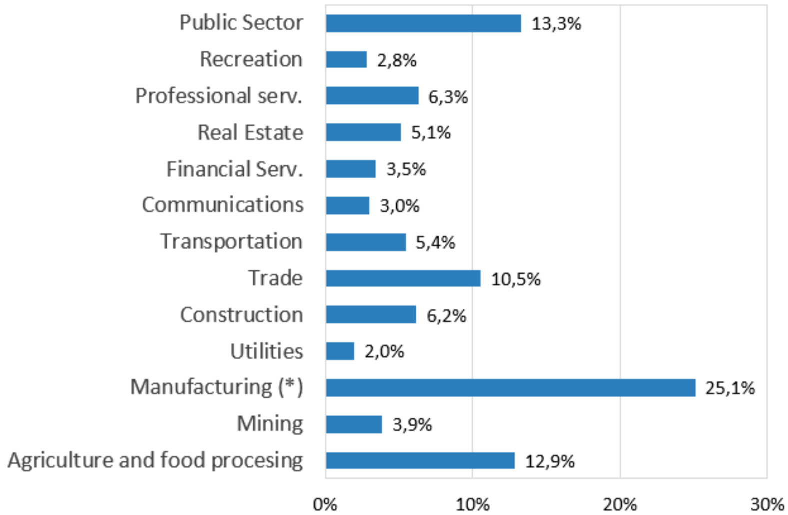
Sector	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Agriculture	16.48%	12.64%	10.58%	14.09%	10.23%	17.96%
Mining	2.77%	3.20%	7.02%	5.44%	4.48%	7.18%
Manufacturing	20.34%	25.30%	21.55%	18.14%	26.71%	36.91%
Electricity Supply, Water Supply	1.11%	2.14%	2.68%	2.14%	1.87%	1.47%
Construction	5.65%	5.39%	8.05%	7.80%	7.83%	7.83%
Trade	12.24%	10.38%	10.23%	13.35%	11.06%	5.47%
Transportation	4.98%	4.93%	7.80%	5.98%	6.60%	5.15%
Communications	2.10%	3.70%	2.23%	2.76%	2.15%	1.38%
Financial Services	2.56%	4.13%	4.55%	2.53%	2.04%	1.80%
Real Estate Services	6.47%	5.07%	4.17%	0.95%	6.66%	0.89%
Professional Services	5.55%	5.74%	9.77%	11.64%	6.86%	5.35%
Recreation and Entertainment	4.33%	1.89%	2.20%	2.38%	4.99%	3.52%
Public Services, Defense, Health, Education	15.43%	15.47%	9.18%	12.81%	8.51%	5.08%
TOTAL	4.79%	4.86%	5.26%	5.32%	5.64%	6.63%

Sources: Global Trade Analysis Project; Telecom Advisory Services analysis

[20] This is necessary because, for example, a sector with intensive use of Communications and little weight in GDP does not represent an important percentage of the contribution of expansive mobile to the gross product.

The extrapolation of per country results to the region as a whole allows visualization of the weight that each industrial sector has in the Latin American gross product (see Graphic 7).

Graphic 7. Latin America: Weight per Industrial Sector in GDP (percentage of supplies)



(*) Includes all manufacturing sub-sectors except for food processing.
Sources: Global Trade Analysis Project; Telecom Advisory Services analysis

Figure 7 shows the importance of agricultural sectors (to which the food processing industry has joined) and manufacturing. The combination of the intensity of telecommunications per sector and its weight in the gross product allows for determining the impact of expansive mobile per industrial sector and country (see Table 16).

Table 16. Latin America: Sectorial impact of Expansive Mobile in each country (% of sectoral product)

Sector	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Agriculture	2.63%	2.42%	2.33%	2.34%	2.66%	2.26%
Mining	2.01%	5.77%	2.14%	0.67%	1.42%	3.16%
Manufacturing	2.20%	2.33%	2.07%	2.59%	2.74%	2.67%
Electricity Supply, Water Supply	1.90%	2.37%	0.88%	1.89%	0.81%	1.13%
Construction	1.29%	0.31%	0.89%	0.45%	2.67%	3.19%
Trade	4.86%	2.21%	4.75%	8.14%	7.21%	23.82%
Transportation	8.03%	1.62%	1.85%	3.74%	3.70%	9.75%
Financial Services	13.97%	5.54%	4.90%	8.73%	19.44%	14.84%
Real Estate Services	1.65%	2.54%	2.14%	8.65%	1.09%	13.14%
Professional Services	7.79%	12.91%	6.16%	5.40%	13.11%	11.39%
Recreation and Entertainment	6.20%	4.64%	3.68%	9.22%	7.46%	8.52%
Public Services, Defense, Health, Education	6.89%	7.72%	4.60%	6.20%	8.86%	15.13%
SUBTOTAL	4.25%	3.84%	2.99%	4.17%	4.83%	5.75%
Impact on Communications	25.60%	27.55%	102.31%	41.61%	37.81%	63.99%
TOTAL	4.79%	4.86%	5.26%	5.32%	5.64%	6.63%

Sources: Global Trade Analysis Project; Telecom Advisory Services analysis

Considering the aggregate economic impact calculated in Table 8, the gross economic impact per industrial sector is estimated by distributing the aggregate impact per sector according to the percentages in Table 16 (see Table 17).

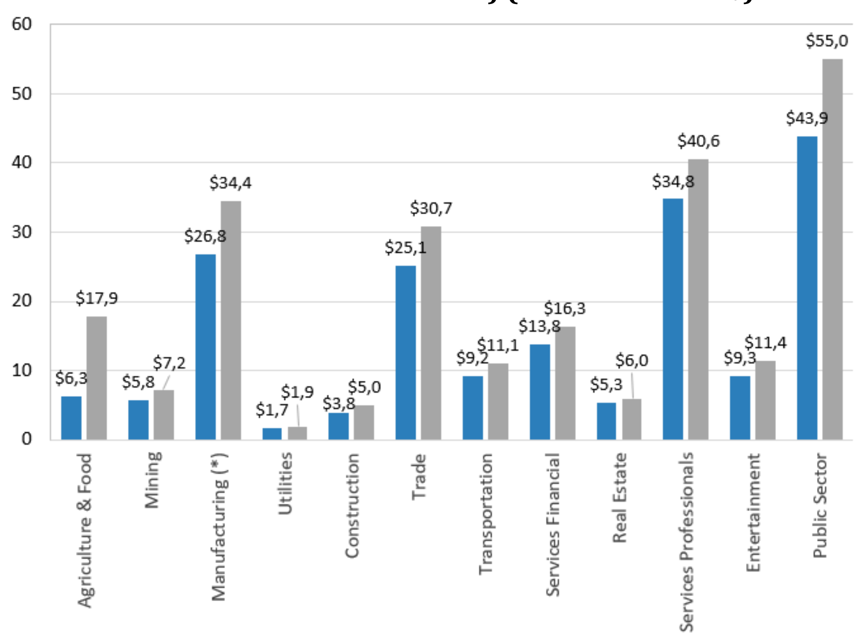
Table 17. Latin America: Economic Impact per Industrial Sector in each country (National Scenario III) (in millions of US$)

Sector	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Agriculture	$2,712	$6,536	$691	$1,082	$3,296	$939
Mining	$348	$3,953	$421	$120	$772	$527
Manufacturing	$2,798	$12,632	$1,253	$1,542	$8,864	$2,283
Electricity Supply, Water Supply	$132	$1,088	$66	$133	$184	$39
Construction	$458	$363	$201	$115	$2,538	$578
Trade	$3,725	$4,900	$1,360	$3,566	$9,668	$3,020
Transportation	$2,504	$1,710	$405	$732	$2,965	$1,163
Financial Services	$2,241	$4,892	$625	$723	$4,801	$619
Real Estate Services	$670	$2,753	$251	$269	$877	$270
Professional Services	$2,708	$15,860	$1,687	$2,062	$10,903	$1,411
Recreation and Entertainment	$1,681	$1,870	$227	$718	$4,521	$695
Public Services, Defense, Health, Education	$6,654	$25,557	$1,183	$2,607	$9,144	$1,780
SUBTOTAL	$26,632	$82,113	$8,370	$13,670	$58,533	$13,323
Impact on Communications	$3,364	$21,821	$6,382	$3,764	$9,880	$2,038
TOTAL	$29,996	$103,934	$14,752	$17,434	$68,413	$15,361

Sources: Global Trade Analysis Project; Telecom Advisory Services analysis

The contribution of expansive mobile to sectoral GDP growth varies depending on the technology deployment scenario. Again, when extrapolating estimates from the countries studied to Latin America as a whole, it is observed that the areas that see the greatest impact are the public sector, professional services and manufacturing (see Graphic 8).

Graphic 8. Latin America: Economic Impact per Industrial Sector (urban-suburban versus national scenario III) (in billions of US$)



Note: (*) Includes all manufacturing sub-sectors except for food processing.
Sources: Global Trade Analysis Project; Telecom Advisory Services analysis

This conclusion is of the utmost importance. First, the impact on the public sector highlights the importance that expansive mobile will have on the quality and efficiency in the delivery of public services (including health, education and safety). For example, among the use cases for the provision of public services are smart cities (supply chains efficiency, traffic monitoring, urban control and management, measurement of drinking water quality, environmental monitoring), and Telemedicine services (such as real-time patient monitoring, provision of services in the event of a natural disaster and the diagnosis and remote treatment of patients). Second, and as expected, are professional services. This is an intensive data usage sector and is a natural beneficiary of expansive mobile. Third, the impact of technology on manufacturing, commerce and agriculture demonstrates the central premise of expansive mobile, that it is a primary vehicle for the digital transformation of Latin American economies.

4.4. Impact of expansive mobile in use cases divided by sector

Having analyzed the sectoral impact of expansive mobile based on an analysis of supply-output matrices, it is important to validate the aggregate results by using a microeconomic analysis. The basic premise is that the sectoral contribution of expansive mobile is made based on the introduction of use cases that are adapted to the needs of industrial sectors. Within this framework, expansive mobile represents a facilitating component that operates within the value proposition of the use case. The following section extends the sector analysis presented above, illustrating through use cases how expansive mobile generates economic impacts. To this end, the analysis focuses first on two strategic sectors of Latin American economies (value chains within the agriculture and food processing sector, and the automotive industry), and later analyzes the impact of expansive mobile on the following two key dimensions of digital transformation: intelligent manufacturing (or Industry 4.0) and intelligent logistics (or supply chain 4.0).

4.4.1. Agriculture and food processing

The value chain within the agricultural, processing and food distribution sectors represents 15% of Latin America's gross product (see Table 18).

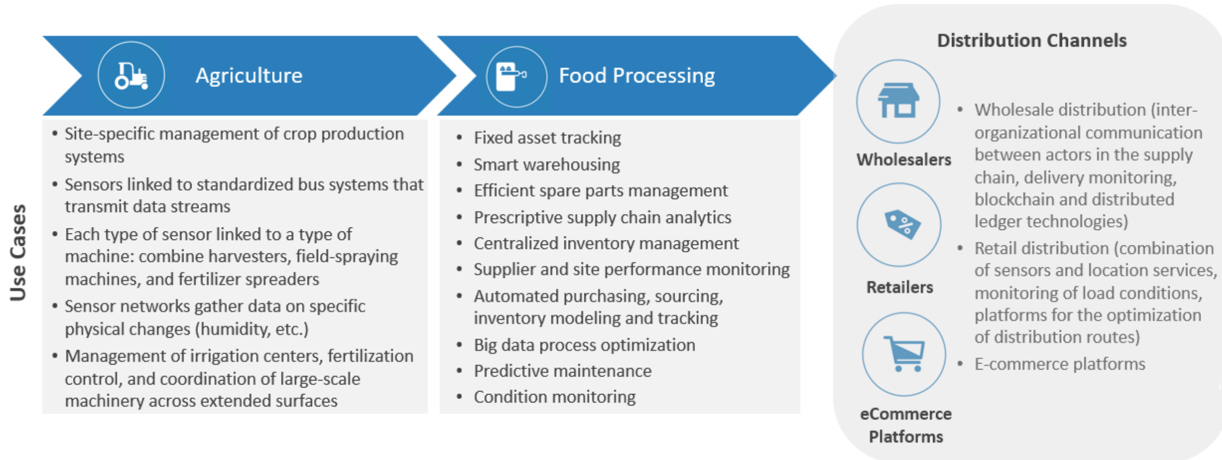
Table 18. Latin America: Agriculture, Food Processing and Distribution Value Chain (in US$ billion)

	Agriculture	Food Processing	Distribution	GDP weight
Argentina	$61.60	$84.50	$29.60	19.80%
Brazil	$227.00	$266.90	$99.80	14.10%
Chile	$11.50	$33.90	$9.20	11.40%
Colombia	$11.90	$14.60	$5.40	16.50%
Mexico	$34.70	$90.50	$25.30	11.90%
Peru	$24.30	$36.20	$12.30	20.20%
Total Latin America	$371.00	$526.60	$181.60	14.58%

Sources: Global Trade Analysis Project; Getulio Vargas Foundation: Food Industry in Brazil and South America; Micronutrient Initiative: Latin America and Caribbean region Food Industry Assessment; Telecom Advisory Services analysis.

This value chain benefits from a set of use cases that are aimed at increasing productivity (see Exhibit 5).

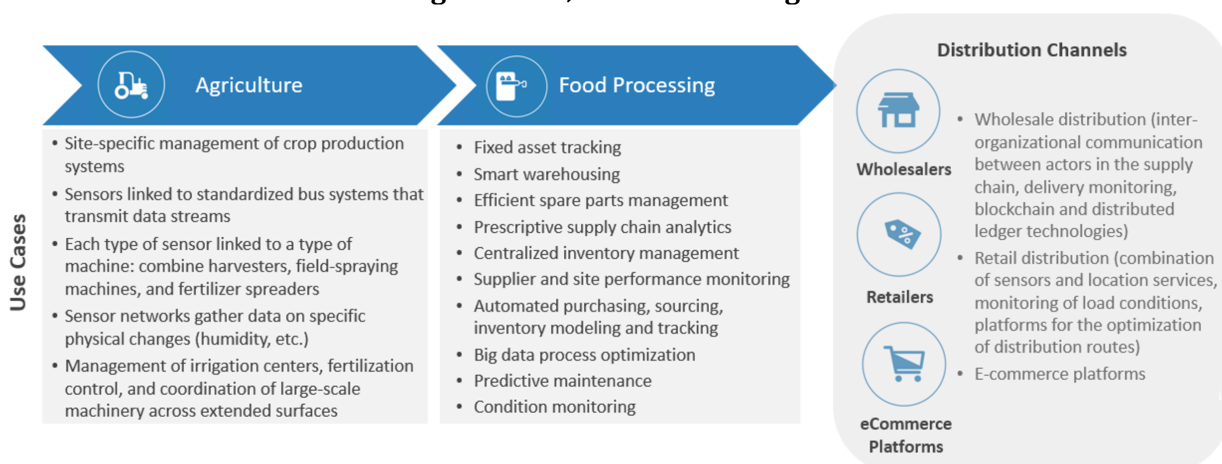
Exhibit 5. Use cases in the Agriculture, Food Processing and Distribution Value Chain



Source: Telecom Advisory Services analysis

These use cases have an important impact on the value chain. For example, the adoption of precision agriculture improves the productivity of the sector by between US$13 and US$28 per hectare[21]. In turn, use cases are facilitated by technologies that are part of the world of expansive mobile (see Exhibit 6).

Exhibit 6. Use cases in the Agriculture, Food Processing and Distribution Value Chain



Source: Telecom Advisory Services analysis

It is estimated that use cases can generate a productivity benefit for this value chain in Latin America in the order of US$19.95 billion (under the national implementation scenario), representing 2.47% of the value chain's gross product (see Table 19).

[21] In the case of Latin America, adoption by 20% of cultivated areas is assumed.

Table 19. Economic impact of expansive mobile in the agriculture, food processing and distribution value chain (in US$ billion)

	Agriculture		Food Processing		Distribution		Total	
	Urban-Suburban	National	Urban-Suburban	National	Urban-Suburban	National	Urban-Suburban	National
Argentina	$0.13	$0.69	$1.69	$2.02	$0.59	$0.71	$2.41	$3.42
Brazil	$0.48	$1.87	$3.85	$4.67	$1.44	$1.75	$5.77	$8.29
Chile	$0.07	$0.20	$0.41	$0.50	$0.11	$0.14	$0.59	$0.84
Colombia	$0.14	$0.32	$0.60	$0.76	$0.22	$0.28	$0.96	$1.36
Mexico	$0.46	$0.64	$1.90	$2.68	$0.53	$0.75	$2.89	$4.07
Peru	$0.29	$0.41	$0.42	$0.61	$0.14	$0.21	$0.85	$1.23
Total Lat. Amer.	$1.83	$4.85	$10.40	$11.23	$3.59	$3.87	$15.82	$19.95

Source: Telecom Advisory Services analysis

According to Table 12, the national deployment of networks associated with expansive mobile will result in an impact of US$4.85 billion on agricultural productivity, US$11.23 billion in the food processing industry and US$ 3.87 billion in the distribution sector. Considering the importance of agriculture in rural areas, urban-suburban implementation significantly erodes the contribution to productivity (only US$1.83 billion in this chain link).

4.4.2. Automotive industry

The automotive industry value chain represents 2.8% of Latin American GDP (see Table 20).

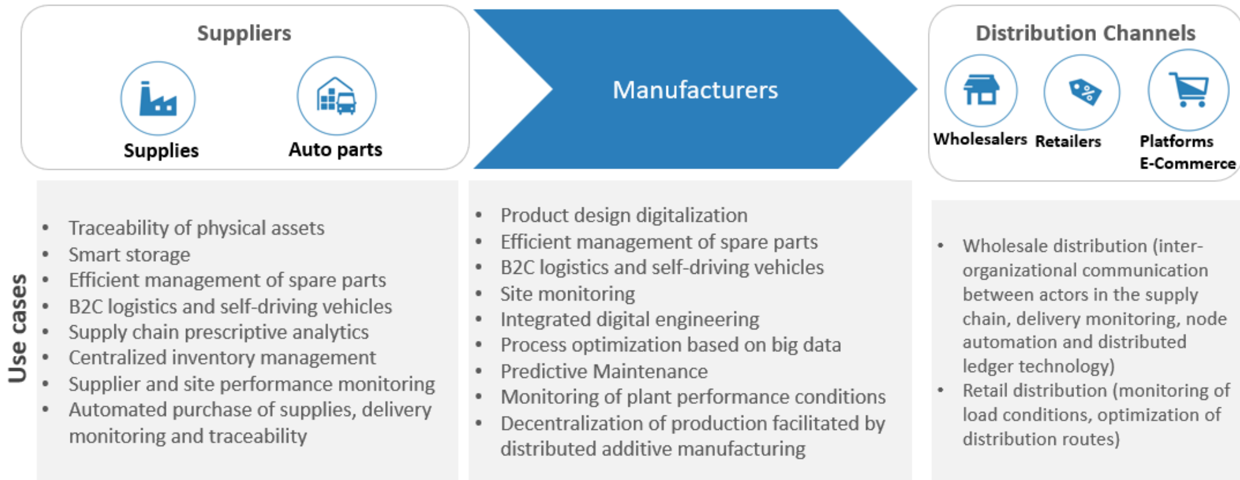
Table 20. Latin America: Automotive Industry Value Chain (in US$ billion)

	Supplies	Auto parts suppliers	Manufacturers	Distribution	GDP weight
Argentina	$0.70	$2.30	$13.61	$1.20	2.01%
Brazil	$11.40	$28.80	$66.20	$12.30	2.82%
Chile	$0.05	$0.07	$0.69	$0.06	0.18%
Colombia	$0.05	$0.07	$1.16	$0.20	0.77%
Mexico	$1.90	$7.20	$36.95	$9.10	4.37%
Peru	$0.20	$1.60	$3.29	$0.10	1.44%
Total Latin America	$14.30	$40.04	$121.90	$22.96	2.76%

Sources: Global Trade Analysis Project; Telecom Advisory Services analysis

As in the case of agriculture and food processing, the value chain in the automobile industry benefits from a set of use cases that are aimed at increasing productivity (see Exhibit 7).

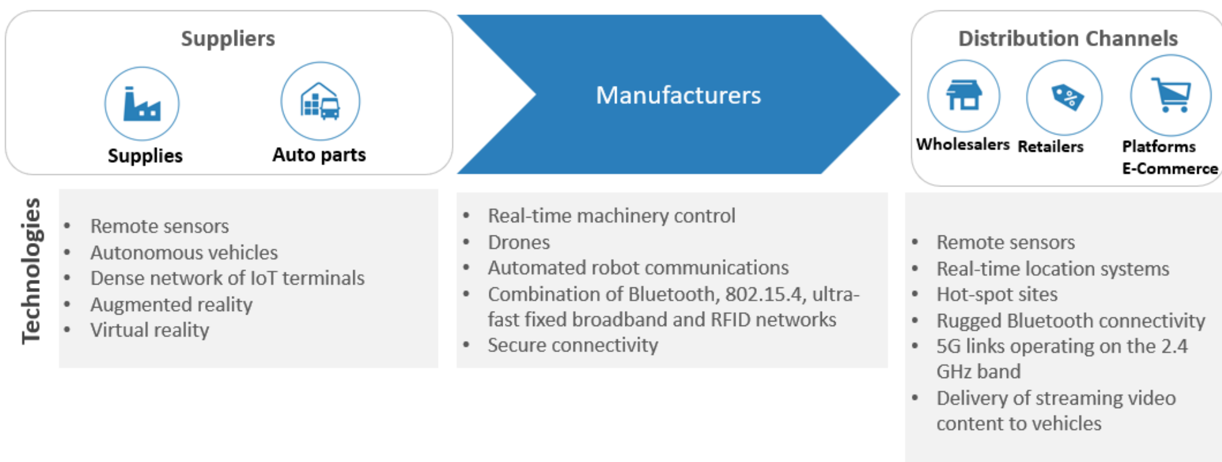
Exhibit 7. Use cases in the Automotive Industry Value Chain



Source: Telecom Advisory Services analysis

Again, use cases are facilitated by technologies that are part of the world of expansive mobile (see Exhibit 8).

Exhibit 8. Technologies in the Automotive Industry Value Chain



Source: Telecom Advisory Services analysis

It is estimated that use cases can generate a productivity benefit for this value chain in Latin America of US$ 8.245 billion (under the national implementation scenario) (see Table 21).

Table 21. Increased productivity as a result of expansive mobile in the automotive industry value chain - National implementation scenario (in US$ billion)

	Supplies	Auto parts suppliers	Manufacturers	Distribution	GDP weight
Argentina	$0.015	$0.049	$0.290	$0.026	$0.380
Brazil	$0.530	$1.338	$3,076	$0.572	$5,515
Chile	$0.001	$0.001	$0.013	$0.001	$0.016
Colombia	$0.001	$0.002	$0.031	$0.005	$0.040
Mexico	$0.073	$0.275	$1,411	$0.347	$2.106
Peru	$0.007	$0.058	$0.119	$0.004	$0.188
Total Latin America	$0.627	$1.723	$4.940	$0.955	$8.245

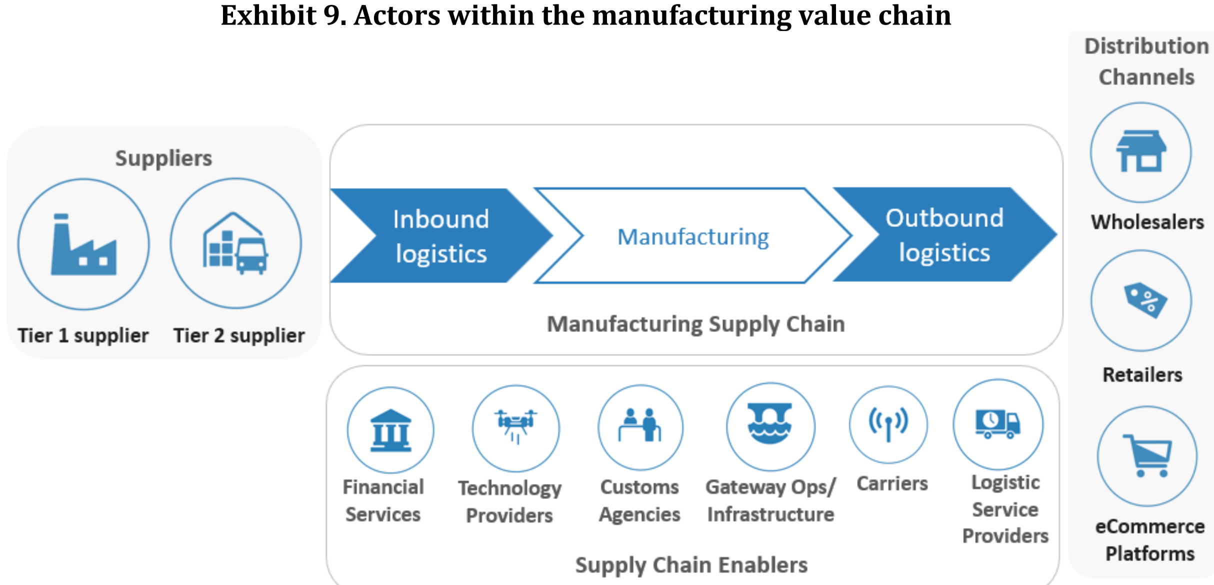
Source: Telecom Advisory Services analysis

As expected, the impact on productivity is more important in the vehicle manufacturing segment, representing US$ 4.9 billion (or 4.02% of the sub-sector's gross product).

4.4.3. Smart Manufacturing

In addition to the impact on the two strategic value chains in the Latin American economy that are analyzed above, the implementation of expansive mobile is an essential facilitator for the deployment of use cases associated with the concept of smart manufacturing or industry 4.0[22]. In the manufacturing industry, the value chain is comprised of a set of activities that range from a product or service's design all the way up to delivery or provision to final consumers. This is why the performance of this chain depends on multiple actors, including not only raw material suppliers, manufacturing companies and marketing channels, but also those who facilitate the flow of products and information (see Exhibit 9).

Exhibit 9. Actors within the manufacturing value chain



Source: Katz and Calatayud (2019).

In general, the main actors participating in the manufacturing value chain are as follows:

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[22] See Ericsson (2018). *5G Business Value: A case study on real-time control in manufacturing*. Stockholm.

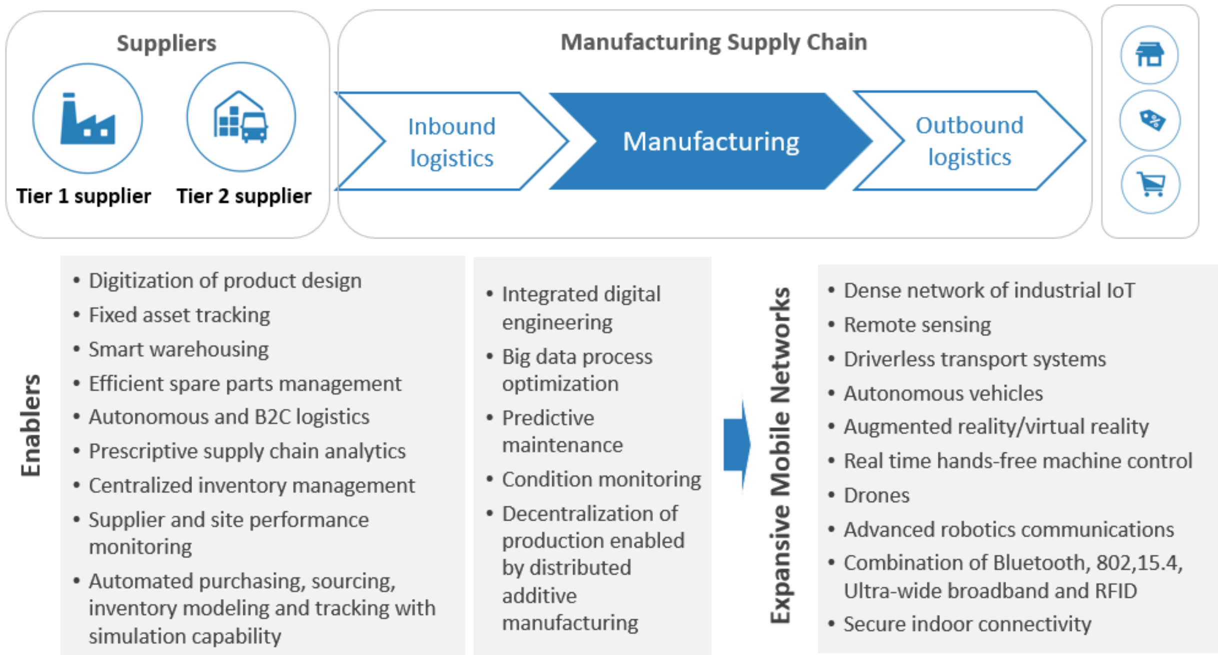
- First and second-tier raw material suppliers. First-tier suppliers are those who provide supplies directly to large manufacturing companies. Second-tier suppliers are those providing supplies to first-tier supplier companies, thus becoming indirect suppliers for large manufacturing companies.
- Manufacturing companies. Normally, these are large companies belonging to different sectors such as the automotive, food or textile industries. To produce a final product, these companies use different supplies in their transformation process, which are provided by first-level suppliers.
- Wholesalers and retailers. These are companies in the marketing sector, channeling manufacturing companies' products to final consumers.
- Logistic service providers, transportation companies and infrastructure operators. These include companies that facilitate the physical movement of supplies and final products using different types of transport (road, sea, air, and rail) and that provide storage, packaging and inventory management services.
- Institutional authorities. This refers to public sector institutions that are involved in the movement of goods, especially the import and export of goods, in order to ensure that they comply with current national and international regulations regarding tariffs and security, along with sanitary and phytosanitary conditions.
- Technology providers. This includes companies that provide computer systems for digital process management, automation and any other technology applicable to the supply chain.
- Financial service providers. This includes banks and financial entities that facilitate access to investment and working capital financing for companies in the supply chain, providing instruments such as loans, factoring, guarantees and leasing.

Given the segmentation of processes and the multiplicity of actors participating in the manufacturing chain, proper orchestration among them all requires a high degree of visibility. This refers to the ability of the actors within a chain to share correct and timely information about the status of the different processes. Increasing visibility within a supply chain is the basis for improving the coordination of processes and actors. Among the benefits of greater visibility and coordination are better inventory control, greater use of resources and equipment, cost and time reduction in the different processes, better monitoring of and faster reaction to changes in demand, greater logistical flexibility and better financial results (Calatayud, 2017).

The increasing complexity of manufacturing chains being experienced currently makes it even more necessary to increase visibility levels and improve coordination between processes and actors. The greatest complexity is evidenced at the following different levels: (i) network complexity, due to an increase in the number of actors within the chain and the links between them; (ii) complexity of processes, due to an increased amount of them; (iii) product complexity, due to the higher number of components; (iv) demand complexity, due to an increase in demand volatility and fragmentation; and (v) organizational complexity, due to the greater number of levels involved and their tendency to work in silos (Christopher and Holweg, 2011). Advanced digital technologies, facilitated by expansive mobile, can generate unprecedented increases in the visibility, coordination and performance of manufacturing industries.

The use cases and facilitators that impact the manufacturing value chain are as follows (see Exhibit 17).

Exhibit 10. Smart Manufacturing: Use cases and facilitators



Source: Telecom Advisory Services analysis

These use cases and their technological facilitators have already demonstrated their significant impact on manufacturing productivity:

- A 5% reduction in supply chain coordination costs
- 5% increase in deliveries of "just in time" merchandise
- Supply cost reduction between 3% and 25%

Expansive mobile offers telecommunications manufacturers and operators the opportunity to build intelligent factories and truly take advantage of technologies such as process automation (monitoring and diagnostic functions), production automation (control of manufacturing processes), logistics (mobile service robots, autonomous transportation, product identification, tracking and location of people and assets).

Considering that Latin American manufacturing production totals US$1,438.3 billion, use cases and facilitators associated with expansive mobile can generate a productivity increase of US$34.4 billion (equivalent to 2.39% of the sector's gross product).

4.4.4. Smart Logistics

An equivalent impact can be foreseen when introducing technologies associated with expansive mobile in the logistics sector. Improving efficiency in a country's logistics has been studied as a lever for stimulating economic growth[23].

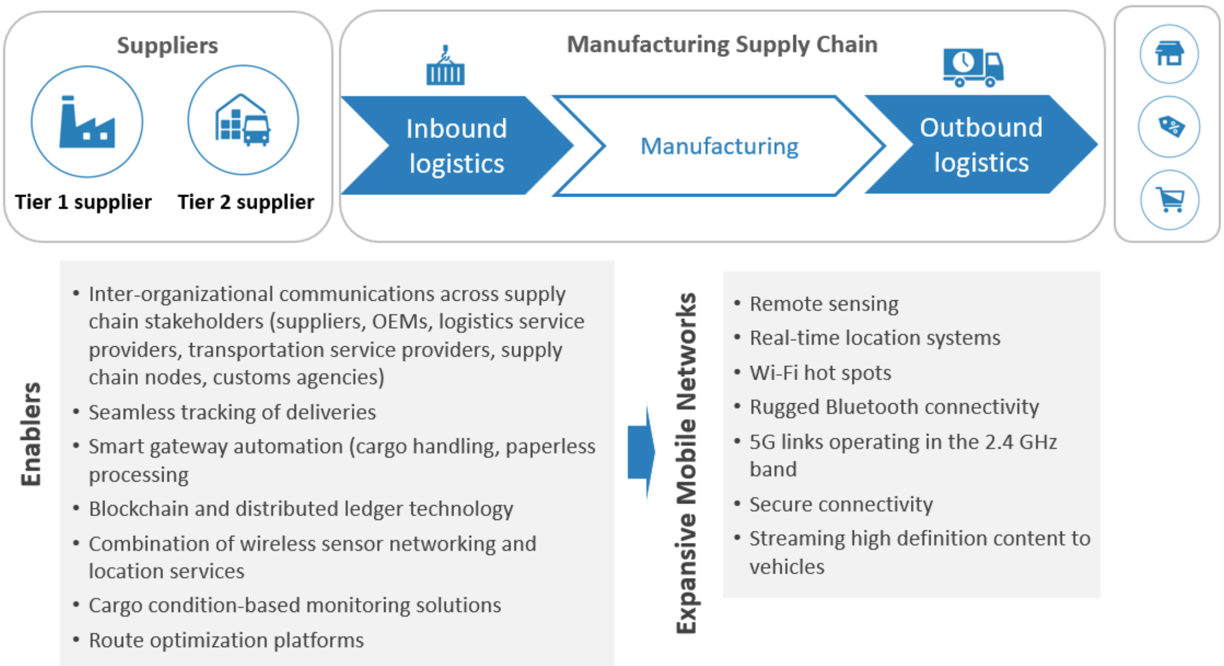
The transportation and storage sector represents 6.04% of the region's gross product (US$345.9 billion out of a total regional GDP of US$5,731.4 billion). On the other hand, logistics costs in the

[23] Codruta Bizoi, A. and Sipos, C. (2014). *Logistics Performance and Economic Development - A Comparison within the European Union* in: Research Direct; Sánchez, R., Cipoletta, G.; Perrotti, D. (2014) "Economic Development and Logistic Performance: a probabilistic approach," *World Economy Magazine* 38, 2014, 27-48.

region are comparatively higher than in advanced economies. For example, logistics costs in Latin American economies range around 12% of gross income, while this number is 8% on average for OECD countries[24].

In this framework, use cases facilitated by expansive mobile can help increase transportation and storage efficiency and reduce logistics costs (see Exhibit 11).

Exhibit 11. Smart Manufacturing: Use cases and facilitators



Source: Telecom Advisory Services analysis

It is estimated that the impact of all these solutions could result in an improvement in productivity within the transportation and storage sector of up to US$11.1 million (i.e. 3.21% of the sector's gross product).

4.4.5. Other use cases by sector

Beyond the use cases identified in the four sectors detailed above, expansive mobile will allow for the development of applications aimed at increasing productivity in other industries (see Table 22).

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[24] Dom Cabral Foundation. *Logistics Expenses Survey 2018.*

Table 22. use cases facilitated by expansive mobile

Sector	Use cases

Mining	• Automation of the extraction and transport of metals to optimize the flow of ore, based on the following:
	  ▪ Fully remote monitoring with very high bandwidth and low latency requirements
	  ▪ Transport of autonomous and remote control machines, being made by different brands and with different control systems
	  ▪ Management of an ever-changing production environment and geography
	  ▪ Maintenance in all areas within the mine where machinery or personnel could be located
	• Tracking and coordination of mobile equipment fleets and many sensors and other devices within a communications network

Construction	• Remote control of heavy construction machinery • Preventive maintenance
Financial Services	• Improve existing banking applications and offer new use cases, such as artificial intelligence, all supported by a series of software-defined network solutions • Secure online consultation (conference call) • Augmented Reality (AR) and Virtual Reality (VR) to create platforms for potential clients • Online Events
Lodging and tourism	• Augmented Reality (AR) • Virtual Reality (VR) • 3D Motion Detection • 4K 360° *streaming* technology content
Recreation and entertainment	• Augmented Reality (AR) and Virtual Reality (VR) • Online events and live stadium experiences • Mobile experience comparable to a console or TV-based experience,

Source: Compiled by Telecom Advisory Services

5. PUBLIC POLICY LEVERAGE FOR PROMOTING EXPANSIVE MOBILE

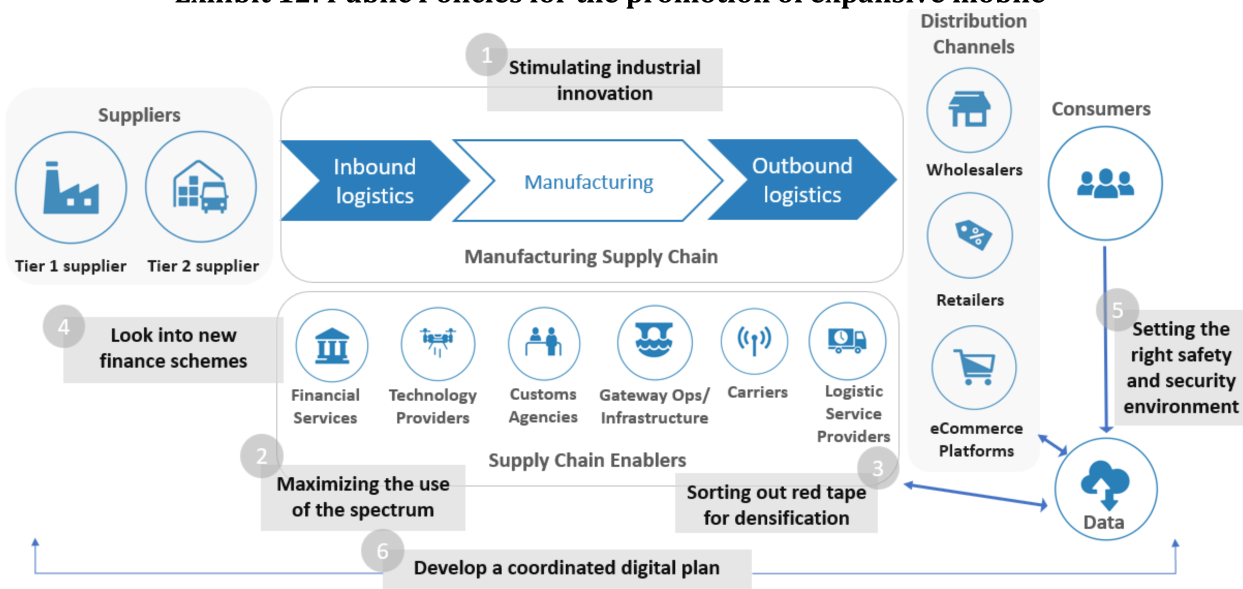
Regardless of the large socio-economic benefits that expansive mobile brings with it, its implementation requires effective mechanisms for the formulation of public policies. The experience of advanced economies in digital transformation and 4.0 industrialization has so far demonstrated attention limited to connectivity needs. In other words, it is difficult to capture the value of technologies such as robotics and artificial intelligence if the underlying infrastructure is not on par. The specificities of mobility, along with its resources and dynamics, require a specific approach so that it can realize all the transformative potential analyzed in the previous sections regarding new and more sophisticated value chains.

The road to expansive mobile requires five fundamental levers in order to provide tangible and intangible resources and present the stimuli (competition, incentives, legal framework) that are a necessary condition (and obviously not sufficient) to achieve the benefits estimated in the previous chapters. As can be seen in Figure 10, each lever acts on specific links within the sectoral value chains, such as those presented in Chapter 4, and needs an integrated digital plan that allows for effective and segmented actions (discussed in Section 6).

First, innovation must be stimulated through policies focused on responding to specific needs for the digital transformation of industrial sectors. For this, it is essential to have a complete vision of the responsibility of existing authorities (for example in relation to industrial policies, creation of emerging companies, development of human capital), as well as coordinated decisions in order to create an effective institutional design that addresses the different types of digital transformation. Second, considering the need for radio spectrum to implement expansive mobile, it is essential to understand where Latin America is located on the transition path between 4G and 5G and to define what critical elements of that change will need to be addressed.

Third, and just as important as the above, it is necessary to define the public policies necessary to resolve administrative barriers that affect the path towards the level of site and radio base station densification that is required by expansive mobile. Fourth, financing alternatives must be explored to respond to the investment challenge that actors within the region's public and private sectors will face. Fifth, it is important to create an environment of trust at the user and device level, as well as to address the challenges that countries face today as they chart their cybersecurity strategies. Finally, considering the multiple relationships between each of the recommendations mentioned above, it is necessary to define a comprehensive digital development plan that is effective in coordinating the mainstreaming of public policies.

Exhibit 12: Public Policies for the promotion of expansive mobile



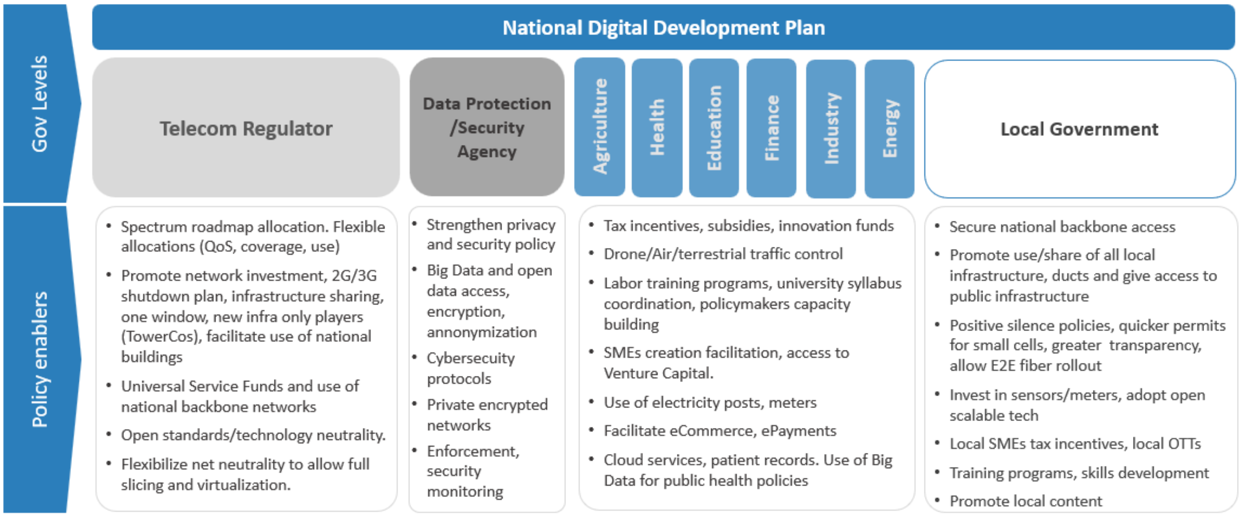
Source: Telecom Advisory Services analysis

5.1. Stimulating the development of use cases by sector

The mainstreaming nature of digital transformation that is caused by expansive mobile will require the coordinated action of numerous instances of public policy. This represents a unique challenge for the public sector, since it will be necessary to align actors using different levels of training, regulations, specificity in digital matter and a very varied structure of incentives and internal dialogue processes.

National institutions, whether federal or unitary, along with local autonomy to provide authorizations and permits, already constitute a highly complex factor to be overcome by those who must offer digital services within the framework of expansive mobile. These difficulties are further exacerbated by the simple fact that the regulations are obsolete when addressing the services of the new digital economy, where data is the main raw material that crosses borders and is stored in the cloud, and where connections are not only between people but also between things, with mediation platforms nourished by artificial intelligence. Beyond the idea of recognizing the impossibility or need to regulate the rapid progress of technology, the promotion or stimulation of innovation requires a major coordination effort.

Exhibit 13: Coordination between public policies and agencies is essential to promote the innovation required by digital transformation



Source: Telecom Advisory Services analysis

In this regard, it can be noted that the current authority of connectivity sector regulators loses relevance when establishing how to operate the different public policy levers that will affect new digital services. In addition to the dilemmas that new services bring to tax and governing agencies, there is an increasingly prominent role on the part of data protection agencies and the entities responsible for establishing security and cybersecurity policies. Issues such as the use, purpose, destruction, aggregation/anonymization or encryption of data are new matters that need to be understood and regulated effectively in line with the mission or plan defined at a national level. At the same time, it will be important that policy makers for each sector that is influenced by digital transformation (agribusiness, health, education, finance, energy, etc.) coordinate the promotion of their sector based on elements provided by their peers.

Many of the new and innovative services enabled by expansive mobile will require sector regulators to encourage and promote in order to face the risks involved in operating with unproven business models. The gain in productivity and integration into the new economy can be very expensive if all efforts are not addressed in a coordinated manner. The national central authority at the Executive level must provide vision within a development plan, as if it were an orchestra conductor, being sure to coordinate all the actors involved to ensure the best use of public resources. This topic will be elaborated on in depth at the conclusion of this study.

Local governments, especially in first-tier cities, are most likely to assume more relevance in this new context. These cities will have the greatest resources to invest in new services for their citizens regarding traffic management and the provision of safety, health, waste management, and other benefits, and at the same time they can make public infrastructure that is suitable for services that their residents value most. The installation of sensors, cameras, small cells, and new means of attention and access to information are key issues today that local authorities cannot ignore. The main cities of Latin America, where entrepreneurial ecosystems and the wealth of the countries are concentrated, are currently responsible for innovation and momentum in areas such as the Internet of Things, and most likely will be those who play an increasingly critical role as engines for the future. Working closely with these cities can help add demand and create a scale for new devices and services, which represents a fundamental way to make them more affordable.

At the same time, cities will be increasingly focused on stimulating the companies that are located within them and on increasing the employability of their inhabitants to avoid emigration. Therefore, these cities will be the entities most interested in demanding or providing job training, developing new skills and generating of local content. An emphasis on local digital ecosystems will be essential to generate synergies and knowledge transfer.

Regulatory "sandboxes" to facilitate the development of new use cases by sector

It is often observed that legacy regulation is an obstacle to innovation and the flourishing of new technologies whose business models are not proven. The "regulatory sandbox", is a method based on pilot studies where experimentation with other levels of regulation can be done in a controlled environment to test their impact. Although its implementation has been more limited to spaces such as "fintech," this experimentation is understood as a path that can provide evidence that contributes towards the modernization of regulation[25].

5.1. Stimulating the development of use cases by sector

The development of use cases that produce the sector benefits described in Chapter 4 face a series of barriers in the area of connectivity. Table 23 presents some of the barriers that must be addressed in order to realize the estimated benefits of expansive mobile.

Table 23: Barriers to achieving the benefits of expansive mobile and public policies that can solve them

Sector	Barriers	Key Public Policies	
		National Level	Local Level
Agriculture and food production	• Lack of coverage and capacity in rural areas • Access to backbone networks and cost of *backhauling* • Limited technological development within the sector	• Access to licensed or shared low and intermediate band spectrum. • Tax incentives for investment in local infrastructure and the development of precision agriculture	• Facilitate access to public infrastructure, demand for access to backbone networks • Investment in infrastructure and connectivity, co-investment with private parties. • Dissemination and training programs
Mining sector	• Low quality indoor connectivity, high cost • Lack of robustness in hostile environments • Concern about stability and use of unlicensed spectrum	• Access to licensed or shared low and intermediate band spectrum. • Co-investment in backbone networks • Promotion of PPDR application development, remote AR/VR monitoring • Update labor framework	• Facilitate access to public infrastructure • Expansion of Wi-Fi connection points • Encourage investments in training and research, due to changes in type of work, AR/VR
Manufacturing industry	• Latency and reliability of connections • Low bandwidth and limited coverage • Restriction to network segmentation	• Access to licensed or shared low and intermediate band spectrum that allows for the automation of processes. • Improve regulation of data integrity and privacy • Make the principles of net neutrality flexible	• Facilitate access to public infrastructure • Promote the adoption of new technologies and encourage investment in training • Promote the installation of industrial hubs

[25] See: https://www.finextra.com/blogposting/15759/the-role-of-regulatory-sandboxes-in-fintech-innovation

Sector	Barriers	Key Public Policies	
		National Level	Local Level
Public utilities	• Lack of extensive and reliable coverage • Little coordination between actors • High costs of smart home monitoring devices	• Access to licensed or shared low and intermediate band spectrum. • Standardization of IoT in LPWD networks and promotion of solution interoperability • Coordinate with vendors and actors to develop accessible intelligent monitoring devices	• Facilitate access to public infrastructure • Encourage the incorporation of intelligent monitoring devices both with local companies and at the retail level
Construction	• Low accessibility level • Absence of outdoor coverage in winding terrain or hostile environments	• Access to licensed or shared low and intermediate band spectrum. • Stimulate infrastructure sharing • Modernization of employment contracts	• Regulations and more dynamic building permits • Facilitate access to public infrastructure • Promote and encourage the incorporation of technology in local companies, training
Commerce and logistics	• Difficulty tracking in real time • Lack of coordination among control agencies • Little development of solutions that are adjusted to the sector's needs	• Access to licensed or shared low and intermediate band spectrum. • Encourage infrastructure sharing • Investment in cloud technology for use by national and local regulatory authorities • Encourage investment in device development	• Access to public infrastructure in high traffic areas (ports, border crossings, loading and unloading areas) • Coordination between departments and local-national authorities (customs, police, prefecture, transportation authorities), standardization, incorporation of technology
Transportation	• Saturation of current capacity due to high density of devices in urban centers • Rigidity of regulations for the deployment of antennas and small cells	• Access to licensed or shared low and intermediate band spectrum. • Stimulate infrastructure sharing • Flexibility in network design • Data protection and privacy	• Facilitate access to public infrastructure that is already installed on routes and highways • More dynamic processes for enabling new infrastructure • Reduction of deployment costs for new antennas and small cells
Health	• Absence of low latency connectivity for diagnosis and remote surgeries • Incomplete coverage in rural areas • Low capacity for intensive use applications	• Access to licensed or shared low and intermediate band spectrum that allows for monitoring and performing remote surgeries • Policies for using Big Data for public health • Coordinate developments with all actors, standardization • Data protection, sensitive handling and safekeeping	• Increased demand for 5G health solutions • Facilitate the • Investment in professional training
Education	• Low mobile bandwidth coverage in rural areas	• Access to licensed or shared low and intermediate band spectrum. • Connectivity at all schools, integrating all possible technologies, co-investment and subsidies • Use of big data for diagnosis and policy definition	• Encourage and aggregate demand for special educational solutions • Investment in teacher and student training • Modernization of the curriculum to incorporate new content, digital tools and programming

Sector	Barriers	Key Public Policies	
		National Level	Local Level
Public Sector	• Restrictions to network segmentation • Undefined PPDR networks • Lack of framework on cybersecurity and privacy	• Definition of long-term public security strategy for PPDR • Use of Big Data for prospective public policy and measurement of impact • Modern regulations on privacy and cybersecurity	• Implementation of PPDR policies with police, fire, military and other local management agencies • Join national government management platforms
Finance and markets	• Absence of coverage in remote areas • Low level of financial inclusion • Lack of framework on cybersecurity and privacy	• Modern regulations on privacy and cybersecurity • Facilitation of payment methods and e-commerce • Design of financial inclusion strategies	• Test all types with digital financial services • Enable merchants and promote new digital payment methods
Real Estate	• Rigidity in the installation of small cells and antennas	• Encourage flexibility of local regulations for the installation of new infrastructure	• Regulate the shared use of private infrastructure for new developments • Acceleration of the process for installing new sites
Professional services	• Low connectivity in rural areas	• Access to low and intermediate band spectrum • Modernization of the regulatory framework for professional services	• Increase the demand for remote professional services at government level
Tourism	• Low connectivity in rural areas • Lack of definition for PPDR strategies	• Access to low and intermediate band spectrum • Definition of PPDR policies aimed at public safety in tourist areas	• Identification of relevant areas • Design tourist experiences with 5G technology • Implement public safety policies based on 5G technology in high tourism areas
Media and videogames - entertainment	• Shortage of reliable connectivity and low latency	• Access to intermediate and high band spectrum for access to highest speed • Modernization of internationally competitive regulatory frameworks	• Design a method for providing incentives to the development of local spots with positive impact on the community

Source: Telecom Advisory Services analysis

Among the possible public policies defined in Table 19, it is important to highlight the importance of access to low and medium frequency spectrum bands to provide ubiquitous and continuous mass connectivity through enriched broadband, along with general support of the Internet of Things. As discussed in Chapter 4, it is by means of this lever that precision agriculture and food production show the greatest productivity increases and generate productive links to the supply chain. The digitalization of production and development of smart cities, as well as the revolution of transportation and logistics, will be supported by the use of higher spectrum bands, above 6GHz, in order to support very low latency and high reliability solutions such as those associated with the provision of remote health services, industrial automation, and self-driving vehicles.

At the national level it will also be necessary to define an aggregation and anonymization data policy that safeguards privacy and provides security to individuals to exploit the data economy and Big Data. In this way, the definition of health policies (vaccination campaigns, purchase of supplies, demand prediction, etc.), education (diagnosis), and transportation, among others, will be greatly benefited. At the same time, authorities over national sectors should promote specific regulations that enable the use of unmanned aerial devices, homologation of new devices, the promotion of interoperability for public sector solutions in order to benefit scale (relevance factor for sectors such as customs, police, transportation and port authorities). Access to low-band spectrum and densification improvements, installing small cells in ports, airports, and container areas, would facilitate the extension of coverage and allow for the use of smart sensors and devices that offer traceability and improve logistics efficiency while reducing losses and crime (see Section 4.4).

The implementation of sector use cases in order to achieve digital transformation within the framework of expansive mobile requires establishing an automatic policy for the use of public infrastructure (towers, pipelines, recreational areas), and incentives for all actors to participate in sharing models in cooperation with the increase in coverage. This topic will be covered more extensively in Section 5.3.

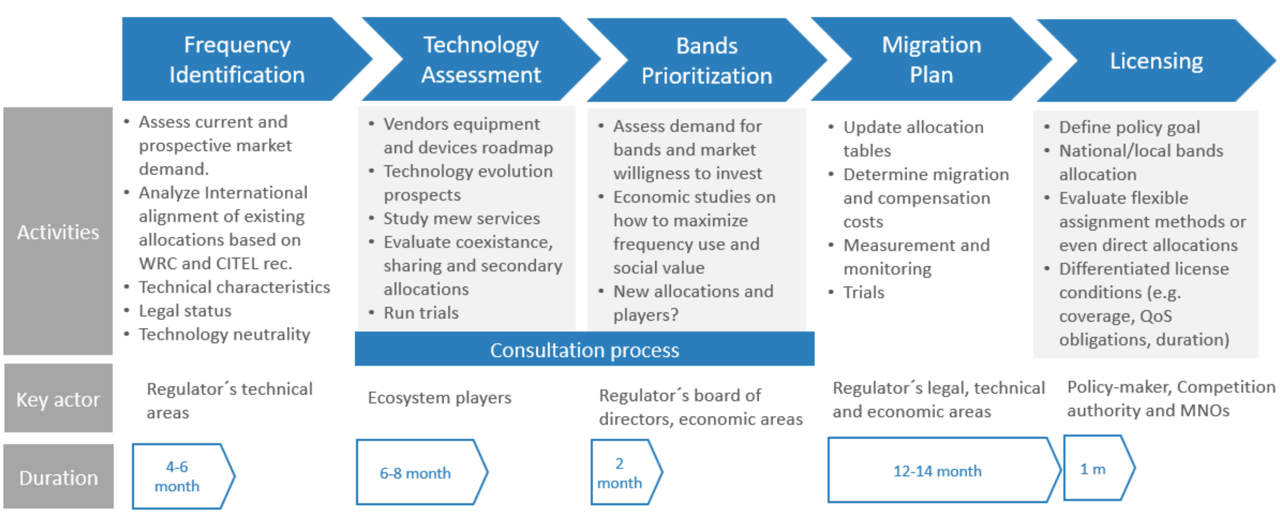
5.2. Maximizing spectrum use with an industrial approach

Radio frequency spectrum is the fundamental resource enabling expansive mobile. Its management requires detailed and anticipated planning where countries cannot act individually. The allocation of frequencies to services must necessarily be aligned with international recommendations from the International Telecommunication Union (ITU) and the Inter-American Telecommunication Commission (CITEL), while at the same time accommodating local demands and interests. Defining a roadmap for spectrum licensing that provides visibility to public and private actors and stakeholders in a transparent and consultative manner, is key to exploiting this resource in order to maximize its economic and social benefits.

A stylized roadmap for spectrum licensing is described in Figure 12, highlighting the stages making up the standard process of frequency identification, technology evaluation, public consultation, band prioritization, and definition of a migration plan, all the way up to the awarding of a tender and/or frequency assignment.

These five stages involve the different technical areas of spectrum authority, with different levels of interaction between State actors and the mobile industry. It is essential to have a good estimate of the demand and its investment capacity in order to be able to estimate the economic and social value of spectrum. Defining the public policy objective for the use or availability of spectrum is perhaps the most critical element guiding the entire design of tenders and migration plans.

Exhibit 14: A stylized roadmap for spectrum licensing



Source: Telecom Advisory Services analysis

Expansive mobile forces us to think about alternative allocation mechanisms to promote new participants, new connectivity technologies and the experimental development of services whose business model is not yet fully proven. Undoubtedly, dynamic sharing and allocation, promotion of a secondary market, allocation of unlicensed spectrum, and granting of temporary trial licenses are dynamic elements that will be fundamental in maximizing efficiency and allowing the growth of new business and solutions.

Regarding the secondary market, although it is not prohibited in Latin America, its use is not automatic and has been difficult. In 2016, Mexico adopted specific secondary market legislation, with prior authorization from regulators. The same is seen in other countries in the region, such as Peru, Ecuador, Costa Rica, and Colombia. All of these require regulatory approval before any such transaction may take place. The proposed regulations that Chile is analyzing is also along these same lines.

Some experiences in shared spectrum management being used to encourage innovation and new services

OFCOM, the UK telecommunications regulator, is analyzing the possibility of using shared licensing in the 3.8-4.2 GHz bands, with the aim of combining current uses and the potential entry of new services. The entity also offers two types of temporary licenses, one for innovative service research and development and another for testing market-ready services[26]. It should be noted that in addition to being temporary, these are non-commercial permits, and that they can include any band —subject to availability and coordination— with low administrative costs (£50) and with the possibility of including user participation, and upon whom it is prohibited to establish a fee for such participation. Finally, following the US FCC model, this regulator is analyzing the possibility of expanding non-licensed band use, with a focus on Wi-Fi services to complement 5G deployment.

At the same time, the FCC, its namesake in the United States, made 150 MHz in the 3.5 GHz band available for spectrum sharing, which was called citizen bandwidth radio service (CBRS) due to the low use of the band by incumbents[27]. Users can access this band through a priority system that consists of 3 levels: the first priority is for access to incumbents (i.e. satellite services); the second tier is priority access, where a 10-MHz block is assigned by county for tender competition; finally, the third priority is authorized general access, where channels that have been released in higher instances and are oriented towards commercial implantation are used. Spectrum use is managed through a spectrum access system (SAS), which maintains a database that is updated with users' information, their priority levels and their geolocation. Beyond opening up to commercial users, the regulator's main challenge is the correct functioning of this system in a way that guarantees the availability of frequencies and access to incumbents[28].

Figure 13 shows the current status of key bands for expansive mobile and their situation both in Latin America and internationally. In recent experience regarding spectrum management and the consideration of new uses in Latin America, 5G consultations carried out by Brazil, Chile, Colombia, Mexico and Peru between 2018 and 2019 are noteworthy. Brazil already approved a regulatory agenda in March 2019 to allocate 3.3 GHz, 3.4 GHz and 26 GHz bands for 5G, with the intention of

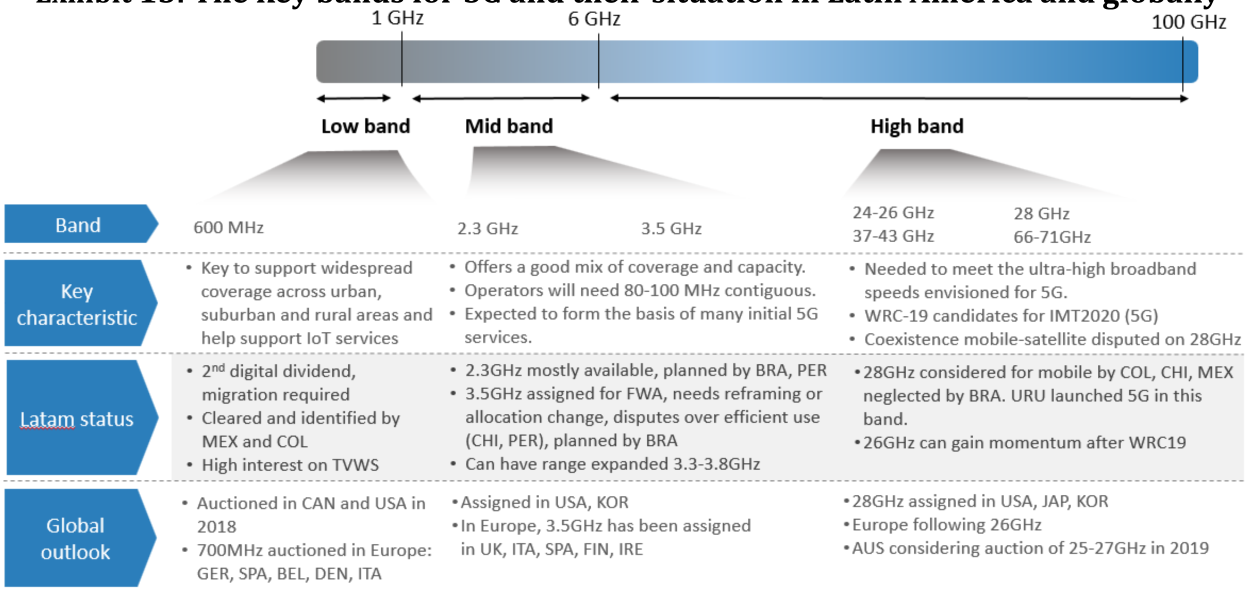
[26] See: *Innovation and trial licensing* - Ofcom. Website: https://www.ofcom.org.uk/manage-your-licence/radiocommunication-licences/non-operational-licences

[27] 3.5 GHz Band / Citizens Broadband Radio Service - FCC. Website https://www.fcc.gov/wireless/bureau-divisions/mobility-division/35-ghz-band/35-ghz-band-citizens-broadband-radio-service

[28] Shared spectrum: What's next and why it matters for businesses - ZDNet (2018). Website: https://www.zdnet.com/article/shared-spectrum-whats-next-and-why-it-matters-for-businesses/

allocating them in 2020. However, Uruguay was the first to implement a commercial 5G network during 2019[29].

Exhibit 15: The key bands for 5G and their situation in Latin America and globally



Source: Telecom Advisory Services analysis based on public information

Among the low bands, 600 MHz stands out for its wide coverage conditions in urban, suburban and rural areas; additionally, it is able to tolerate massive use of IoT and there is high interest in its secondary and dynamic use. For the moment, at the regional level this band has only been identified by Mexico and Colombia.

In the intermediate bands, 2.3 GHz and 3.5 GHz frequencies stand out. These combine coverage with capacity, as long as they are licensed between contiguous 80 and 100 MHz, and 5G implementation in the region will be initially based on them. Brazil and Peru have already identified 2.3 GHz in successive public consultations; while 3.5 GHz will require refarming and range expansion procedures at 3.3 GHz and 3.8 GHz.

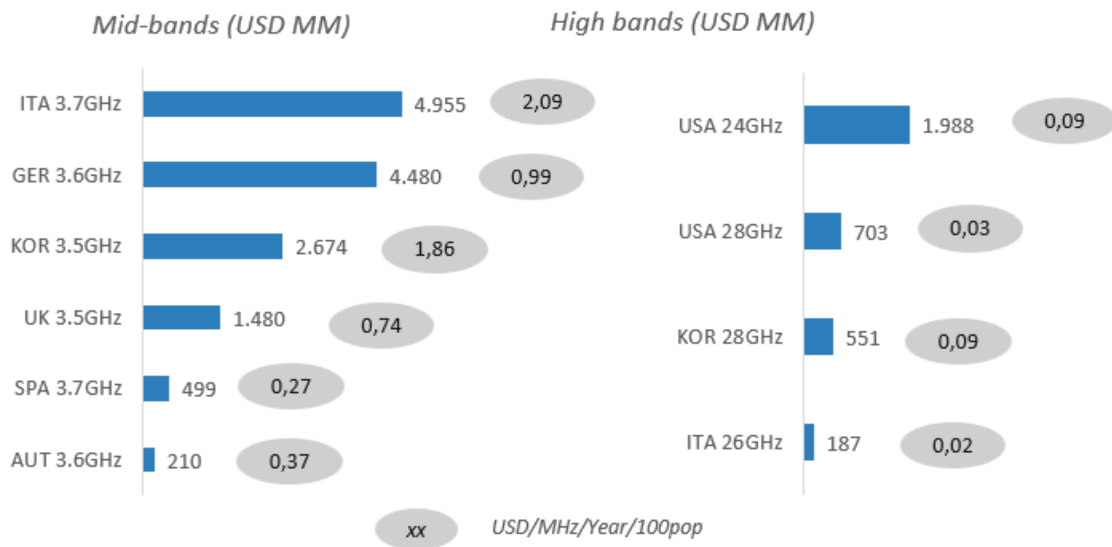
Regarding high bands, the most relevant frequencies are found in the 24-26 GHz, 28 GHZ, 37-43 GHz and 66-71 GHz bands, all candidates to be defined as IMT2020 (5G) in WRC19. The licensing of all these frequencies is a key factor for a second stage of 5G implementation in the region, to deepen the required low latency and high speed while contemplating coexistence with satellite services. In the region, 28 GHz is not considered in the WRC19 Conference, but due to the availability of devices it could be the first millimeter band to be used in Colombia, Chile and Mexico, which are already considering it. The 26 GHz band may be repositioned after the WRC19. Internationally, the 28 GHz band has already been licensed to EE. USA, Japan and South Korea and the 26 GHz band has acquired relevance in the European continent, while Australia is considering the 25-27 GHz band.

The results of the allocation processes through bidding mechanisms for the intermediate and high bands at an international level have yielded disparate situations. While in Australia they barely exceeded US$200 million, in Italy they approached US$5 billion. Something similar happened in the

[29] Nine countries in Latin America have already started on their way to 5G - Digital policy & law (2019). See: https://digitalpolicylaw.com/nueve-paises-de-america-latina-ya-comenzaron-su-camino-hacia-5g/

United States, where almost $2 billion was raised for the 24 GHz band, while Italy came close to $190 million (see Graphic 9).

Graphic 9: Recent tenders for medium and high spectrum 5G bands



Source: Telecom Advisory Services analysis based on regulators

The normalization (US$/MHz/Year/100 pop) of the totals paid at international auctions for the middle bands (3.5 GHz) highlights the high amounts paid in Italy and South Korea compared the rest of the countries. This situation raises a wake-up call for Latin America, which faces a huge dilemma of capital shortage needed to invest in the new spectrum magnitudes that are required for 5G implementation. Therefore, it would not seem that the objective of maximizing State income should be a priority when bidding for new frequencies, if a new generation implementation is to be carried out. This has been reflected in the recent approval of law 1978 that was passed on July 25, 2019 in Colombia and which replaces the economic consideration for obligations to act[30]. At the same time, it will be necessary to weigh innovative and flexible allocation methods, with moderate base prices, differentiated coverage conditions, quality of service and license duration. This will allow for the promotion of investments of infrastructure implementation that 5G demands and thus enhance the economic and social impact of the new technologies that the expansive mobile process entails.

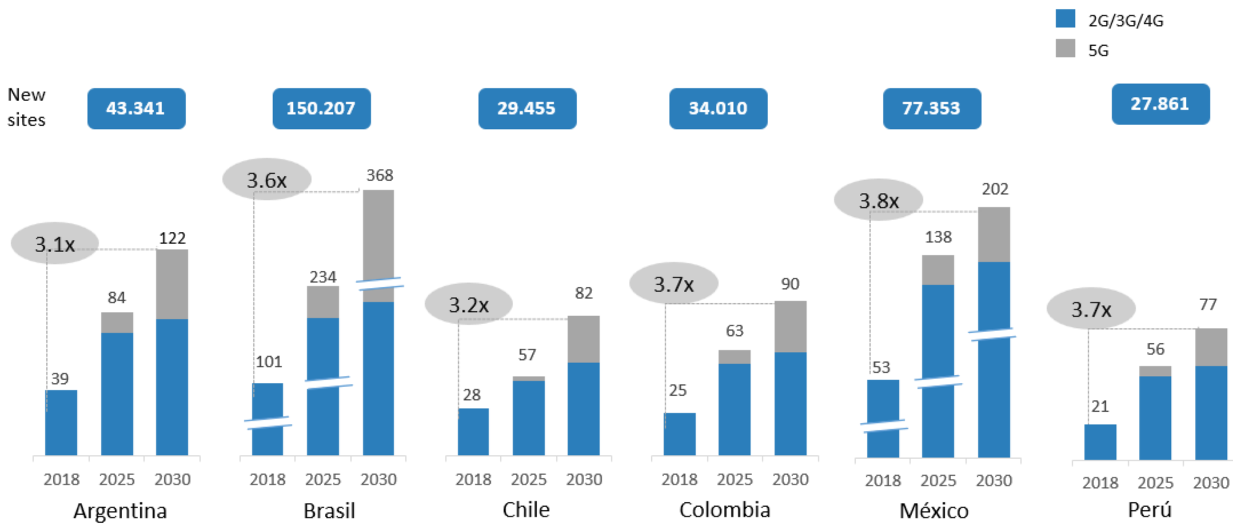
5.3. Removing red tape to reach the needed level of site densification

As noted, the use of millimeter band spectrum will be critical for the provision of very low latency and high reliability (URLLC) services as well as for the mass internet of things (mIoT). This will require significant expansion of the level of densification and antenna arrangements so as to have useful coverage in some high data traffic spaces (shopping centers, train stations, busy streets and avenues, highways, stadiums, industrial parks, etc.), so that these services will have continuity in a context of mobility. Densification of expansive mobile will require the installation of significant quantities of small cells, which are not necessarily installed on specific roofs or towers but rather on the sides of buildings, on poles or on street infrastructure. The capacity of these cells will generally be limited to a couple of frequencies and will support a smaller number of operators than a macrocell.

[30] See: “President Duque sanctioned the Law of Modernization of the ICT sector”

For the projection of the number of sites required, the current context of radio base stations in the countries under analysis is taken into account, foreseeing a normal trajectory of decreasing growth for 4G, being the base of the services, and with 2G / 3G basically being maintained or replaced (the latter over the former). At the same time, it is assumed that 5G will begin to slowly deploy from the use of the 3.5GHz band towards the end of 2020, and that the millimeter bands, most likely 28GHz, will be allocated and go into use by 2022. Finally, under a conservative scenario, it is considered that by 2025 the densest points of the three largest cities in terms of population in each country will be covered, and by 2030 this coverage will reach fifteen of the principal urban areas. Following the recommendations of the Small Cell Forum (2017 and 2018)[31] and COMMSCOPE[32], and considering an implementation of 225 small cells per km2 in these densely populated areas, and 10 for each macrocell, this could imply very high growth of radio base stations, by between 3 and 4 times as many by 2030, as can be seen in Graphic 10.

Graphic 10: Growth Projection of Radio base stations (in thousands) and Sites



Note: Modified Y axis scale for graphic simplicity
Sources: Telecom Advisory Services analysis based on Enacom, Anatel, Telecom paper, Subtel, CRC, IFT, MTC Peru

The number of radio base stations does not necessarily imply a proportional increase in the number of sites, as there may be several radio base stations per site along with sharing between mobile operators**.** On the other hand, small cells would not be useful if they are located at current sites, whereas regardless of the achievement of some solutions by optimizing current sites and even sharing facilities between them, it could effectively be argued that a significant percentage of those small cells will require new sites. If the existing proportion of radio base stations per site in each country is projected, the new ones to be deployed for 4G and 5G are added, and a 25% sharing level is assumed, it can be estimated that by 2030 between 2 and 3 times the number of sites existing at the end of 2018 will be needed. Thus, it can be seen that Argentina will need 43,341 new sites (2.1 times the current amount), Brazil 150,207 (2.9), Chile 29,455 (2.2), Colombia 34,010 (2.6), Mexico 77,53 (2.8) and Peru 27,861 (2.5). These values align with the public objectives of governments, as is the case in Peru, or simply project recent developments and behavior from past spectrum tenders. Estimates represent a minimum conservative demand for expansive mobile for the National Base

[31] Small Cell Forum (2017):"Vision for Densification into the 5G Era," Document 110.10.01, December 2017 and Small Cell Forum and 5G Americas report (2018):"Small Cell sitting Challenges and Recommendations," Document 195.10.01 August 2018 where between 10 and 30 small cells for each macrocell is estimated.

[32] COMMSCOPE (2018):"Powering the future of small cells and beyond" where between 100 and 350 small cells per km2 for densely populated areas is estimated.

Scenario (2Mbps in rural areas) that may be required in order to have an acceptable experience, at least for the massive use of the Internet of Things, and limited or circumscribed implementation of low latency and high reliability communications services, which will most likely take a little longer to reach the region.

5.3.1. Persistent problems with infrastructure deployment at a local level

At present, Latin American municipalities have constitutional autonomy to grant installation permits for antennas and rights of way for fiber rollout. Accordingly, they can interfere with the provision of telecommunications/internet services that are under federal authority. Frequently, in most countries of the region, local regulations have been imposed over federal authority, becoming very restrictive, not transparent, bureaucratic and even irrational for obtaining municipal permits. Local governments or municipalities exercise power by applying their own interpretations on the subject of non-ionizing radiation, and fix their own limitations on minimum distances and tower heights, use of public spaces or how environmental impact should be measured. This has meant that there are countless laws that regulate elements that are quite standard and common (see Table 24).

Table 24: Characterization of the main barriers to local implementation

Administrative	Environmental	Health	Technological
• Request for unnecessary or excessive information • Request for information by multiple institutions • Lack of regulatory uniformity • Lack of regulations or ignorance • Lack of knowledge regarding the Good Practice code • Absence or extension of deadlines • Establishment of public consultation • Lack of regulation regarding rights of way • Lack of continuity for local decisions • Disproportionate or disparate rates • Lack of legal certainty in appeal processes	• Minimum distance between antennas • Minimum Area Requirement • Land use restriction • Designation of special places • Excessive camouflage requirements • Authorization by aeronautical authorities • Prohibition in places of cultural and heritage conservation • Prohibition on the use of land that is under rural or natural preservation	• Lack of exposure limit regulations for non-ionizing radiation • Lack of dissemination of current regulations and international recommendations • Approval of different exposure limits and control procedures • Use of different exposure limits depending on the area • Request for studies by multiple institutions • High periodicity in the delivery of radiation reports	• Prohibition of shared use • Obligation of operators to prepare their infrastructure for shared use • Lack of differentiation between macro and small cells • Establishment of different rates per technology

Source: CAF/Analysis Mason (2017)[33]

This problem is well known in Latin America. There are extreme cases in cities with strong restrictions to infrastructure deployment. For example, in São Paulo, Brazil, 700 unresolved requests for the installation of antennas were recently registered, and 2 years went by without any new authorizations[34]. Federal governments have often felt they "have their hands tied" when it comes to carrying out their connectivity plans, the implementation of new technologies, improvement of the service quality or obtaining the coverage requirements for a spectrum tender.

33 Summarized by the authors based on the "Mobile Broadband Expansion" CAF report (2017) by Analysis Mason.

34 See: http://www.telesintese.com.br/entidades-pressionam-por-volta-de-licenciamento-de-antenas-em-sp/

As mentioned earlier, small cells will be essential in order to provide high capacity connectivity and reliability, and therefore they will be vehicles for innovation and the development of emerging companies and services with high added value. However, as Webb (2019) [35]points out, the growth of these small cells so far has faced the typical restrictions to permitting, in particular when using public spaces managed by local authorities which, when lacking a special administrative route, can demand payment for easements or rent similar to that of traditional antennas. While the value of one of these small cells can range between US$5 thousand and US$12 thousand, the cost of the equipment will be very small compared to the total cost of obtaining, maintaining, providing energy and *backhauling* to the new antenna sites. If the deployment of small cells requires rates similar to those of a macrocell or permits that take 2 years to authorize, this will be a factor undermining the profitability of the expansive mobile business model.

5.3.2. Regional solutions

In recent years, numerous efforts have been made by regulators or public policy makers in the region to reduce the administrative and technical barriers found in municipalities, mainly in an effort to harmonize regulations and improve transparency. Education campaigns and the generation of positive incentives have also been attempted, for example, by promoting friendly municipalities. The boldest regulation has been Peru's Law of Antennas[36] that promotes the principle of "positive administrative silence", which has been quite disputed[37] but remains in force and has allowed that country to make significant advances in the installation of antennas. This is how Peru was able to move from a disadvantageous position in 2012 with around 5,000 antennas, to four times as many, reaching 21,000 at the end of 2018. The regulator, OSIPTEL, estimates that the country still needs a US$3 billion investment to deploy services in the 42% of yet uncovered territory, which means about 15,524 more sites by 2022[38].

It is clear that the desired solution would be the implementation of a single nationwide point of contact, an expedited process for the use of federal buildings and simplification for the installation of small cells[39]. This, coupled with a regulatory framework that encourages the conclusion of trade agreements for the use of existing street infrastructure, as well as the sharing of passive and then active infrastructure between operators and new players to achieve cost reductions and efficient investments[40], should be the guiding principles.

[35] Dr. William Webb: "Are we risking a Mobile Connectivity Crisis," June 2019.

[36] Law 30228 of 2015 (amending Law 29022 of 2007)

[37] See: https://elcomercio.pe/lima/mtc-antenas-telefonia-autoriza-polemicas-instalaciones-noticia-534415

[38] See: https://www.gob.pe/institucion/mtc/noticias/23465-al-cierre-del-2018-en-peru-hay-mas-de-20-989-antenas-de-telefonia-movil

[39] The only record registered regarding the facilitation of small cell deployment in the region corresponds to Resolution ANE 774 of December 27, 2018 which, in Art. 14, established that radio base stations that do not require civil works may be installed without land use authorization license. However, it is not exactly known how well this regulation is working in practice.

[40] See: Decree 1060/2017 dated December 20, 2017 that seeks multiple or shared access of passive infrastructure for valuable consideration.

Table 25: Types and Examples of Initiatives to Reduce Implementation Barriers at the Local Level in Latin America (Not comprehensive)

Initiative	Countries	Characteristics
Laws on antennas/infrastructure	Peru, Brazil	These promote the principle of "positive administrative silence" and later denial by the municipality in the case of non-compliance with any regulations.
National Infrastructure Plans, Connectivity	Argentina, Colombia, Costa Rica, Brazil	Federal plans from the Executive branch, focused on reducing barriers, promoting the deployment of fiber (backbone networks and inside buildings) and setting rules or incentives ("affirmative agreements")[41] for municipalities to enable new infrastructure. It has been difficult to carry out mandates at the local level.
Single point of contact	Colombia, Argentina	In Colombia, follow-up of the online procedure is offered, but only some municipalities report consistent information. In Argentina this has been approved but not implemented.
Facilitating the use of federal buildings	Mexico, Chile, Costa Rica, Brazil, Argentina	If technically possible, regulate the use of public buildings or land owned by the Federal Government (Argentina, Mexico) or by state and/or private companies that provide public services such as roofs, pipelines and towers (Colombia, Chile).
Ranking of friendly cities	Argentina, Brazil, Peru	Classify (for example, OSIPTEL of Peru)[42], reward and/or promote good practices in some ENACOM/Argentina "Friendly Cities"[43].
Good practice standards	Argentina, Colombia	Provide a model ordinance for voluntary adoption that aligns local regulations. A lack of incentives for municipalities to adhere to has been observed.
Educational campaigns regarding antennas and radiation.	Peru, Colombia, Bolivia, Argentina	Sometimes marketed by private sector lobbying groups as "More Antennas, Better Communication" in Peru[44], or in conjunction with the Ministry in Colombia's case[45], or by the regulator as "Friendly Antennas" in Argentina, or the mobile operators themselves.
Radiation Level Maps	Colombia, Argentina	Maps showing measurements made by the regulating agency are available, but are seldom consulted. Continuous measurements have been proposed and even standardized, but they are expensive, seldom consulted in practice and have not been implemented[46].

Source: Telecom Advisory Services analysis

As can be seen in Table 21, the region's countries have explored multiple known alternatives to address the problem. Clearly, the most difficult of all is creating new legislation. Beyond these efforts, in practice the results have been mixed in all cases and nothing has proven to be 100% effective in

[41] For example, Colombia's National Development Plan 2018-2022 includes a provision wherein municipalities that eliminate unjustified barriers to infrastructure deployment (after verification by the CRC) will be included and prioritized in the list of potential candidates to be benefited from the agreements for infrastructure operators (Article 309 of Law 1955 of 2019).

[42] See, for example, OSIPTEL's "District Quality Ranking" in Brazil, ranking by a private Teleco consulting firm "Ranking da Cidades Amigas da Internet"

[43] See ENACOM campaign: https://www.enacom.gob.ar/antenasamigables

[44] AFIN Campaign "More Antennas, Better Communication." The government also made its own campaign with "Good vibes Antennas" awareness workshops

[45] The ASOMOVIL campaign: "More Antennas, More Progress" had the support of MinTIC.

[46] Continuous measurements have been strongly promoted by Argentina under a pilot project that allowed for the development of an ITU K83 standard and have been partially implemented particularly in Brazil, El Salvador and Colombia.

aligning municipalities or owners of federal buildings. Finally, attempts to implement a single point of contact, a measure recommended by the OECD and promoted in Colombia and Argentina, do not yet show successful results.

5.3.3. Shifting towards a new paradigm for infrastructure deployment

Expansive mobile to an urban-suburban scenario will bring new service models and infrastructure provision along with new players that perhaps have not yet been fully estimated. The model of vertically integrated operators that operate infrastructure and are regulated by a single authority is practically lost for the medium term. As William Webb (2019) points out, motivated by the growth of network traffic, the momentum of the richest cities, or arriving-first marketing, must move to a new era of densification for massive large-scale networks.

Some signs of these new models are seen in the growth in the presence and visibility of tower companies or the discussion of the possibility of "micro operators" appearing with exclusive licenses at the local level, for example, for small indoor cell networks for Internet of Things services[47]. Just like in the United States with the deployment of 5G, the growth of neutral asset holders will begin to be observed more and more, which will undoubtedly stimulate more efficient uses, along with better operation and management of sites. Regional operators such as Telefónica and América Móvil have also moved in this direction, with the "spin off" of Telxius and Tele sites, respectively.

However, all of these efforts have faced difficulties and hurdles, when looking outside the sector. This fact indicates that it is necessary to truly empower those leading the agenda at a national level in order to be able to "discipline" the other vertical national and subnational actors. The mandate should be clear and unambiguous from the plan proposed to the policy maker within the Executive Power and, if possible, should provide it with regulations and institutions that allow it to act in an institutionalized (non-voluntary) manner in every way. This direction is associated with the need to define a new paradigm in the management of authorizations and permits in order to support the implementation of expansive mobile infrastructure (see Table 26).

Table 26: Characterization of the new paradigm for Expansive Mobile

	Traditional Model	Expansive Mobile
National regulatory authorities	"*Command and control*" type, with competencies contested with the Executive branch	Focused on promoting innovation in vertical markets and coordinating other sectors/regulators.
Local government	Bureaucracy, lack of transparency and non-harmonized regulations.	Looking to become smart cities, making initial investments in pipelines, fiber and sensors, and promoting the deployment of small cells.
Operators	Vertically integrated infrastructure owners	Fragmented and focused wholesale Business, New asset holders (towers), association with public utilities.
Networks	Fixed legacy copper networks with fiber in urban and core areas only. Underutilized national backbone networks.	Massive deployment of small cells and MIMO antennas, with cutting edge computing. *RAN sharing / open RAN*. Maximization of the use of backbone networks and national resources. Flexible/dynamic uses of spectrum

[47] See: UO5G project by the University of Oulu, Finland: https://www.oulu.fi/uo5g/

New Players	Network and virtual operators	Atomized and niche, micro-operators, OTT platforms

Source: Telecom Advisory Services analysis

5.4. Developing new financing mechanisms to respond to investment needs

As seen in Chapter 3, expansive mobile at a national level and the resulting impact on productivity in the economy will require large investments for the development and updating of digital infrastructure. It is clear that the lack of a clear business model in the new innovation sectors discourages operators from making the necessary short-term investments[48]. That is why it is necessary to explore new financing strategies based on public-private cooperation, which can help mobilize private capital. An example of this is the "Internet for all" project developed in Peru, which will help expand the limits of mobile coverage within the country by creating a rural operator (see box).

The case of Internet for All in Peru

The "Internet for All" project carried out in Peru is an example of the possibilities that combined financing opens up for digital infrastructure initiatives in the region. Telefónica, Facebook, IDB Invest and CAF (the Development Bank of Latin America) have taken advantage of the regulatory framework for the rural wholesale operator that exists in that country and jointly launched a "Network as a Service (NaaS)" wholesale operator type for open access to telecommunications infrastructure. This operator mainly covers rural areas and aims to reduce the digital divide, bringing mobile broadband to populations that until now have been remote and economically unfeasible. Telefónica del Peru provides services to current rural businesses, while the rest of the actors provide the financing needed to improve services and deploy new infrastructure[49]. With the final objective of providing service to 6 million people, the company has already connected more than 600,000 Peruvians belonging to more than 2,000 rural Amazonian communities and towns throughout the country[50].

In the new financial structuring mechanisms for increasing acceptance in multilateral organizations, there is a more comprehensive and long-term view since the cost-benefit is calculated in relation to profits for the economy and societies in general and not only for a single investor[51]. The so-called blended finance is a mechanism that the OECD defines as "the strategic use of development financing to mobilize additional financing for sustainable development[52]." This is a type of public-private collaboration that seeks to channel infrastructure investment flows to strategic areas with high-impact public benefits, through more favorable financing conditions than those found in the commercial sector.

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[48] Inter-American Development Bank (IDB) and World Economic Forum (2019). *Supply Chain 4.0. Global Practices and Lessons Learned for Latin America and the Caribbean*.

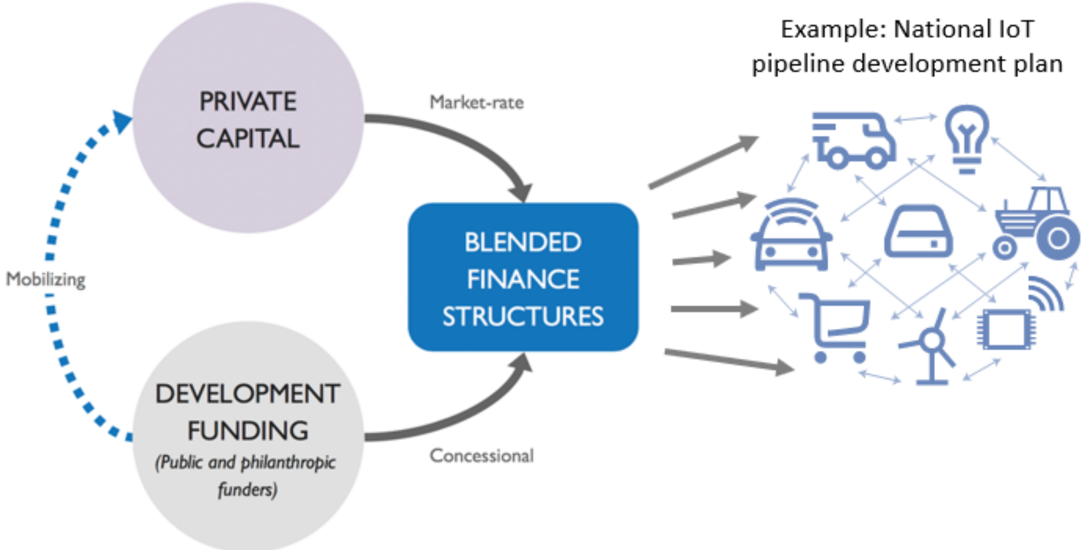
[49] IDB Invest (2019). "Telefónica, Facebook, IDB Invest and CAF create Internet for All Peru to expand internet connectivity in Latin America."

[50] See: https://www.telefonica.com.pe/es/internet-para-todos

[51] World Economic Forum (2018). *Financing a Forward-Looking Internet for All*.

[52] OECD (2018). *Making Blended Finance Work for the Sustainable Development Goals*. OECD Publishing, Paris.

Exhibit 16: Combined financing will be key to developing Industry 4.0 projects



Source: Adapted by Telecom Advisory Services

National governments, philanthropy funds, multilateral agencies and development banks can provide part of the financing, in conjunction with traditional actors such as mobile service providers and internet platforms. By adding funds, risks are reduced, and investments are attracted for the installation of infrastructure that at the same time generates profits for the private sector. In this way, this type of financing can be used to overcome investment barriers at different project stages. The Inter-American Development Bank, for example, uses blended financing methods for pilot projects and for replicating or scaling initiatives, as well as for creating emerging companies centered on innovative business models or new technologies[53].

The use of combined or blended financing shows great potential in Latin America and the Caribbean. Convergence, the global network using this method to channel funds, accounts for about 80 projects since 2000, with a total value of US$14 billion. In fact, more than a third of those amounts (over US$5 billion) come from agreements closed in 2018. Among the largest investors in the region are Calvert Impact Capital, the International Finance Corporation (IFC) for the World Bank Group and the United States Agency for International Development (USAID)[54]. All these multilateral agencies have a broad interest in financing connectivity and new digital infrastructure development models, as long as these are aligned with Sustainable Development Goals (SDGs)[55].

Latin America countries must be prepared to take advantage of these new financial structuring models and take advantage of the centrality of the digital world in order to finance the modernization of their infrastructure and the development of use cases within the framework of expansive mobile that can offer a productivity leap. To this end, it is necessary that states develop a hierarchical list of Industry 4.0 projects aligned with their development plans and the SDGs. The latter is fundamental, as many interesting projects often fail because they do not "speak the same language" of those who can give the initial investment kick that provides the necessary confidence to other actors that may wish to participate. Feasibility studies, business model proposals and expected impact analysis all contribute to increasing the chances of obtaining the necessary funds. Another possibility is the

[53] IDB (2018). *"Pushing boundaries with blended finance in Latin America and the Caribbean."*

[54] Díaz Loyola, A. (2019). "Blended finance builds momentum in Latin America." *Convergence*. March.

[55] See recommendations and goals of the United Nations Development Program (UNDP): https://www.undp.org/content/undp/en/home/sustainable-development-goals.html.

creation of spaces for dialogue and meetings between infrastructure companies, investors and public sector actors, among others, in order to discuss possible initiatives and promote blended financing proposals[56].

Advancements that are interestingly aligned have been made in Brazil since 2015 under the "Action Plan for the Internet of Things" that seeks to stimulate the development of four priority areas: health, agriculture and livestock, industry and smart cities. This project estimated that the sector could represent between US$50 and US$200 billion for the country's economy in 2025 and is viewed with interest for new financing models[57]. An important public-private dialogue led by Congress was convened for this. Through this dialogue, there was a presentation of proposals to test technological solutions related to the Internet of Things for the industry, with non-refundable financing from the National Development Bank (BNDES)[58] and from the state's research and innovation company (EMBRAPII)[59]. Despite the change of administration and government in 2018, the plan was approved in June 2019. There, among other measures, exemption from payment for the Telecommunications Control Fund (Fistel) was proposed, and the Chamber of Management and Support for the Development of Machine-to-Machine Communication Systems and Internet of Things (IoT) was instituted[60].

5.5. Building a secure digital environment

As previously explained, expansive mobile can grow and thus improve people and businesses' connectivity, impacting different sectors of the economy. In many of its applications, the level of penetration will reach the key processes of each business, exposing them to the digital world and thus jeopardizing not only their information but also the organizations' performance. Below, some strategic areas that serve to classify different types of public policy levers to be addressed in order to create a secure digital environment in this new economic context are defined. This is of fundamental importance, since in order to reap the benefits of digital transformation it is necessary to generate confidence so that more transactions are carried out by through it while at the same time promoting a robust cybersecurity environment, so that actors can operate without vulnerability.

First, digital trust can be analyzed through two dimensions: users and devices, and privacy and confidentiality. Second, the key aspects of cybersecurity are analyzed, beginning with the issues of public security, networks and connectivity. For each of these elements, a series of public policy levers are proposed for use by different competent authorities and/or policy makers. These aspects are highly dynamic and undergo constant changes that are often addressed by institutional arrangements or the definition of policies at a later time.

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[56] World Economic Forum (2018), op. cit.

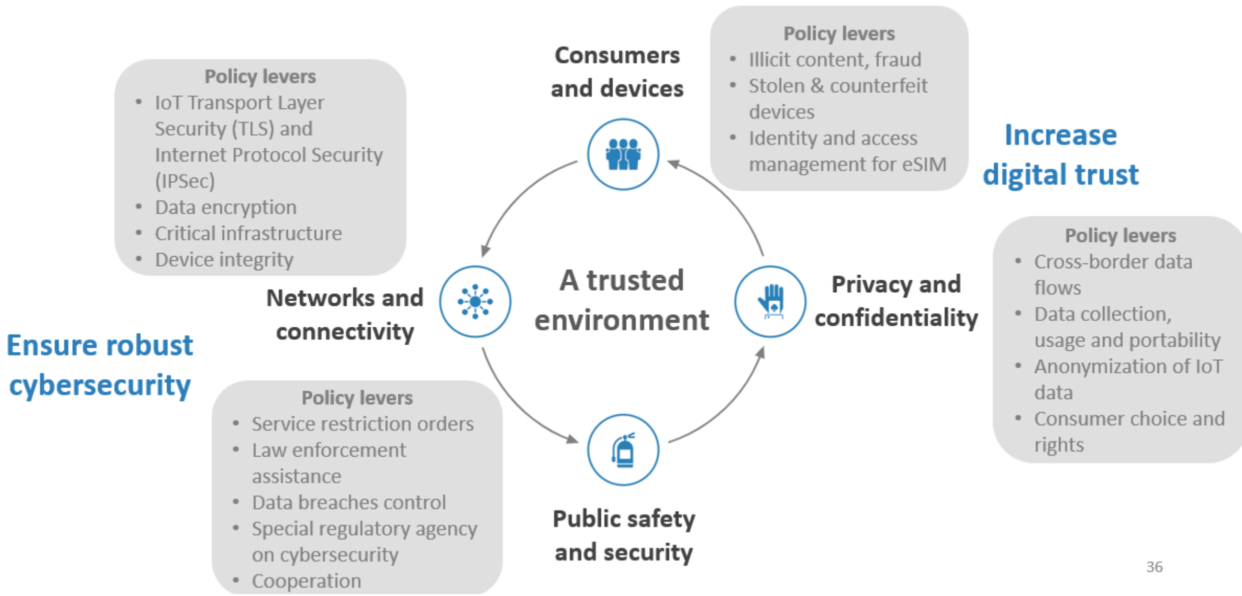
[57] BNDES (2018). *Internet das Things: um plano de ação para o Brasil. Product 9B: Síntese do relatório final do estudo.*

[58] See: https://www.bndes.gov.br/wps/portal/site/home/financiamento/produto/bndes-funtec.

[59] See: https://bucket-gw-cni-static-cms-si.s3.amazonaws.com/media/filer_public/3f/6e/3f6eb83c-2ab7-4dc7-b23b-a7eb7ec6a1a4/30102018_regulamento_bndes.pdf.

[60] See: Decree 9,854

Exhibit 17: Create a secure digital environment to contain the new connection ecosystem for vertical markets



Source: Prepared by the author

5.5.1. Users and devices

It is a fundamental role of the government to control the misuse of technology when it comes to the distribution of illicit content, not only on public networks but also on the dark web[61]. To this end, it is necessary to have modern regulations that allow reporting and quick action, by judicial order, to stop this type of content. Security efforts must continue to improve knowledge and capabilities within their specialized departments that are responsible for detecting and investigating cases of illegal content. Fraud in mobile devices and digital media is a growing problem and has become sophisticated, particularly in terms of identity theft, electronic money scams, spam and a growing trend towards social engineering fraud[62]. E-commerce could be expanded much more if there were specific regulations in these aspects that allow for criminalizing crimes and distributing responsibilities to ensure that communication connections, platform interaction, use of digital banking and new public sector transactions work with security standards and common principles. At the same time, investing in risk diffusion and citizen training is essential in making this problem visible and reducing the number of perpetrators.

Being a product of the sophistication and value of high-end mobile devices, a parallel market associated with theft and terminal forgery has developed in the region. This has aroused the interest of public officials, who have been incorporating tools to minimize the threat. One of these tools is

[61] This is a network used by people who live in repressive countries to ensure the anonymous use of internet and communications. However, this network has also contributed to the misuse of the internet, such as the emergence of illegal black markets. See "*The dark web*" - IBM Security (2015)

[62] This type of fraud consists of deceiving victims, getting them to share personal information and the services they consume, without understanding the fact that they are compromising their own security. Examples of this problem are phishing, SMiShing or vishing. See "*Phishing, vishing and SMiShing: old threats present new risks*" - RSA (EMC corporation)

IMEI [63]monitoring of devices, which, in cooperation with mobile operators, allows for blocking devices that are reported on the equipment blacklist. Regarding counterfeit devices, cooperation between operators and the public sector is required not only to track them through the IMEI database but also by focusing on illegal traffic. The incorporation of eSIM and remote provisioning will undoubtedly be a milestone in device security. Since they can't be removed from equipment, these chips allow for user profile downloading. Upon receiving a request to change a profile, the operator will request a unique address associated with the device, called subscription manager data protection (SM-DP+)[64], to allow for this update. If not available, the use of the device will be blocked. In addition to this, since it can't be removed, the eSIM allows for online tracking of the device.

5.5.2. Privacy and Confidentiality

The expansion of mobile and internet services has been accompanied by growth in network data traffic. Currently, commerce depends on the ability of organizations to transfer data –including personal consumer data– across borders, without restrictions. Being able to do so generates positive results, not only for organizations, but also for citizens and countries. Whenever the circulation of data is allowed, any organization –regardless of its size– can use the internet to market and offer its ideas, goods and services. Cross-border data transfers allow access to digital goods and services almost instantaneously, along with requests for the shipment of physical goods, regardless of where those items are produced. By expanding, organizations respond to consumer demand, serving more geographic markets and offering more options to the consumer. At the same time, the efficiency of companies operating in multiple countries increases thanks to the centralization and virtualization of data analysis, processing and storage. This is why restrictions and conditions must be kept as low as necessary, as applicable in each situation. Information transfer regulations must be proportional to the risks, while ensuring the security and privacy that is required, depending on the sensitivity of the data[65]. It is necessary that regulations issued by the public sector support, rather than impede, this flow of international data, being limited only to cases of confidential documentation. In pursuit of this objective, regional and global coordination between governments is relevant when establishing common principles that facilitate interoperability and data flow.

Privacy and security are cornerstones when building consumer confidence in mobile services. The main challenge of companies providing digital connectivity and services is to protect digital identities and provide secure communications and transactions that protect users' personal data, and to ensure that the data collection occurs under agreed terms and conditions[66]. From the perspective of regulators, it is necessary to inform consumers regarding the information that they must protect; added to this is the issuance of regulations that update and standardize processes that control the user information being collected, processed and archived, for the purpose of minimizing risks of violating people's privacy.

Continuing in the field of data privacy, the penetration of IoT devices into far-reaching areas of citizens and businesses lives could deepen the threats related to the sensitivity of applications and

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[63] See: "*Safety, privacy and security across the mobile ecosystem*" - GSMA (2017)

[64] This consists of providing the device eUICC (embedded universal integrated circuit chip) with a unique subscription manager data protection (SM-DP+) address during the manufacturing process. Once the device is turned on for the first time, it connects directly to the SM-DP+ server to receive the full eSIM profile. See "*Building of GSMA 3.1 compliant eSIM commercial system for IoT/M2M through partnership between operators*" - NTT Docomo (2018) and "*eSIM simplified: a quick guide to consumer eSIM-ready IoT device activation | Default SM-DP + address & Root Discovery Service*"- Gemalto (2019)

[65] See: "*Cross border data flows: realizing benefits and removing barriers*" - GSMA (2018)

[66] See: "*The general data protection's (GDPR) impact on data-driven business models: the case of the right to data portability and Facebook*" - ITU Journal: ICT Discoveries (2018)

the privacy of available information. This is where identity parameters, location, filtering of confidential information, among several other issues comes into play. This is why it is considered essential that private actors who collect data from their users and IoT devices, ensure that they are used anonymously, avoiding the possibility of associating a battery of information with a defined identity[67]. Users must have the ability to control their personal information, clearly knowing their rights, as well as being trained to handle issues related to their privacy[68]. To meet this objective, private actors must be responsible for developing transparent privacy policies for users. Regulators must commit to defining guidelines and regulations that promote transparency of privacy policies, and they must take part in informing citizens so that these may make use of them and understand their rights.

5.5.3. Public safety and security

Service restriction orders are a tool that governments can use to protect national security. However, their use could present a threat in terms of human rights. That is why it is essential that these types of measures be adopted as an exception, prefixed by protocols that are designed in a coordinated manner between public and private sectors while specifying legal conditions, restricting areas of application and minimizing the number of affected citizens[69]. On the other hand, the request for user information by governments from connectivity providers will be subject only to the issuance of judicial documents that support these requests, provided that they have been made by an authorized entity and in accord with established procedures. Within this framework, it is essential that government officials design a transparent regulatory framework, which specifies the protocol and bodies that are authorized to carry out such requests[70].

Cooperation between different levels of government and countries in the region in order to create harmonized approaches and strategies can greatly help in the operation and investment from the private sector to minimize hacker attacks and data leaks, reducing the risk of private and public data exposure. From a normative perspective, establishing high security standards is complicated because neither companies nor governments have comprehensive catalogs of potential threats or absolute know-how regarding attack tools. The focus of cybersecurity could be reoriented, placing less responsibility on the organization that suffers the attack, in an effort to enhance the development of a comprehensive and coordinated tool to avoid future leaks[71].

Despite its relevance and the high exposure risk, only a few countries in Latin America have defined central cybersecurity strategies, such as Argentina and Colombia. In many other countries, the approach is more fragmented and is dependent on the actions of different distributions.

5.5.4. Networks and connectivity

Encryption enhances the development and scope of the expansive mobile and will be a key element in providing reliability to the enormous data flow that is needed by massive internet of things services and low latency and high reliability services. To ensure the integrity of devices, programs that define secure accreditation schemes and that provide certificates of provision while ensuring compliance with certain security protocols are paramount. This not only includes mobile data network operators, but also application developers.

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[67] See:"*5G and the EU General Data Protection Regulation*" - Ericsson (2017)

[68] See: "*Safety, privacy and security across the mobile ecosystem*" - GSMA (2017)

[69] See: "Security and privacy of mobile networks" - GSMA (2018)

[70] See: "How 5G Challenges and Benefits Law Enforcement" - Cellbrite (2019)

[71] See:"*2019 Data Breach Investigations Report*" - Verizon (2019)

Encryption allows protecting the information by means of a set of complex algorithms that make access to data difficult, while allowing for modifications that have been made to the information to be followed through on[72]. Here it is important to distinguish between the different security levels that need protection in mobility networks, particularly regarding the transport layer (TLS) and the use of internet security protocol (IPSec), which are technologies used to create private virtual networks or VPNs. These are fundamental tools because they serve to protect against threats that limit the development of IoT devices both for organizations and in users' homes. Each is located in a different layer of the network and they do not have interoperability; while TLS is in the transport layer, IPSec is incorporated into servers, routers, firewalls and users[73].

Eventually, along with the development and extension of services, specific resources will be required to protect the critical infrastructure of a mobile network. This includes specialized equipment, processing power and technical capabilities. Additionally, it is important that service providers cooperate in the detection of new threats; even incorporating the participation of government authorities. The regulations to be defined must consider all suppliers throughout the entire value chain for the services that will be created by expansive mobile.

[72] See: "How Encryption is Powering the Future of IoT" - IoT for all (2018)

[73] Security aspects of NextGen System (5G) - Samsung research (2018)

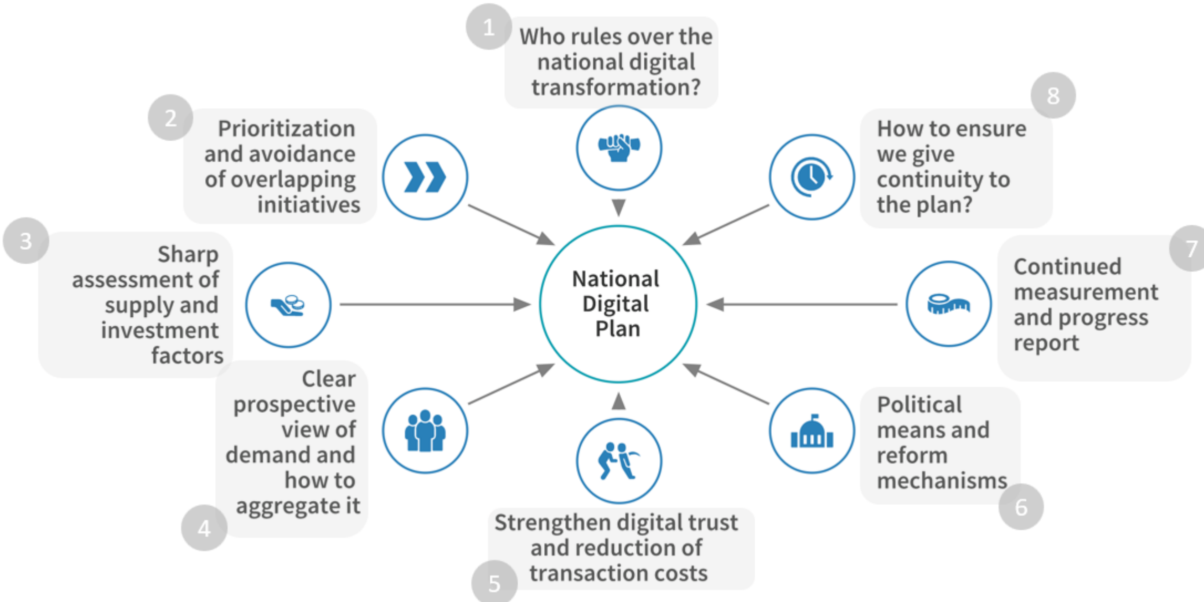
6. CONCLUSION: EXPANSIVE MOBILE REQUIRES PUBLIC-PRIVATE COORDINATION AND THE FORMULATION OF AN INTEGRATED DIGITAL DEVELOPMENT PLAN

To summarize, expansive mobile represents a more advanced version of mobile services, offering, without geographical limits, services with much faster symmetrical speeds and minimal latency. The investment required for its development is significant if an attempt is made to deploy a quality infrastructure with national coverage (amounting to US$120.07 billion for Argentina, Brazil, Chile, Colombia, Mexico and Peru). However, the return is very positive. First, the implementation of technologies associated with expansive mobile entails a significant advance in the digital transformation of Latin America. Advances will be seen in infrastructure, connectivity, digitalization of homes, digitalization of production, growth of digital industries and production digitalization factors, all of these being pillars that will bring the region closer to the average digitalization levels of OECD countries. Second, this progress will result in a positive contribution to the region's GDP, in the order of $249.8 billion for the six countries studied. This implies an annual increase attributed to direct and indirect effects of expansive mobile of US$ 29.28 billion (an increase of the Latin American GDP of 0.54%). Third, expansive mobile will generate an impact on the productivity of strategic sectors for Latin American economies: in the case of agriculture and food processing (representing 15% of Latin American GDP), use cases facilitated by expansive mobile will generate a 2.47% increase in productivity. In the case of the automotive industry, the increase is even greater: 4.02% of the sector's gross product. In horizontal terms, expansive mobile is an essential component in the universalization of the 4.0 industry concept in the region.

However, for these effects to be seen, expansive mobile should not be conceived as a gradual improvement to the services that are already being offered today in the market, but as a quantitative leap in the connectivity value proposition. The implementation of expansive mobile implies the creation of emerging companies and retrofitting existing service models based on the adaptation of new use cases that are enabled by improved connectivity and new technologies. Therefore, the need to modify regulatory frameworks, in particular to spectrum allocation, eliminate barriers to the deployment of networks, structure new financing models and create a more secure and reliable environment for digital transactions will be evident. All this will have to be accompanied by a definition of goals and programs for educational development and the generation of digital capabilities. It is clear that the main challenge of such a plan is not in its design, but rather in its implementation, since this entails a unique reform effort that will affect all intersecting sectors.

The coordination of all these aspects into one integrated plan, as well as its implantation and monitoring, must be controlled from the highest level of state power, because only from there can an integrative vision be formed, along with the ability to manage the costs and the political, economic and social benefits from the reforms that occur. Undoubtedly, this is highly complex task, but it will be critical for countries that wish to take advantage of the boost to innovation and productivity that this expanded connectivity brings with it. For all this, below we recommend eight issues to take into account when designing, implementing and measuring what could be the new wave of national digital development plans (see Exhibit 18).

Exhibit 18: Key issues to consider in an effective digital development plan



Source: Telecom Advisory Services

Each of these issues represents a paradigm shift in the way in which technological plans are formed within the region:

1. **Who controls the digital transformation?** It is often observed that a digital dimension is included in all the plans of any ministry, state government or city government. On the one hand, this reflects a universal understanding of the importance of this infrastructure in the economic and social development of a country. On the other, this duplication is a source of redundancy and misuse of resources. In light of this, it is essential that a government policy maker be empowered to act as director of all digital initiatives within other state areas or agencies, which will supervise and guide these areas to help them reach their objectives in view of the fact that new digital players need sector policies and incentives that are different from traditional ones.

2. **Prioritize and avoid overlapping initiatives.** It is common to observe state entities with redundant and/or overlapping initiatives in the digital ecosystem. In one country in the region there were five programs aimed at deploying Internet in schools at the federal level without counting the multiple initiatives at the provincial level. When programs are not centrally coordinated, many overlapping efforts are often found, along with poor creation ideas on how to act, and projects that remain incomplete due to a lack of resources. Only by organizing and guiding the different initiatives at each level of government, assigning roles and avoiding overlaps, will better use of state resources be achieved. To this end, it is necessary to have an interventionist vision and attitude so that the different State entities work in coordination towards the same purpose.

3. **Precise diagnosis of the offer and investment determinants.** Plans that are designed usually have an outlook of five to ten years in terms of connectivity, broadband speed, network laying, etc. However, these are usually not credible and are rarely followed because they do not originate with a thorough understanding of who will invest and why they should

do so. That is why it is necessary to begin with a precise diagnosis of the behavior of private and public investment and work on its determinants and incentives.

4. **Prospective demand analysis with focus on aggregation.** What do users and companies want? We usually have an idea of what families and individuals spend on digital services and we can project how their connectivity needs will evolve, but how much do we know about how they use them to improve their productivity? Or how could the different segments or niches be included for some productive purpose? Service platforms have the function of being aggregators of supply and demand and thus develop new markets with idle resources (lodging, transportation, personal care, general services). Starting from the public sector at its different levels, it is possible to stimulate the development of new value chains if different sectors with unsatisfied demands are studied, typified and added. This can be an important lever for private and public investment in order to stimulate new services.

5. **Stimulating digital confidence and lowering transaction costs.** The deployment of expansive mobile requires increasing consumer confidence when performing digital transactions. This can only be achieved by strengthening consumers' rights (improving standards and regulations regarding privacy, data portability, etc.), offering lower transaction costs for performing transactions, digital payments and online claims. This will contribute to the creation of incentives for the digitalization of processes, cost reduction and productivity improvement. In some countries in the region, simple certification of a signature, registry of a title, tax payments, civil transactions and customs and logistics procedures still require physical, face-to-face transactions, which are excessively expensive when compared to the value of the service.

6. **Political means and reform mechanisms.** Transformational reforms cannot be made without measuring costs, knowing who the winners and losers will be, knowing how to include the former or how to deal with and compensate the latter, or listening to the individuals subject to regulation. On the one hand, the proposed reforms usually lose their essence and effectiveness when they pass from the Executive to the Legislative Power and are approved (if approved) under political compromise, adding elements from other sectors that make them lose their essence. They definitely require high sagacity and push from the government. Particularly with regard to new technologies and disruptive services, it is necessary to have a broad consultative and cooperative vocation and to make definite provisional and flexible future-proof regulations that can accommodate situations that are not yet known.

7. **Measurement and continuous progress report.** It is not possible be an engine of modernization without being able to measure or quantify the desired product, nor is it possible to have a clear idea of the quantitative impact we want to create. Therefore, it is essential to continuously and objectively measure how the proposed plan is proceeding and how each of the indicators and objectives are evolving.

8. **How do we give continuity to the initiatives?** Independent regulators and oversight bodies are critical for a government plan to be transformed into a state plan and to transcend the various political administrations or the well-known economic fluctuations in developing countries. Ensuring institutional mechanisms that enable legal security for investments is essential since enormous capital flows are required to carry out the digital transformation.

In summary, it is necessary to define a comprehensive digital development plan that is effective in coordinating the mainstreaming of public policies, and that makes possible overcoming the uncertainty of new innovative and high-productivity use cases whose profitability or sustainability is still unclear. By working on these eight areas of transformation in the formulation of public policies, and by harmonizing the relationship between the public and private domain, it will be possible to make expansive mobile a reality, a fundamental platform for the economic and social development of Latin America.

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APPENDICES

A. METHODOLOGY

A.1. Analytics Framework

The analysis has been conducted through a detailed study of cases in Argentina, Brazil, Chile, Colombia, Mexico and Peru.

The analysis begins by estimating the CAF Digital Ecosystem Development Index for the six countries for the year 2018. To make this estimate, data from the following sources were compiled: International Telecommunications Union, World Bank, Akamai, FTTH, OECD, Packet Clearing House, UNCTAD, Business Bureau, Ovum, PwC, GSMA, OWLOO, UN, WHO, Regulators, INSEAD, BSA (The Software Alliance) and Speedtest. Through this study, it was determined that as of 2018 Argentina had an index of 59.97; Brazil had 55.34; Chile had 60.24; Colombia had 55.71; Mexico had 52.21 and Peru had 44.35 (see Table A-1).

Table A-1. CAF digitalization index as of 2018

	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Infrastructure Pillar	49.73	44.12	59.60	45.53	44.45	42.65
Connectivity Pillar	82.82	67.65	78.75	64.56	68.66	59.43
Household Digitalization Pillar	66.06	63.83	53.78	51.67	56.67	49.73
Production Digitalization Pillar	56.63	65.35	73.82	78.37	46.15	47.98
Competition Pillar	88.75	66.30	70.85	92.59	80.02	48.02
Digital Industries Pillar	24.76	23.25	30.65	23.15	22.16	22.83
Production Factors Pillar	33.29	33.53	38.77	29.52	23.15	19.09
Institutional and Regulatory Pillar	70.05	68.93	63.23	51.68	72.85	53.83
Index	59.97	55.34	60.24	55.71	52.21	44.35

Source: Telecom Advisory Services Estimate

A.2. Calculation of the evolution of CAF's Digital Ecosystem Development Index as a result of the implementation of expansive mobile in the region

At this stage, a calculation was made regarding how each of the indicators in the CAF Digitalization Index for each of the countries studied changed as a result of the development of technologies associated with expansive mobile. Each indicator is evaluated based on the following options:

- Without change: the indicator will not show changes as a result of the introduction of technologies associated with expansive mobile;
- Growth rate: A growth rate for the indicator is estimated to result from the implementation of expansive mobile. For example, according to the CAPEX analysis associated with the implementation of expansive mobile, telecommunications investments will grow at a rate of 10%;
- Value: A value is set regarding the indicator that will be reached as a result of the implementation of expansive mobile. For example, 4G network coverage will reach a value of 100%;
- OECD level: It is forecasted that the indicator for the Latin American country being analyzed will close the current gap between it and the average for OECD countries as a result of the implementation of expansive mobile.

Taking as an example the Infrastructure Pillar in Argentina, the analysis was carried out as follows (see Table A-2).

Table A-2. Example of the selection of indicator changes as a result of the introduction of 5G technology

Infrastructure Pillar	Argentina
Investment	
Investment in telecommunications (US$ per capita PPP at current prices. Totaling 5 years)	Growth rate
Quality of service	
Fixed broadband download speed (average Mbps)	No change
Mobile broadband download speed (average Mbps)	Value
Fixed broadband connections with download speed greater than 4 Mbps (% of connections)	Value
Fixed broadband connections with download speed greater than 10 Mbps (% of connections)	Value
Fixed broadband connections with download speed greater than 15 Mbps (% of connections)	Value
Fixed broadband connections per fiber as a percentage of total fixed broadband connections	Value
International bandwidth per internet user (bit/s)	Value
Coverage	
Fixed broadband coverage	No change
2G network coverage	Value
3G network coverage	Value
4G network coverage	Value
Infrastructure for services	
IXP per 1,000,000 inhabitants	No change
Secure internet servers per 1,000,000 inhabitants	No change
Number of satellites in orbit per 1,000,000 inhabitants	No change

Source: Telecom Advisory Services Estimate

Next, considering the changes in each of the eight Pillars within the CAF Digital Ecosystem Development Index, the values that this index will reach as a result of the implementation of expansive mobile are calculated. In Table A-3, an example is presented for the case of Argentina, where it is estimated that the index will rise from a value of 59.97 to 69.04.

Table A-3. Argentina: Changes in the CAF digitalization index as a result of the introduction of 5G technology

	Current Index	Final Index
Infrastructure Pillar	49.73	57.30
Connectivity Pillar	82.82	86.98
Household Digitalization Pillar	66.06	84.23
Production Digitalization Pillar	56.63	78.86
Competition Pillar	88.75	88.75
Digital Industries Pillar	24.76	32.22
Production Factors Pillar	33.29	38.31
Institutional and Regulatory Pillar	70.05	70.05
Final Index	59.97	69.04

Source: Telecom Advisory Services Estimate

Regarding this estimate, it is important to highlight some methodological matters:

- For each indicator, only the changes caused as a result of the implementation of expansive mobile are considered, without considering the natural growth of expansive mobile;

- Consequently, according to the counterfactual case (that is, the non-implementation of expansive mobile), the index would not change (in the example given in Table A-3, the index would remain at 59.97);
- The model calculates the rate of change in the CAF digital ecosystem development Index within the starting point (2018 - without implementation of expansive mobile) versus the current situation, assuming that expansive mobile has already been implemented. The time that it can take to reach this level of development can vary between countries and depends on different scenarios. Therefore, the faster the technology develops, the faster the resulting economic benefits will be reflected.

A.3. Estimation of the aggregated economic impact as a result of the implementation of expansive mobile

Once the change in the Digital Ecosystem Development Index caused by the implementation of expansive mobile is calculated, the subsequent economic impact is estimated. For this, we use econometric models developed by the authors of previous studies.

The contribution of digitalization to GDP growth, labor productivity and multifactor productivity is highly significant as evidenced by the results of econometric models[74] (see Table A-4).

Table A-4. Result of econometric models regarding the impact of digitalization on GDP[75], labor productivity, multifactor productivity and the contribution of ICTs to labor productivity

Variable	(1) GDP	(2) Labor productivity	(3) Multifactor Productivity	(4) ICT contribution to (2)
Growth of CAF digitalization index	0.3169 (0.0735) ***	0.2622 (0.0683) ***	0.228 (0.0674) ***	0.0948 (0.0603) *
CAF digitalization index	0.0221 (0.0630)	0.0358 (0.0585)	0.0605 (0.0577)	0.0520 (0.0500)
Comments	201	201	201	180
R-Squared	0.7341	0.6914	0.5832	0.6111
Fixed effect per period	Yes	Yes	Yes	Yes
Fixed effect per country	Yes	Yes	Yes	Yes

*Note: All estimates factor in population and GDP. Asterisks represent the level of significance, * being 15%, ** being 5% and *** being 1%.*

According to the models in Table A-4, a 1% increase in the digitalization rate results in a 0.32% increase in gross domestic product, 0.26% in labor productivity, 0.23% in multifactor productivity and 0.09% in the contribution of ICT to labor productivity. Of these models, the result that shows that a 1% increase in the digital ecosystem development index results in a 0.32% increase in gross domestic product is used. With this, this coefficient is applied to the expected growth in each

[74] Based on available data on GDP growth, labor productivity, multifactor productivity and ICT contribution to labor productivity between 2004 and 2015, the data was divided into 3 periods (2004-2008; 2008-2012; 2012-2015). With this information from 67 countries (60 in the case of the ICT contribution to labor productivity), regressions were run explaining the different variables from the growth of the CAF digitalization index, the initial level of the digitalization index, current GDP level and population. They included fixed effects by period and per country.

[75] This econometric model is different from the one published in Katz and Callorda (2018). In it, based on the classical role of production, physical capital as well as human capital is included as explanatory variables. What this structure does is capture the direct impact that digitalization has on GDP. However, it does not capture the impact that digitalization makes through changes in physical and human capital levels.

country's digital ecosystem development index as a result of the implementation of expansive mobile (see Table A-5).

Table A-5. Impact of Expansive Mobile implementation on GDP per country

	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Current Index	59.97	55.34	60.24	55.71	52.21	44.35
Final Index	69.04	63.83	70.25	65.06	61.50	53.63
Index growth	15.12%	15.33%	16.61%	16.77%	17.80%	20.93%
Impact coefficient	0.3169	0.3169	0.3169	0.3169	0.3169	0.3169
Impact on GDP	4.79%	4.86%	5.26%	5.32%	5.64%	6.63%
Impact in millions of US$	29,996	103,934	14,752	17,434	68,413	15,361

Source: Telecom Advisory Services analysis

Once the impact of the implementation of expansive mobile on GDP per country is obtained, it is estimated how it is distributed by sector.

A.4. Estimation of the economic impact per industrial sector

Using the GTAP database (General Trade Analysis Project) for the year 2011 (last available base at the time of this study), three estimates are calculated for each of the 57 industrial sectors in each of the six countries:

- Telecommunications supplies used in the sector's production;
- Total expenditure on intermediate products;
- The weight of each industrial sector within the GDP.

To simplify the analysis, the information from the 57 industrial sectors is consolidated into 13 sectors according to the grouping indicated in Table A-6.

Table A-6. Consolidation of supply-output matrices in 57 industrial sectors

Sector	Group
Paddy rice	Agriculture
Wheat	Agriculture
Cereal grains	Agriculture
Vegetables, fruit, nuts	Agriculture
Oil seeds	Agriculture
Sugar cane, sugar beet	Agriculture
Plant-based fibers	Agriculture
Crops	Agriculture
Cattle, sheep, goats, horses	Agriculture
Animal products	Agriculture
Raw milk	Agriculture
Wool, silk-worm cocoons	Agriculture
Forestry	Agriculture
Fishing	Agriculture
Coal	Mining
Oil	Mining
Gas	Mining
Minerals	Mining
Meat: cattle, sheep, goats, horse	Manufacturing
Meat products	Manufacturing
Vegetable oils and fats	Manufacturing
Dairy products	Manufacturing
Processed rice	Manufacturing

Sugar	Manufacturing
Food products	Manufacturing
Beverages and tobacco products	Manufacturing
Textiles	Manufacturing
Wearing apparel	Manufacturing
Leather products	Manufacturing
Wood products	Manufacturing
Paper products, publishing	Manufacturing
Petroleum, coal products	Manufacturing
Chemical, rubber, plastic products	Manufacturing
Mineral products	Manufacturing
Ferrous metals	Manufacturing
Metals	Manufacturing
Metal products	Manufacturing
Motor vehicles and parts	Manufacturing
Transport equipment	Manufacturing
Machinery and equipment	Manufacturing
Electronic equipment	Manufacturing
Manufacturers	Manufacturing
Electricity	Public service providers
Gas manufacture, distribution	Public service providers
Water	Public service providers
Construction	Construction
Trade	Trade
Transport	Transportation
Sea transportation	Transportation
Air transportation	Transportation
Communication	Communications
Financial services	Financial Services
Insurance	Real estate services
Business services	Professional Services
Recreation and other services	Recreation and entertainment
Pub. Admin./ Defense / Health / Education	Public Administration, Defense, Health and Education
Dwellings	Real estate services

Source: GTAP and analysis of Telecom Advisory Services

Based on information compiled from GTAP for the thirteen resulting sectors, the weight of telecommunications sector supplies is calculated under the assumption that in agriculture, mining, manufacturing and public administration that value is at least equal to 35% of the national average.[76] Table A-7 shows the use of telecommunications as a percentage of sector supplies per country and industry.

[76] In most cases, for 2011 the weight of telecommunications supplies was low for agriculture and manufacturing. However, it is assumed that with the development of 5G technology these industries will become more intensive in their use of telecommunications services (on average double the intensity of the use of telecommunications in agriculture and manufacturing). In the case of urban/suburban only implementation, this assumption is not considered for the agricultural sector

Table A-7. Use of telecommunications as a result of the implementation of expansive mobile

Sector	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Agriculture	0.92%	2.13%	1.05%	0.86%	0.90%	0.56%
Mining	1.56%	6.39%	1.05%	0.86%	1.10%	0.89%
Manufacturing	0.92%	2.13%	1.05%	0.86%	0.90%	0.55%
Public service providers (water, electricity)	0.85%	3.99%	0.86%	1.02%	0.22%	0.31%
Construction	0.59%	0.42%	0.48%	0.18%	0.92%	1.06%
Trade	3.72%	3.95%	2.34%	3.73%	4.88%	3.64%
Transportation	4.09%	2.01%	1.27%	1.64%	1,82%	1.67%
Communications	21.83%	35.11%	47.10%	18.32%	16.68%	32.02%
Financial Services	10.37%	10.92%	2.19%	4.95%	9.75%	6.54%
Real Estate Services	6.94%	8.27%	2.13%	4.94%	2.00%	5.48%
Professional Services	4.11%	25.26%	4.47%	5.14%	7.49%	5.05%
Recreation and entertainment	6.47%	7.78%	3.05%	5.92%	4.68%	3.17%
Public Admin., Defense, Health and Education	5.19%	13.03%	4.33%	3.25%	7.41%	3.94%
TOTAL	2.62%	6.08%	3.00%	2.45%	2.57%	1.57%

Source: GTAP and analysis of Telecom Advisory Services

At the same time, the weight of each industrial sector in the GDP of each country is calculated (see Table A-8).

Table A-8. Weight of each industrial sector in the GDP of each country

Sector	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Agriculture	16.48%	12.64%	10.58%	14.09%	10.23%	17.96%
Mining	2.77%	3.20%	7.02%	5.44%	4.48%	7.18%
Manufacturing	20.34%	25.30%	21.55%	18.14%	26.71%	36.91%
Public service providers	1.11%	2.14%	2.68%	2.14%	1.87%	1.47%
Construction	5.65%	5.39%	8.05%	7.80%	7.83%	7.83%
Trade	12.24%	10.38%	10.23%	13.35%	11.06%	5.47%
Transportation	4.98%	4.93%	7.80%	5.98%	6.60%	5.15%
Communications	2.10%	3.70%	2.23%	2.76%	2.15%	1.38%
Financial Services	2.56%	4.13%	4.55%	2.53%	2.04%	1.80%
Real Estate Services	6.47%	5.07%	4.17%	0.95%	6.66%	0.89%
Professional Services	5.55%	5.74%	9.77%	11.64%	6.86%	5.35%
Recreation and entertainment	4.33%	1.89%	2.20%	2.38%	4.99%	3.52%
Public Admin., Defense, Health and Education	15.43%	15.47%	9.18%	12.81%	8.51%	5.08%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: GTAP and analysis of Telecom Advisory Services

Finally, the weight of each industrial sector is weighted in the GDP of each country, and how intensive the use of telecommunications is in each industrial sector is calculated in order to distribute the economic impact calculated in Table A-5 per industrial sector (see Table A-9).

Table A-9. Economic impact per industrial sector (in millions of US$)

Sector	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Agriculture	2,712	6,536	691	1,082	3,296	939
Mining	348	3,953	421	120	772	527
Manufacturing	2,798	12,632	1,253	1,542	8,864	2,283
Public service providers	132	1,088	66	133	184	39
Construction	458	363	201	115	2,538	578
Trade	3,725	4,900	1,360	3,566	9,668	3,020
Transportation	2,504	1,710	405	732	2,965	1,163
Communications	3,364	21,821	6,382	3,764	9,880	2,038
Financial Services	2,241	4,892	625	723	4,801	619
Real Estate Services	670	2,753	251	269	877	270
Professional Services	2,708	15,860	1,687	2,062	10,903	1,411
Recreation and entertainment	1,681	1,870	227	718	4,521	695
Public Admin., Defense, Health and Education	6,654	25,557	1,183	2,607	9,144	1,780
TOTAL	29,996	103,934	14,752	17,434	68,413	15,361

Source: GTAP and analysis of Telecom Advisory Services

Regarding these values, it should be noted that the economic impact in the sector corresponding to "Communications" indicates the direct contribution that results from the implementation of expansive mobile (impact within the same sector), while the impact on other sectors represents externalities in the rest of the industrial sectors.

The values found in Table A-9 can also be expressed as a percentage of the total impact, so that the percentage of impact per industrial sector is shown (see Table A-10). The estimates can also be presented in relation to each industrial sector, which would show to what extent the GDP of each sector would improve (see Table A-11).

Table A-10. Economic impact by industrial sector (% of total impact)

Sector	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Agriculture	9.04%	6.29%	4.68%	6.21%	4.82%	6.11%
Mining	1.16%	3.80%	2.85%	0.69%	1.13%	3.43%
Manufacturing	9.33%	12.15%	8.50%	8.85%	12.96%	14.86%
Public service providers	0.44%	1.05%	0.45%	0.76%	0.27%	0.25%
Construction	1.53%	0.35%	1.37%	0.66%	3.71%	3.76%
Trade	12.42%	4.72%	9.22%	20.46%	14.13%	19.66%
Transportation	8.35%	1.65%	2.75%	4.20%	4.33%	7.57%
Communications	11.22%	21.00%	43.26%	21.59%	14.44%	13.27%
Financial Services	7.47%	4.71%	4.23%	4.15%	7.02%	4.03%
Real Estate Services	2.23%	2.65%	1.70%	1.54%	1.28%	1.76%
Professional Services	9.03%	15.26%	11.44%	11.83%	15.94%	9.19%
Recreation and entertainment	5.61%	1.80%	1.54%	4.12%	6.61%	4.53%
Public Admin., Defense, Health and Education	22.18%	24.59%	8.02%	14.95%	13.37%	11.59%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Source: GTAP and analysis of Telecom Advisory Services

Table A-11. Variation within each industrial sector as a result of the implementation of expansive mobile

Sector	Argentina	Brazil	Chile	Colombia	Mexico	Peru
Agriculture	2.63%	2.42%	2.33%	2.34%	2.66%	2.26%
Mining	2.01%	5.77%	2.14%	0.67%	1.42%	3.16%
Manufacturing	2.20%	2.33%	2.07%	2.59%	2.74%	2.67%
Public service providers	1.90%	2.37%	0.88%	1.89%	0.81%	1.13%
Construction	1.29%	0.31%	0.89%	0.45%	2.67%	3.19%
Trade	4.86%	2.21%	4.75%	8.14%	7.21%	23.82%
Transportation	8.03%	1.62%	1.85%	3.74%	3.70%	9.75%
Communications	25.60%	27.55%	102.31%	41.61%	37.81%	63.99%
Financial Services	13.97%	5.54%	4.90%	8.73%	19.44%	14.84%
Real Estate Services	1.65%	2.54%	2.14%	8.65%	1.09%	13.14%
Professional Services	7.79%	12.91%	6.16%	5.40%	13.11%	11.39%
Recreation and entertainment	6.20%	4.64%	3.68%	9.22%	7.46%	8.52%
Public Admin., Defense, Health and Education	6.89%	7.72%	4.60%	6.20%	8.86%	15.13%
TOTAL	4.79%	4.86%	5.26%	5.32%	5.64%	6.63%

Source: GTAP and analysis of Telecom Advisory Services

A.5. Regional impact estimation

Once the impact per country was calculated, the impact for the whole of Latin America is calculated. The assumption made in this instance is that the rest of the countries in the region will experience an impact equal to the weighted average of the countries analyzed. In particular, considering that the six countries analyzed represent 85.34% of regional GDP, it is assumed that the aggregate results of those countries will also represent 85.34% of the total impact of expansive mobile in the region.

Finally, it is also assumed that the distribution by industrial sectors will be the same as the weighted distribution for the six countries under analysis.

B. Detail of barriers and sector policies

Agriculture and food production. This type of activity is mostly carried out in rural areas with reduced population density, and therefore mobile broadband lacks the coverage and capacity that would allow for the massive use of sensors and the development of precision agriculture. Here, connectivity is a key to sustaining the local population near operational areas. The food industry can make important advances in quality if the traceability of supplies and food is improved. At the national level, the provision of low band spectrum is essential to improve coverage, and intermediate bands are important to increase capacity. Technification of the sector through the use of unmanned aerial devices and the development of crop monitoring platforms will also be essential. Local governments can help a lot by facilitating the use of public infrastructure, or even by becoming partners in financing or in demand for access to backbone networks and the installation of small cells, as well as in the development of workforce capacities.

Mining sector. Given that this sector performs its tasks in hostile environments, one of the main barriers is the absence of robust mobile connectivity in these types of environments, further impacted by the low indoor connectivity observed in remote work areas. The high cost of reaching these very remote areas implies an additional challenge that can only be addressed with public-private co-investment mechanisms. Added to this are some concerns regarding the stability of the use of unlicensed spectrum which is generally used in these types of operations. The availability of low band spectrum is a determining factor in improving indoor communication and providing robustness to the service. Also, intermediate bands would facilitate the use of automation tools with high intensity of use. This would accompany the extension of non-licensed or shared use frequencies in work areas. In addition, support for the development of public safety applications (*PPDR*) and the modernization of workflows to incorporate the use of remotely controlled machines *(AR/VR),* among other measures, are fundamental. From the local level, Wi-Fi connection points in work areas can be expanded, since these are very useful to the operation given their greater stability and capacity. As a result of the potential incorporation of automated tools, local governments should encourage investment in training and research activities.

Manufacturing industry. One of the main barriers seen in the industrial sector is the absence of low latency and high reliability connectivity, coupled with a lack of bandwidth and extensive coverage. This has had an impact by limiting the development of advanced tools, such as the use of the cloud. Another issue to consider is that there are no restrictions on network segmentation (network slicing) and traffic management according to the needs of each task. At the federal level, the regulator will need to have low and intermediate bands spectrum in order to increase the volume of traffic data, and it must improve capacity and low latency services by promoting the connectivity of millimeter bands via small cells and *MIMO*-type antenna arrangements to ensure bulk stable connections. In addition to this, the regulations associated with the integrity and privacy of data for connected items and machines must be updated, and the principles of net neutrality must also be adjusted if they were originally defined with restrictions on the segmentation and configuration of networks according to the demands of each company. At the local level, it will be necessary to facilitate access to public infrastructure, encourage the adoption of new technologies, encourage investment in training and foment the installation of industrial hubs.

Public utilities. The public services sector requires a series of resources to allow it to benefit from extensive and reliable coverage for remote and real-time monitoring. In addition, it suffers from lack of coordination between technological actors and the entities within its sector that should implement an intelligent electric network with connected meters. Added to this are the high costs of smart home devices. For the federal regulator, access to low-band spectrum is essential to foment the extension of services with extensive connectivity and the assembly of standardized low-power and wide-range networks (*LPWA*). Intermediate band spectrum is also necessary to allow for the incorporation of technology with high data traffic and low latency requirements. It must also coordinate efforts with suppliers and local actors to develop intelligent devices for monitoring consumption supply and demand. At the local level, it is important to support access to public infrastructure (poles, pipelines, recreational areas) with sharing models among all actors in order to support the increase in coverage. Likewise, they should favor the adoption of smart measuring devices in local businesses, as well as disseminate and support the incorporation of these tools at the household level as ways to control consumption and avoid wasting resources.

Construction. The main barriers experienced by this sector are the low level of accessibility to low-latency mobile networks and the lack of outdoor coverage in winding terrain or hostile environments. To improve this situation, the regulator must make low and intermediate band spectrum available to extend the scope of the service, allowing for the incorporation of intelligent work tools that demand high traffic and a high level of service. In turn, it could promote the sharing of infrastructure to extend reach. From the sectoral point of view, it is essential to modernize labor regulations in order to be able to perform tests with 5G connections that incorporate intelligent devices and remote control machines. Local governments must cooperate by adapting regulations and building permits so that they promote and allow the incorporation of intelligent machinery. At the same time, they should facilitate access permits for public infrastructure and rights of way so that fiber can be laid to reach workers' locations. It will also be important to encourage the creation of local construction company hubs to bring in new technologies and promote job training for their use and incorporation.

Commerce and logistics. This sector needs robust and ubiquitous connections for fleet monitoring, and continuous performance measurement to improve productivity and provide real-time data to other parts of the supply chain and the customer, as well as to deliver greater transparency and predictability in the delivery of products. Additionally, there are coordination problems between control agencies (customs, police, transportation authorities, port authorities) for the incorporation of interoperable technologies and data sharing. Low-band spectrum access and densification improvements with small cells in ports, airports and container areas would facilitate the extension of coverage and allow for the use of smart sensors and devices that provide traceability, thus reducing losses and theft, and improving efficiency. Likewise, it is necessary to encourage investments in technology in the public and private cloud to promote coordination among agencies. In this sector, coordination and homologation of permits, bills of lading and insurance, and tax rates that would reduce transaction costs and facilitate the incorporation of new technologies is especially critical.

Transportation. With regard to large cities, the high density and the number of devices saturates the current capacity of networks, making it impossible to have a reliable platform that transmits data in real time. Added to this is the rigidity of regulations for the mass installation of small cells and different antenna arrangements to guarantee ubiquitous, high quality service. To avoid saturation and guarantee quality of service, national regulators should make low and intermediate band spectrum available, as well as provide incentives to share infrastructure between private parties and facilitate access to public buildings. In addition, they could be adding to this the modernization of regulations to allow for flexible design and reconfiguration of the on-the-fly networks. Given the sensitivity of the data, it is also necessary to reconfigure the regulatory framework associated with the integrity, safety and privacy of vehicles and monitoring sensors on highways and routes. Flexibility of access to public infrastructure by local governments with a unified approach to the main routes, coordinated by federal authorities, is required. This will compensate for the current saturation and ensure low latency and coverage. They could even include the promotion of 5G transportation solutions at the public level in this adjustment.

Health. The use cases for mobile technologies are in their infancy and suffer mainly from a lack of low latency connectivity, a lack of coverage in remote areas and the lack of capacity for intensive use applications. That is why they require low and intermediate band spectrum access for coverage and high band access for video monitoring services, remote operations and assistance. This should be complemented by coordination between regulatory agencies, hospitals, suppliers, developers and pharmacists to define standards that allow for the creation of solutions and devices at the local level, according to the capabilities that new wireless technologies can offer. The use of Big Data will be essential to make public health decisions, but this requires very sensitive and segmented management of patient data that guarantees privacy and security. From the local point of view, governments can support this process by increasing the incorporation of technology in local health centers, as well as through training.

Education. In this sector, quality connectivity for all educational centers is key regardless of whether they are urban, suburban or rural. Spectrum should be used to ensure coverage in a neutral way for the deployment of all kinds of technologies, either licensed or shared, and to facilitate the construction of new alternatives for self-managed networks. This is why the segmentation of educational centers according to their location, and designing a way of addressing connectivity for each center, and even subsidizing or co-investing in them, is important in order to ensure that no public educational center is left unconnected. This milestone should be accompanied by a modernization of the educational regulatory framework to incorporate new content, online courses, videoconferences and virtual reality or augmented reality applications into traditional education and remote training. To do this, local regulators must invest in training teachers and students at public schools in both new digital tools and new content, accompanying this with an increase in the demand for 5G-based educational solutions.

Public Sector. As we have seen previously, productivity gains can be enormous in this sector if the service and data platforms reduce their overlays. For this reason, sharing is encouraged. At the same time, an open government policy and access to data will be essential to maximize the benefits of coordination and the use of all government resources. The main barriers that seen are the restriction to network segmentation, the lack of definition for the use of public safety networks (PPDR), and the lack of an appropriate regulatory framework for the use of Big Data to make more informed public policy decisions that would allow for a prospective view and proper measurements of impact, while at the same time keeping in line with data protection standards. To this end, federal governments must define a long-term strategy regarding PPDR networks and should increase the demand for these types of solutions and have a continuously revised cybersecurity policy. At the same time, they must develop a reliable regulatory framework regarding privacy, cybersecurity and net neutrality. Local governments should implement PPDR solutions, for which they must improve their coordination with police, firefighters and other local government agencies for the implementation of these solutions.

Finance and markets.
The lack of coverage outside large cities impacts access to digital financial services, coupled with the low regional financial inclusion rate. Added to this is the absence of a cybersecurity and privacy framework, which could affect the reliability of digitally performed operations. Low and intermediate band spectrum auctions should be carried out at a national level to extend coverage. A regulatory framework regarding cybersecurity and privacy should not only be structured, but banking regulations must be modernized to adjust to new systems that have emerged. Additionally, the strategic design of financial inclusion policies is essential to increase the level of access to banking services. At the local level, governments should contribute with flexibility of access to public infrastructure, as well as by promoting initiatives and the implementation of financial inclusion policies and the coordination of digital financial services tests.

Real Estate. The real estate sector is facing an absence of regulations that makes it impossible for companies to install antennas and small cells on a large scale. Federal governments should work together with their local peers in the formulation of a new framework that meets the deployment needs of this new technology. Meanwhile, local agencies will require greater flexibility for access to public infrastructure, in addition to greater dynamism and agility in the delivery of permits for new facilities.

Professional services. Access to professional services in non-urban areas is affected by the poor quality of connectivity in rural areas. This is a fundamental element, and one that creates a clear disadvantage among citizens in large urban areas when compared to the rest of the territory. The availability of intermediate and low band spectrum will generate high-capacity mobile broadband access, reducing that gap. The need to modernize the regulatory frameworks for professional services in order to facilitate the process of digitalization and the incorporation of new technologies into everyday practices should be noted. Local governments may participate, not only by making their infrastructure available, but by generating demand for remote professional services, as well as by training local professionals in the use of new tools, such as virtual reality or augmented reality.

Tourism. The low indoor and non-urban coverage, as well as the limited capacity of current mobile networks, are the most serious barriers in the tourism sector with respect to the incorporation of new technologies. Knowing that tourist areas require a greater degree of security, the lack of definition regarding public safety networks (PPDR) could be included as a factor to consider. As a solution from the federal level, not only the auctioning of intermediate and low bands spectrum is needed to increase coverage and capacity, but also strategic definitions of PPDR networks on which to design protocols in the most important areas under discussion. The work of local governments is essential to identify current and potential areas to develop as tourist hubs. In these areas, they should not only design experiences that incorporate 5G technologies (for example, virtual and augmented reality), but also work to implement security policies that protect visitors.

Entertainment - media and video games. The main barriers are the lack of reliable connectivity and low latency. This impact streaming quality, which is essential not only for VoD platforms but also for gaming platforms, which have grown strongly in recent years. For this, auctions for low and intermediate spectrum bands are required to ensure better indoor coverage and latency reliability. This will be fundamental since the traffic level in this area will increase exponentially, and it is necessary to have a mobile broadband network that supports future demand levels. In addition, the federal government should work on the modernization of the sector's regulatory framework in order to introduce national companies to the global competitive environment. From the local level, governments will be able to work on schemes that encourage the creation of companies dedicated to the generation of this type of content, being on the cutting edge of innovation and generating positive externalities for the community.