U.S.-MEXICO FOUNDATION

Mexico Powered by the Cloud: Inclusivity, Innovation and Growth

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Chapter 1.

General Description of Cloud Services

Cloud computing is, in essence, the on-demand delivery of IT resources over the internet, including servers, storage, data, software, and analytics, through telecommunications networks connections on a pay-as-you go model.[1]

Cloud computing has many advantages over traditional on-premises IT resources, with the following five outlining why the adoption of cloud services has grown rapidly in the last few years:

1. Cloud computing has large economies of scale on IT infrastructure and software operating costs. Much of these are passed on to users, translating into lower overall costs.

2. Cloud services can be accessed from anywhere, providing there is a sufficiently good connection (usually broadband), and that the user has a compatible access device (e.g., mobile phones, tablets, laptops, and workstations).

3. For any given user, IT resources can rapidly be adjusted to changing needs (also known as rapid elasticity[2]). This allows for a better use of resources as there is no need to build or hire capacity for peak demand that goes unused most of the time. This also reduces unmet demand for services based on cloud platforms, as demand at the peak will not be postponed or go unattended. All of this contributes to lower costs and higher productivity.

4. Cloud services are always offered as the latest version. Hence, they allow users to access cutting-edge technology and software seamlessly, without the need to spend time and resources on updating. Thus, the service operates at its best for everyone and not just for the few that can pay a premium to become early adopters.

5. Capital expenditures are replaced by operating expenditures. Upfront investments are minimized, and costs are incurred on a pay-as-you-go basis to reflect actual usage.[3] This translates into lower market entry barriers and increases the depth of the potential market.

1. In this paper we will adhere to National Institute of Standards and Technology cloud computing definition: "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."
2. NIST defines rapid elasticity as "Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time."
3. Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service.

Cloud computing is changing the way computers and other IT resources are used. The concept is not new; many older systems worked in a similar way. Mainframe computers were commonly accessed on-site or remotely via "dumb terminals," whose only role was to provide the physical interface. All the computing power, the systems, and the software resided elsewhere. For remote access without dedicated links, users accessed the mainframe through a modem connection. In the late 90s, with the popularization of the internet, and more so with the advent of broadband, many providers started experimenting with the concept of "applications service provider" (ASP). This was software or a platform that could be accessed remotely as it did not reside on the "customer premise equipment" (CPE), which at the time were mostly personal computers. However, ASPs did not become as widespread as originally envisioned, among the main reasons being bandwidth was not enough to support a good customer experience. It took a few more years for cloud services as we know them today to take off; the first large commercial cloud service was launched in 2006. Today, the technological conditions – software, hardware, and telecommunications networks – are ripe enough to allow cloud services to flourish.

Cloud computing services are usually grouped into three broad categories[4], based on the degree to which IT resources are outsourced from the client to a cloud computing service provider (CSP): [5]

Infrastructure Model

The Infrastructure as a Service (IaaS) model is known as the "least managed" of the cloud computing services. IaaS customers rent infrastructure (computers, servers, storage capacity), which then is accessed through network connections. The CSP manages and controls the infrastructure, but the customer deploys, runs, and manages the operating systems and anything built on top (i.e., software, applications, and data).

Platform Model

The Platform as a Service (PaaS) model allows customers to buy access to underlying infrastructure (IaaS) and operating systems. Clients deploy consumer-created or acquired applications developed using programming languages and have control over the deployed applications and software. It sometimes includes the possibility of controlling configurations settings for the application-hosting environment.

Service Model

The Software as a Service (SaaS) model provides customers with access to software and applications hosted in the cloud; however, they do not manage or control any of the underlying infrastructure or the software. These types of services can be bought either directly to a CSP or through a third party which owns or resells the software. SaaS is mostly licensed through recurring payments (e.g., monthly fees) in combination with a secondary fee based on consumption (a two-part tariff).

4. Minjae Song. "Trends and Developments in Cloud Computing and On-Premise IT Solutions." Brattle Group, December 2021.
5. The three most prominent public cloud computing providers are Amazon, Microsoft, and Google. Many large, traditional IT firms also participate in the cloud computing industry, including Dell, Oracle, and IBM.

With respect to who has access to a given cloud, these can be private (exclusive use by a single organization), public (accessible to the general public), a community cloud (accessible to a group of organizations that are bound together by some agreed-upon criteria), as well as hybrid. Many different combinations of users, elements, and providers have emerged, so definitions and categories are not clear-cut.[6]

Regardless of the model or environment in which cloud services are deployed, these services are being widely adopted by businesses, governments, and individuals. Cloud adoption strategies, including the extent of roll-out and number of providers, depend on the specific considerations at play for each of these users. These include security and confidentiality, make vs buy considerations, economies of scale, demand load curves, and regulatory and compliance issues.

What is undeniable is that the adoption of cloud services is bound to accelerate. A Harvard Business Review survey of 750 C-level business leaders in 2020 found that 20% to 30% of work was being done through the cloud, although they planned to accelerate this to around 80% over an 8 to 10 year period[7]. Some analysts see this shift happening sooner as a result of the COVID-19 pandemic and its effect on consumption and working trends[8,9]. The latest survey carried out by Flexera found that 66% of companies had higher cloud usage than predicted a year before.[10]

It is worth highlighting that, as this report is being written, there is no specific regulatory regime for cloud computing services. Cloud service providers usually are only subject to certification rules, privacy and use of personal data regulation, antitrust, and general business rules. Nevertheless, sectorial rules might apply for the use of cloud services depending on if a particular regulation applies to the costumer utilizing the service (e.g., financial institutions).

6. For this document, we will concentrate on the benefits of a public cloud, i.e., the case where multiple unaffiliated costumers share computing resources at a remote data center managed by the CSP.
7. Bhaskar Ghosh and Karthik Narain, "What CEOS Need to Know about the Cloud in 2021," Harvard Business Review, May 3, 2021, https://hbr.org/2021/03/what-ceos-need-to-know-about-the-cloud-in-2021.
8. In the context of COVID-19 pandemic, businesses and governments had to shift, practically overnight, from working in an office and with technology on-premises to working remotely. Cloud computing was used to ensure business continuity (including in educational institutions) through the pandemic as the cloud's elasticity to scale capacity up and down quickly helped millions adjust to these difficult circumstances. The same happened for remote operations in government and government services. Cloud will continue to be important as we transition into a new normal as hybrid learning and work schemes are part of a new normality.
9. According to McKinsey & Company in "The Next Normal Recovery Will be Digital" (20202) during the COVID-19 pandemic, consumers and businesses adapted to the digital world to a degree that what was expected to take 5 years.
10. "2022 State of the Cloud Report," Flexera, 2022, https://www.flexera.com/about-us/press-center/2022-state-of-the-cloud-report-by-flexera.

Chapter 2.

Potential Impact of Cloud Services on Economic Growth

Cloud Computing is considered to be one of the most disruptive technologies. It has allowed ecosystems to be fully digitalized rapidly and affordably, extending the most modern versions of hardware and software to small enterprises. Additionally, it opens access to cutting-edge IT resources, on demand, and without the need for significant capital expenditures. These direct cost reductions contrast with the traditional corporate IT infrastructure that can be underutilized due to over-provisioning and is expensive to build and operate. Cloud computing's widespread deployment is bound to have a profound impact on how business is done and how telecommunications are used.

Cloud computing is expected to have a positive impact on economic growth, although "at this stage, there is still a lack of data to thoroughly assess the economic impact of cloud computing on the economies (...) One of the main challenges is that data on the different cloud services is currently not available and not even retrievable from annual reports of cloud computing providers.[11] " Despite this lack of information, it is easy to understand why the use of cloud computing is clearly a vehicle to reduce the digital divide, democratize leading-edge IT solutions throughout the economy and the population, and promote innovation and productivity, all of which have a positive impact on economic growth.[12]

Cloud computing unlocks growth opportunities for small and medium sized enterprises (SMEs), which are an important source of economic growth and job creation.

Cloud computing provides a unique means for organizations and consumers to access powerful computing resources at a low cost. In terms of upfront IT investments, users of cloud services do not have to build up their own server infrastructure, nor do they have to invest significant amounts of capital in IT infrastructure and software as in the past.[13] These two aspects are particularly relevant for SMEs, many of which would otherwise face cost and technology barriers to use the best available IT resources to enter a market and operate.

Cloud computing promotes democratization in the latest computing technologies.

By leveraging cloud computing solutions, users benefit from gaining access to cutting edge technology and services, including software updates. The economics of cloud computing virtually eliminates the gap between those who can make the major capital investment required to access and update the latest computing technologies and those that cannot.

11. "Cloud Computing: The Concept, Impacts and the Role of Government Policy", OECD iLibrary (OECD, August 19, 2014), p. 15.
12. For examples on how cloud services support gains in productivity, reduction of costs, agility to adopt new technologies. and the monetary value of these gains, ncluding Big Data, Artificial Intelligence, and IoT for some Latin-American organizations see Amazon Web Services report on "The Business Value of Amazon Web Services (AWS) for Latin American Organizations" (2019).
13. In particular, Software as a Service (SaaS) allows companies to consume all software services they need without having to create the software themselves, often paying through a predictable subscription model, and saving themselves from having to write new code.

Cloud computing is a platform for innovation in the development of new products and services.

Businesses are increasingly using cloud computing to develop new and improved products and services. This trend is taking place in sectors such as entertainment, manufacturing, insurance and banking, retail, telecommunications, healthcare, education, and government. With most of the IT already taken care of by a CSP, innovations can be built into and powered by cloud services, leaving entrepreneurs to focus on building their core operations. Additionally, entrepreneurs have instant on-demand access elasticity in computer power and storage capacity to scale for testing environments and on costumers' segments, geography, and channels. Internet of Things (IoT), GPS tracking, artificial intelligence, and machine learning, combined with data analytics and open-source information, are all cloud-driven. New and enhanced analytical techniques for improving performance, predicting demand, identifying clients' needs, and forecasting climate catastrophes, amongst other activities, are also cloud powered. [14]

In a study, McKinsey & Company argues that the value of adopting cloud technology by far transcends IT savings. It estimates that more than $1.2 trillion dollars stands to be made just for Fortune 500 companies, and that almost all that value comes from business innovation and optimization rather than IT cost reduction. Specifically, $430 billion could come from potential cost savings from the optimization of IT developments, IT infrastructure investments and maintenance, and from having access to the latest technological advances. The remaining $770 billon comes from innovation driven growth, accelerated product development, and scalability.[15]

Cloud computing can help reduce the digital divide.

A key challenge to digitalization is ensuring that all citizens enjoy the same opportunities and benefits from it. For this to happen it is important that all members of the community have access to the network, and services and content provided through the internet, as well as the skills and tools to manipulate technology and benefit from technological advances. We can see this effect in greater detail through the following mechanisms:

- Cloud computing fosters the need for more and better networks, yielding more investment and broadband penetration, with a positive impact on gross domestic product (GDP) growth. While all existing studies in the matter probably overestimate the impact of this trend, they all point in this direction.[16]

- Cloud computing lowers access costs, boosting affordability for end users. This is particularly true regarding the unserved or underserved, with content, apps, and services in general. Also, there are new models of financial, education, and health services that use telecommunications and technology powered by the cloud, such as delivering healthcare services outside of traditional facilities.

- Cloud computing also reduces the digital divide among countries. Cloud services can be accessed from any country, as long as there are no restrictions on internet access and cross-border data flows. Thus, they eliminate an international barrier to the consumption of cutting-edge computing resources.

14. The main providers of cloud services constantly introduce new IT services, including a variety of services related to artificial intelligence, blockchain services, IoT, encryption services, and others.

15. For examples on how cloud computing adoption can unlock value for businesses oriented in using technology as a core part of their business models, see Exhibit 2 in McKinsey & Company's "Cloud's Trillion-Dollar Prize Is up for Grabs" in the February 2021 McKinsey Quarterly ediion.

16. See, for example, Qiang, C. Z. & Rossotto, C. M. (2009). "Economic impacts of broadband in information and Communications Development 2009: Extending reach and increasing impact", 35-50, Washington, D.C.: World Bank.; Waverman, L. (2009). "Economic impact of broadband: An empirical study". London: LECG.; Koutroumpis, P. (2009). "The economic impact of broadband on growth: A simultaneous approach." Telecommunications Policy, 33, 471-485; IDB (2012) "Socioeconomic Impact of Broadband in Latin American and Caribbean Countries." Antonio García Zaballos & Rubén López-Rivas. Technical Report No. 471. http://www20.iadb.org/intal/catalogo/PE/2013/11427.pdf.

With cloud computing, the public sector can save on resources and use these savings to deliver better government services, healthcare, education, and public safety, amongst others, in a more equitable manner.

Similar to the impact on businesses, the move from traditional IT hardware and software to cloud services can also help governments free themselves from outdated, inefficient, and slow technology processes. At the same time, the pay-as-you-go model serves public enterprises and governments well, particularly those with tight budgetary restrictions. For example, the U.S. Accountability Office in 2019 recognized that several federal agencies had increased usage of cloud computing, acknowledging benefits and in some cases cost savings, although data on this needed to be better tracked.[17]

In light of the COVID-19 pandemic, governments around the world also increasingly recognized the benefits of cloud-based technologies. This was driven by the urgency to carry out certain activities (primarily in health-tech, education, and other basic services) and respond to the increased demand for certain services.

Cloud technology has also helped authorities integrate technology and data into public services, which is becoming more critical as they explore digital modernization. A report from the McKinsey Global Institute on digital services defines that the migration to digital public services is an imperative to deliver higher quality costumer experiences.[18] This creates less time-consuming digital interactions with governments, accessibility 24/7, and reduces administrative burdens. It is also true that many smart-city's initiatives need to run in the cloud as they need to be analyzed in real time, such as parking services, cloud empowered Wi-Fi hot spots, and security cameras.

Cloud computing and climate change.

Cloud computing is expected to have an overall positive environmental impact, mostly due to significant economies of scale, although this is still an on-going discussion as positive and negative effects on the environment can be observed.

Cloud computer providers host their infrastructure in data centers.[19] These vary in size, but all contain racks of servers and data storage systems, as well as infrastructure to keep the facility properly cooled, secured, and connected to the internet. The main impact of cloud computing on the environment is the vast amounts of electricity required to power the servers and keep them cool. Data centers accounted for between 1% and 2% of global electricity demand in 2020. [20]

Demand for cloud computing will only continue to grow globally. At the end of 2020, 597 hyper-scale[21] data centers were in operation (39% in the US, 10% in 22 China, 6% Japan), up by almost 50% since 2015. [22] There will be a pressing need to install more of these centers around the world, and thus increase pressure on the demand for electricity. This goes hand-in-hand with the need for water, which is not only used for on-site

17. "Agencies Have Increased Usage and Realized Benefits, but Cost and Savings Data Need to Be Better Tracked." GAO, April 2019.
18. Matthias Daub et al., "Digital Public Services: How to Achieve Fast Transformation at Scale," McKinsey & Company (McKinsey & Company, July 15, 2020), https://www.mckinsey.com/industries/public-and-social-sector/our-insights/digital-public-services-how-to-achieve-fast-transformation-at-scale.
19. A Data Center is an installation that houses the electronic equipment necessary to run a network of computers, servers, and applications that provide the infrastructure to support services offered.
20. Masaō Ashtine and David Mytton, "We Are Ignoring the True Cost of Water-Guzzling Data Centers," GCN (GCN, October 20, 2021), https://gcn.com/cloudinfrastructure/2021/10/we-are-ignoring-the-true-cost-of-water-guzzling-data-centers/316441/.
21. There is no agreed-upon definition of "hyperscale data center". The most cited definition was put forth by International Data Corporation (IDC), which defines a data center as "hyperscale" when it exceeds 5,000 servers and 10,000 square feet (1,000 squared meters).
22. "Microsoft, Amazon and Google Account for Over Half of Today's 600 Hyperscale Data Centers" (Synergy Research Group, January 26, 2021), https://www.srgresearch.com/articles/microsoft-amazon-and-google-account-for-over-half-of-todays-600-hyperscale-data-centers.

cooling, but also linked to the power plants that generate the electricity that powers data centers. Although, if cloud services are imported, that is, hosted in one country and consumed in another, the demand for electricity and water, which is local in nature, does not exist.

In terms of its positive impacts, large and relatively new server farms of cloud service providers have the potential to process data in a highly energy-efficient manner. For example, Google claims that while the amount of computer processing at its data centers increased by 550% between 2010 and 2018, the amount of energy consumed grew by just 6%.[23] Amazon Web Services also reported that it is 3.6 times more energy efficient than the median of surveyed enterprise data centers in the U.S. [24] Furthermore, cloud computing is a major enabler of both home and remote working, reducing the need for commuting and therefore decreasing emissions. Finally, as stated above, the over- provisioning of IT infrastructure can be avoided at the business and government level. As a result, cloud computing helps address energy inefficacies by reducing excess capacity.

23. Urs Hölzle, "Data Centers Are More Energy Efficient than Ever," Google (Google, February 27, 2020), https://blog.google/outreach-initiatives/sustainability/data-centers-energy-efficient/.
24. "Energy Transition," Amazon (AWS), accessed May 24, 2022, https://aws.amazon.com/es/energy/sustainability/.

Chapter 3.

Cloud Computing Adoption Enablers

Cloud computing can become an engine for economic growth and improve living standards for everyone. As the range of cloud computing applications grows, adoption will become more widespread. However, the pace of adoption by individuals, businesses, and governments, and the economy in general, is not straightforward, as it depends on demand and supply issues.

Supply Side Enablers

Broadband Connectivity

Cloud service providers can only offer quality services if these are supported by a well-functioning broadband network in terms of upload and download speeds, stability, and latency.[25] Several cloud computing services require high bandwidth and low latency to work properly. Some of these issues have been solved with distributed networks and content delivery networks (CDNs), which help bring content closer to users, not only reducing latency but also decreasing the need for long-haul capacity. It should be noted, though, that speed is capped at the weakest link. This is usually found in the last-mile connection, which is usually a bottleneck.

Latency is of the utmost importance for synchronous uses and for applications that require a constant flow of data. Video streaming requires low variability in latency, as large variations in this parameter will make the video stop. Voice, videoconferencing, gaming, and certain financial transactions (e.g., trading) require very low latency, as time delays in communication make them almost unviable. New applications, such as autonomous cars, remote surgery, and remote monitoring, require extremely low latency. Banking and retail servers could also be sensitive to the latency rate if the number of transactions per second is high.

Electricity and Water

Another important element to consider with cloud technology is the energy required at the location where the infrastructure is deployed. Cloud computing equipment needs to be "always on." This requires an uninterrupted flow of electricity, redundancy, and other energy backups (emergency generators). The probability of a power outage must be minimal at the place where cloud services are hosted.

Although the amount of energy cloud computing and data centers will use in the future is still a debatable issue, there are no doubts that the energy required to keep systems running is high and growing. As previously stated, data centers accounted for between 1% and 2% of global electricity demand in 2020. In the same line, an EU report estimated that in 2018 the energy consumption of data centers in that region was 76.8 TWh, equivalent to 2.7% of total demand.[26] To put this number in perspective, Mexico's total electricity consumption was 397.47 TWh in 2020. [27] In other words, the EU's data center's energy consumption in 2018 accounted for almost one-fifth of Mexico's total electricity consumption in 2020.

25. Latency is a synonym for delay. In telecommunications, latency is an expression of how much time it takes for a data packet to travel from one designated point to another. Thus, low latency is associated with a positive user experience.
26. Montevecchi et al., "Energy-Efficient Cloud Computing Technologies and Policies for an Eco-Friendly Cloud Market" (Publications Office of the European Union, November 26, 2020), https://op.europa.eu/en/publication-detail/-/publication/.
27. "Mexico," IEA, accessed May 25, 2022, https://www.iea.org/countries/mexico.

Energy consumption arises from the need to keep the equipment running, as well as for data storage and transmission. As the equipment produces heat, energy is also required for cooling, which accounts for around 40% of energy consumption of the data center. In a typical data center, this energy goes into cooling water, which is either sprayed into air flowing past the servers or evaporated to transfer heat away from them. The U.S. Department of Energy estimates that every kWh consumed in a data center requires almost 25% additional water than the water used for its production.[28]

Individual Cost/Benefit Considerations

Individual cloud computing adoption requires a cost-benefit analysis. The potential for cost savings is one of the main reasons why businesses have adopted cloud computing solutions. For certain uses, such as computing- intensive analytics and storage backup, hosting costs can indeed be reduced with the cloud. Additionally, benefits from cloud computing adoption, such as scalability and flexibility without having to incur in large upfront capital expenses, are other main drivers for firms. This is particularly the case for growing firms.

What is the cost-benefit case of using cloud computing?[29]

Costs	Benefits
Security: Perceived concerns of business when choosing to adopt a cloud solution is potential data loss, data privacy, and confidentiality.[30]	**Cost savings:** Customers can derive cost savings from both technical features and the payment model of cloud.
Latency: Customers access the cloud through a network, often the internet, which potentially introduces latency issues, a delay between the consumer's request and a CSPs response. In certain sectors, even low latency can have a significant impact on a consumer's experience.	**Availability:** Employees can access data and applications wherever there is an internet connection. The cloud enables employees to work simultaneously on a project.
Legacy IT capital costs and operating costs: On-premises computing solutions, including costs related to the purchase (or rental) of physical space for servers, the cost of acquisition of hardware and software, maintenance of physical space, software and hardware, licensing software, and administration costs such as IT personnel, are usually an important consideration.	**Scalability and elasticity:** Scaling up on infrastructure to support increasing demand (versus an upfront investment in hardware) over time or revising down in response to workload changes is simple, as it is an intrinsic characteristic of the cloud.
Restrictive software licensing: Certain legacy software providers, those vertically integrated, could prohibit the use of their software on a CSP not operated by the software provider.	**Innovative features from cloud providers:** Artificial intelligence and machine-learning modules and more state-of-the-art, resilient and reliable technology, are readily available in the cloud.
Switching cost: The price of migrating from traditional on-premises to the cloud include moving data (staff fees to oversee the migration, costs charged by the CSP throughout the migration) and setting up the cloud environment could be high, and the process could be disruptive to on-going operations.	**Bundled costs:** Direct cloud computing costs include those associated with the network (data egress and ingress, data storage, capacity, computation, and maintenance).

28. Arman Shehabi et al., "United States Data Center Energy Usage Report," United States Data Center Energy Usage Report (Technical Report) | OSTI.GOV, June 1, 2016, https://www.osti.gov/servlets/purl/1372902.

29. For more details on each of these cost and benefits, see "Trends and Developments in Cloud Computing and On-Premise IT Solutions." Brattle Group, December 2021.

30. Cloud service providers invest heavily in security. Although their investments do not provide a 100% guarantee against cyberattacks, because of their economies of scale versus an individual investment, they do offer their clients a comprehensive set of the latest security measures together with redundancies and back-up infrastructure. It should be considered that organizations will also need to invest in individual security tolls such as network firewalls, automatic encryption of its traffic, and configured accesses to protect their cloud workloads.

Data Hosting and Data Localization Laws

Cloud computing is rapidly accelerating the amount of data that is transferred and stored across borders. Nevertheless, some countries have put policies in place that restrict cross-border data flows. Governmental reasoning for such regulations relates to national security, protecting personal data and privacy in line with their own national laws and regulations, and reducing the flow of data that could compromise national public order. In some instances, obstacles to cross-border data flows have been accompanied by regulation on geographic data localization, requiring data to stay in and be processed at a particular jurisdiction. As data centers tend to exist in areas that are cost effective for CSPs, there could be regulatory constraints on firms from moving their workload to the cloud for remote storage and data processing. [31]

Additionally, for regulated industries, such as financial services and healthcare, legal specifications regarding the use of technology and outsourcing of services (such as cloud computing for data storing purposes) could also become an obstacle to adopting this technology.

31. According to a 2021 study by Harvard's Belfer Center on sovereignty and data localization, the increasing adoption of data localization laws has been driven by the fear that a nation's sovereignty will be threatened by their inability to exert full control over data stored outside their borders.

Chapter 4.

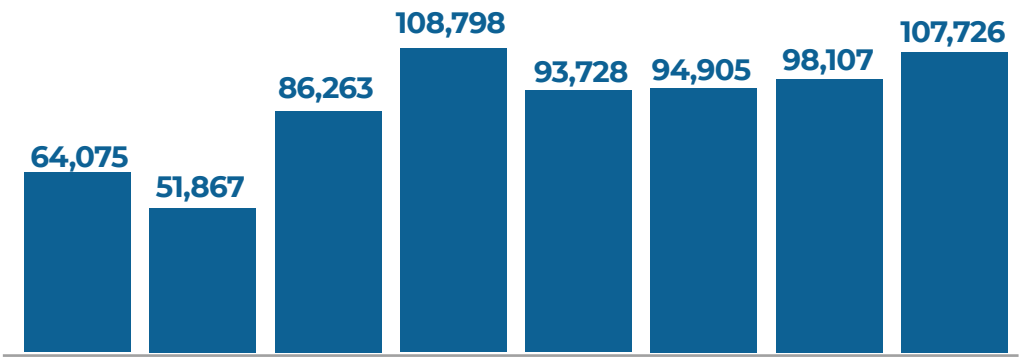
Cloud Computing Services Adoption Enablers in Mexico

Mexico is following the international trend of cloud computing adoption. In this section we look at the stage of internet adoption and how it is used, as well as other factors that could accelerate or hinder cloud computing adoption in the county.

Investment in Telecommunications

Mexico has never invested enough in telecommunications to have a state-of-the-art network. Since 2013, investment in telecommunications has been constant at around $5 billion dollars per year, equivalent to around $40 dollars per capita, roughly at 40-60% of OECD countries.[32] Nevertheless, this has not stopped a constant increase in the number of internet users and appropriation, as shown in the next two sections.

Chart 1. Investment in Telecom Networks in Mexico
(in Millions of Pesos)



	2013	2014	2015	2016	2017	2018	2019	2020
Investment per capita (in USD)	**42.4**	**32.5**	**44.8**	**47.4**	**40.0**	**39.4**	**40.2**	**39.2**

Source: BIT, IFT (consulted in May 2022)

Of the 2,454 municipalities in the country, approximately 25% of them do not have access to broadband.[33] One of the reasons for this is precisely the lack of investment in fiber optic networks. This, in part, is due to the difficulty of laying down said infrastructure. The set ofprerequisites, uncertainty of the red tape process and the tariffs involved in securing the necessary rights of way to install the networks can relegate any work as being too costly. Whether through underground ducts or aboveground via poles, or even from radio bases (towers, radios, antennas) for wireless services, such complications can freeze an installation project indefinitely. [34]

32. See, for example, "Estudio de la OECD sobre políticas y regulación de telecomunicaciones en México", OECD, 2012, https://www.oecd.org/centrodemexico/49528111.pdf.
33. With information from the IFT portal, last updated in June 2021.
34. "Recomendaciones que emite el Consejo Consultivo del Instituto Federal de Telecomunicaciones en la regulación de derechos de vía como habilitador de la construcción de infraestructura de fibra óptica" (2017).

A number of authorities at different levels of government are responsible for granting these permissions and setting such fees. Authorizations could come from authorities at the municipal, state and federal level, depending on who is in charge of the necessary rights of way. Moreover, there is no public information on the fees for these authorizations. Nor is there a public registry of all already ducts that telecommunication cables could pass through, or its availability on the different highways in the country.

Internet Access

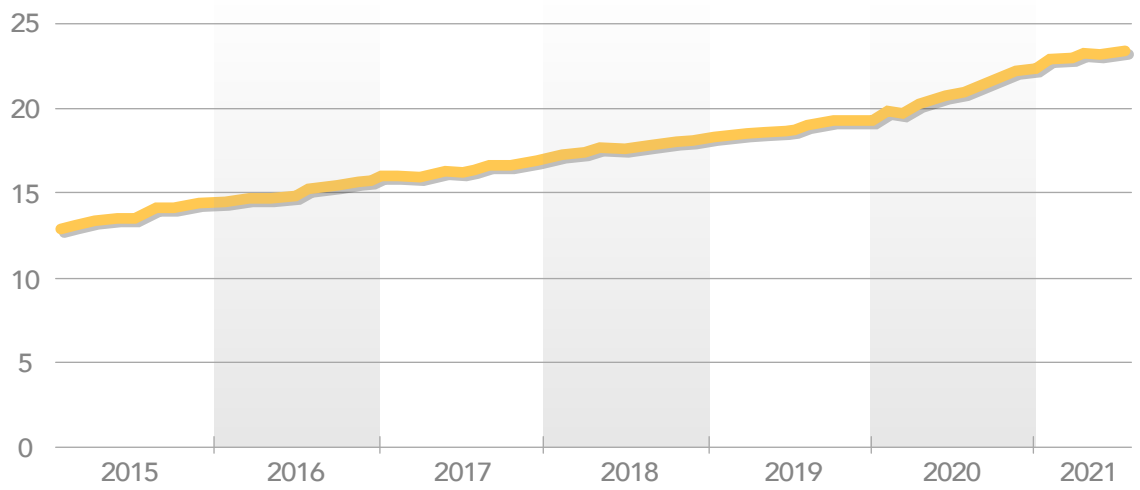
The number of internet users in Mexico has grown exponentially in recent years. As elsewhere, the internet is accessed through both fixed and mobile networks, which complement each other depending on availability, reach, and cost.[35]

Having grown at an annualized rate of 11.6% since 2015, the installed base of fixed broadband accesses has reached 23.3 million.[36] During 2020, probably reflecting the effects of the pandemic and lockdown, 3.1 million accesses were put into service. That is equivalent to an accelerated annual rate of 16.3%. Growth has since returned to single digits.

Four providers account for more than 97% of the market.[37] According to IFT, 45.7% of these accesses are optic fiber, up from 24.5% at the end of 2019. In the same period, satellite access technologies started making inroads, growing only from a few thousands accesses to more than 480,000 subscriptions by 2021.

Household penetration stands at around 66%, up from 55% before the pandemic. Uptake varies significantly by state. Baja California and Nuevo Leon have a household penetration of 89%, while Mexico City has 108%.[38] In contrast, Chiapas and Oaxaca have 24 and 28 accesses per 100 households, respectively.

Chart 2. Broadband Access Lines
(in Millions)



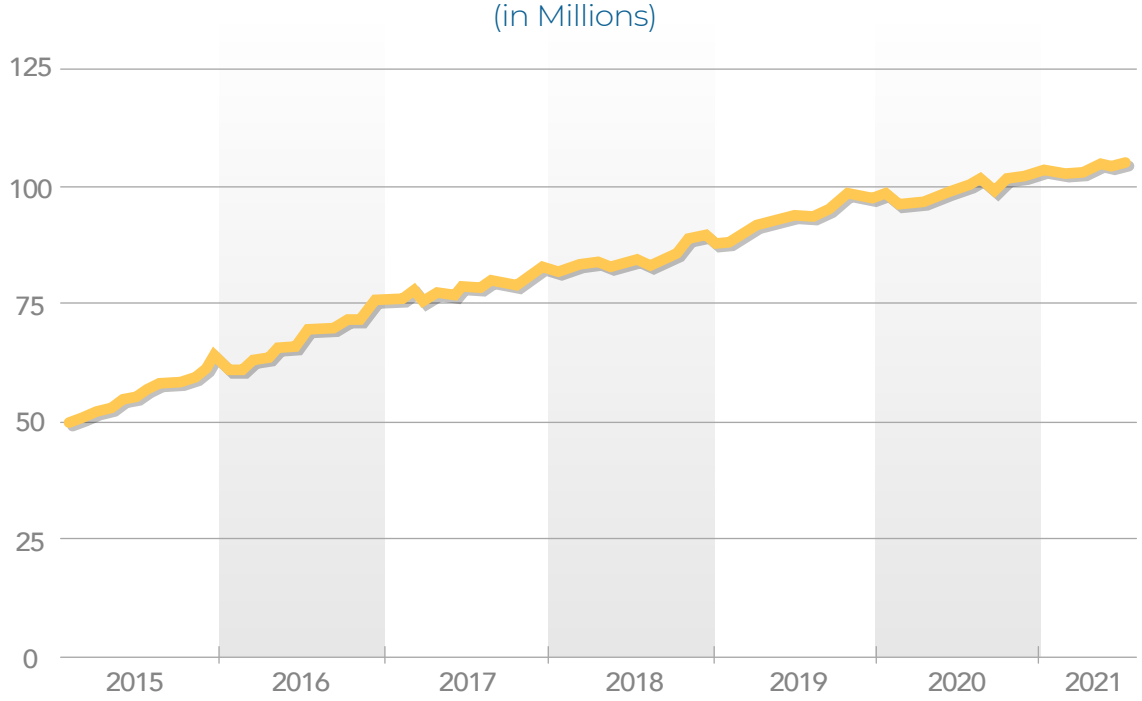
Source: BIT, IFT (consulted in April 2022)

35. Regarding network access, the quality of the user experience will depend on, among several factors, the type of connection available. These factors include aspects such as whether the connection is fixed – digital, cable modem, or fiber optics – or mobile. Mobile typically suffers more from higher latency than fixed broadband access.
36. Accesses is equivalent to number of lines and are the sum of household and businesses lines. June 2021 is the latest date for which the IFT has published information.
37. In June 2021, Telmex, Televisa, Megacable, and Totalplay had 42.7%, 26.8%, 14.3%, and 13.1% of market share, respectively.
38. Household penetration is calculated as the number of access lines divided by the number of households. The number of access lines includes business lines.

With respect to mobile internet access, the number of lines in service has reached 104.5 million.[39] That is equivalent to a penetration of around 83%.[40] Contrary to the evolution of fixed broadband, from 2015 to the beginning of the pandemic, annual growth stood at 14.1% but decreased significantly to 4.1% during the pandemic. Net growth has not yet resumed. The first nine months of 2021 saw a meagre growth of 3.1%. The three mobile network operators (MNO) hold a 97.1% market share; the 13 virtual operators (MVNO) have only 3 million lines in service. Penetration varies by state, but not quite as much as fixed broadband. Chiapas and Oaxaca have respectively 43 and 54 mobile internet connections per 100 inhabitants, while Tamaulipas, Sonora, and Baja California have around 100.[41]

Chart 3. Mobile Broadband Access Lines

(in Millions)

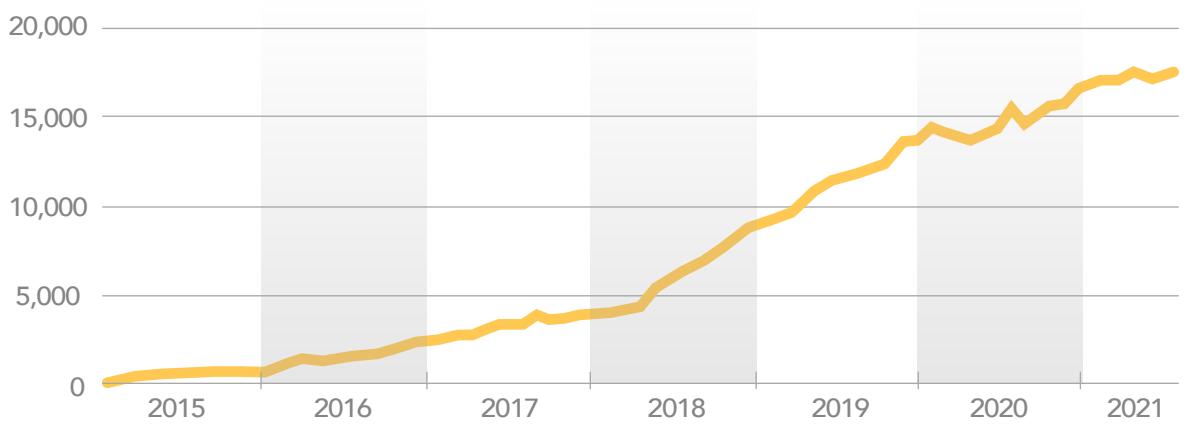


Source: BIT, IFT (consulted in April 2022)

Traffic carried by mobile operators has seen outstanding growth, from only 740 terabytes (TB) per month in 2015, to almost 17,000 TB in 2021.[42] From 2018 until February 2020, traffic grew at an annualized rate of 78.2%, but since the beginning of the pandemic it has slowed significantly to just 16.2%. This may be explained by the lockdown, as people did not leave their homes and traffic was off-loaded to WiFi networks. Fixed networks carry the bulk of traffic, as most high-definition video is consumed in fixed locations and the price consumers pay is based on a monthly fee which is independent of data consumption.

39. September 2021 is the latest date for which IFT has published information.
40. Unless otherwise stated, penetrations are calculated with respect to population.
41. Of these mobile internet accesses, the IFT does not report on the breakdown of connection lines between 2, 3, 4 and 5G. This is the case as internet plans are secured on the base of technology. With the arrival of 5G suppliers have begun to do it differently, though.
42. To put this number in perspective: 1 TB is about 500 hours of movies.

Chart 4. Daily Traffic Carried by Mobile Networks
(in TB)



Source: BIT, IFT (consulted in April 2022)

Internet Use

While penetration statistics present reasonably accurate numbers, how much and for what purposes the internet is used is much harder to measure. INEGI, the Mexican statistics bureau, publishes an annual national survey on the use of ICTs by individuals and households.[43] The latest survey dates from August and September of 2021, thus capturing many changes brought about by the COVID-19 pandemic.

Appropriation is a diffuse term which can go from just measuring internet users to how the internet is used.[44] As elsewhere in the world, the internet has become widespread in Mexico. At the end of 2021 there were approximately 88.6 million people accessing the internet (75.6% of population), up from 62.5 million (57.4%) six years earlier. More than 89% of users access the internet daily.

Smartphone penetration has grown much faster than the number of connections, due to the renewal of handsets, the fast-approaching disappearance of feature phones, and the substantial decrease in prices. Having a broadband connection at home is important, as costs are incurred monthly instead of on a per-usage basis. Data carried by mobile operators can still be expensive and not fast enough, so off-loading to a WiFi network allows for a more intensive usage at a negligible marginal cost. A mobile internet connection is not a perfect substitute for a fixed connection.

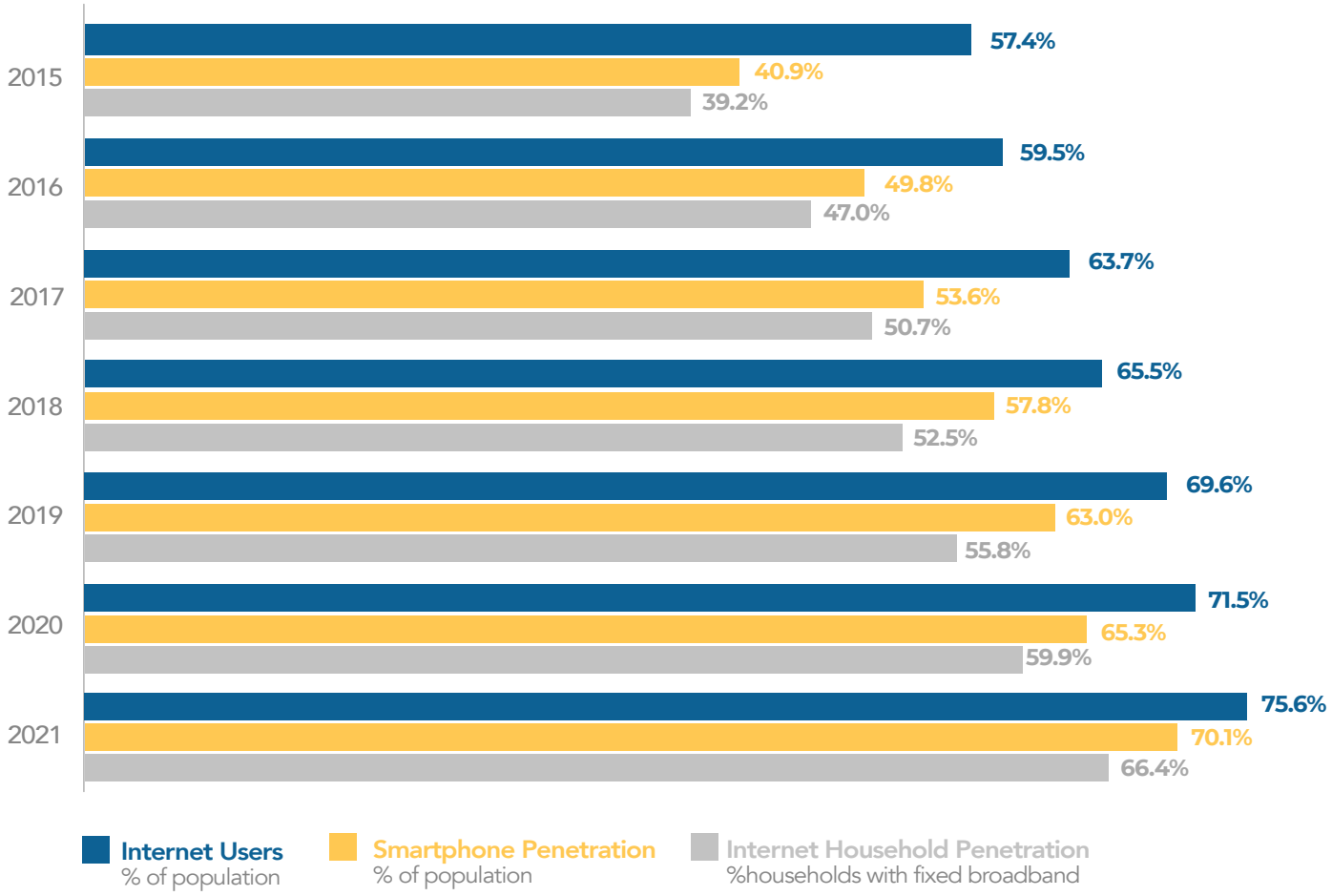
Internet household penetration has reached over 66% (24.3 million households).[45] The number of connected households increased by 1.8 million per year on average from 2015 to 2021, three times as much as the increase in the number of households (Chart 5). The growth trend accelerated significantly during the lockdown, as almost 3 million additional households subscribed to an internet service.

43. ENDUTIH – National Survey on the Availability of Information Technologies in Homes. All surveys carried since 2015 were consulted. As of 2021, INEGI revised the expansion factors with its most recent population estimates and updated the ENDUTIH figures for the period 2017-2020. The 2015 and 2016 surveys will be updated during the fourth quarter of 2022. For additional information, see https://www.inegi.org.mx/programas/dutih/2021/

44. For example, if the person has accessed the internet recently. The ENDUTIH defines as an "internet user" as persons 6 years or older that have used the internet in the last three months.

45. These results come from a survey of households, which means over 60% households responded that they have an internet connection. It does not compare directly to the penetration measure reported by IFT, which divides the total number of lines (including business lines) by the number of households.

Chart 5. Appropriation Statistics in Mexico



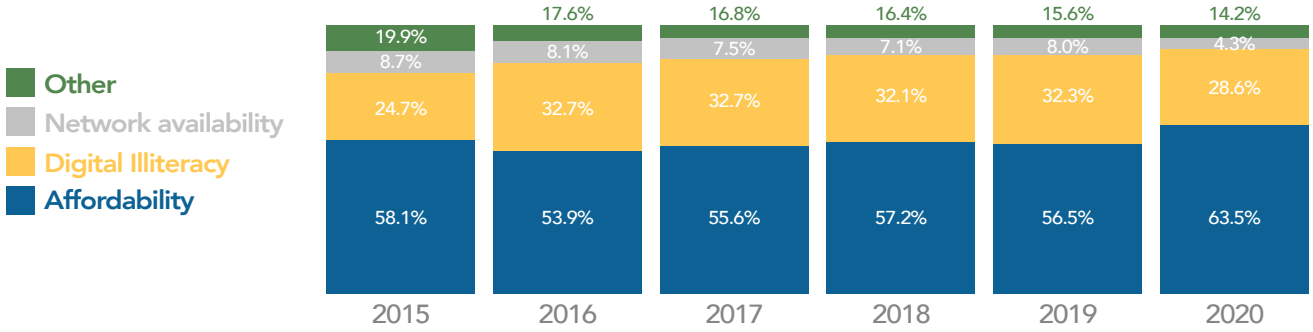
Source: INEGI (ENDUTIH 2015, 2016, 2017, 2018, 2019, 2020, 2021), accessed directly at INEGI (www.inegi.org.mx)

Affordability, digital illiteracy, and network availability (coverage) are the main roadblocks to higher internet penetration (Chart 6). Affordability is seen as the main barrier. More than 60% of Mexican households that do not have a fixed internet connection cite economic reasons for not subscribing to the service. The absolute number – around 9 million households – has barely budged in the last 5 years.

Year after year digital literacy has been increasing, though only marginally. The number of households indicating that they do not need an internet connection or that they do not know how to use the internet has decreased by around 250,000 per year over the same period. Another point of consideration is network availability. Only 4.3% of non-internet households cite this as a problem, a figure that has halved in five years. At this point in time, only 1.7% of households in Mexico cite coverage as a reason for not having a broadband connection.[46]

46. It should be highlighted that lack of coverage probably substantially affects the almost 9 million households that do not have an internet connection because of affordability. However, this conclusion cannot be drawn from the ENDUTIH surveys.

Chart 6. Main Reasons for Not Having an Internet Connection at Home



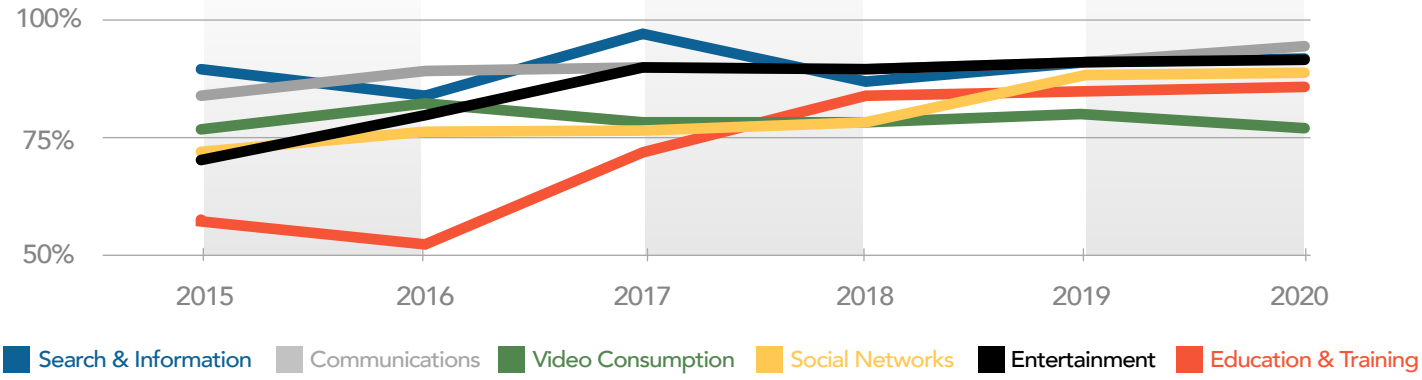
% of households without fixed internet	60.5%	53.0%	49.1%	47.1%	43.6%	39.4%

*These numbers have not been updated with the 2021 ENDUTIH survey
Source: INEGI (ENDUTIH 2015, 2016, 2017, 2018, 2019, 2020), analyzed from metadata; authors' analysis

The economic value of the internet can be observed from how it is used. It should come as no surprise that the five main activities –information searching, communications, entertainment, video consumption, and social networking – are carried out by 80 to 90% of users in Mexico. Internet use for education merits special mention. The absolute number of users of such content has doubled in five years to over 71 million users and has now reached a level of penetration similar to that of the other most popular uses of the internet.

Chart 7. What the Internet is Used For?

% of Internet Use



*These numbers have not been updated with the 2021 ENDUTIH survey
Source: INEGI (ENDUTIH 2015, 2016, 2017, 2018, 2019, 2020), accessed directly at INEGI (www.inegi.org.mx)47

A clear trend that has emerged is users are starting to feel more at ease with using the internet. Other activities, like shopping, making payments, banking, and selling through the internet, all of which require trust from users, have substantially increased in penetration in the last few years. The user base for these first three activities has more than tripled over the last five years, an indicator not only of trust but also of how simple it has become to transfer money using the internet (Chart 8). Selling through the internet is making inroads for smaller economic units, individuals, and micro enterprises who are now using the internet to offer their products and services; this increases their potential market substantially.

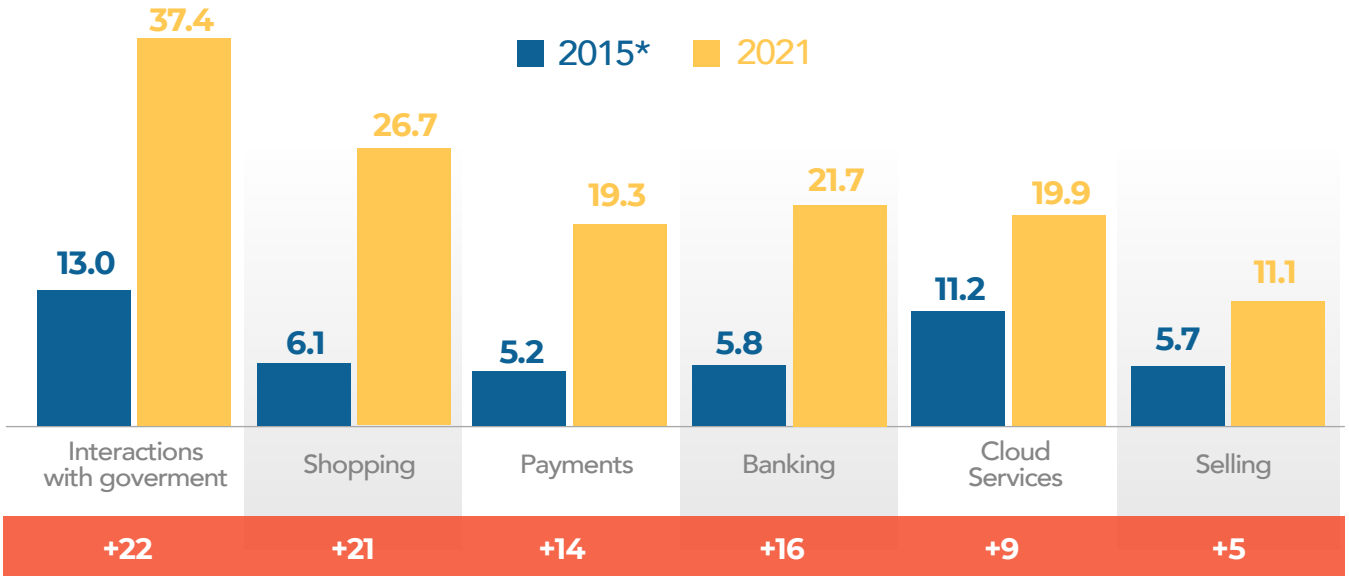
47. Digital illiteracy comprises those who responded that they do not need it, that they do understand its value, and that they do not know how to use it.

Finally, the internet is facilitating how citizens interact with their governments. This requires not only trust and digital literacy but also that governments embrace e-government services. According to INEGI, the number of people that interacted with the government through the internet increased to 54.5% in 2021 from 32.4% two years earlier.[48,49] It should be highlighted that all these services are commonly powered cloud, so more intensive use can only be satisfied with more cloud services.

With the growing importance of the use of cloud services, INEGI, in its ENDUTIH survey, since 2018 has included the option of "accessing cloud services" as a reason for using the internet. Although many users do not know they are accessing cloud services while using certain services and applications such as their email, almost 20% responded this was an activity they carried out, 9 percentage points higher than four years earlier. We believe that in this survey cloud services are commonly understood as a means of accessing software that has not been downloaded (like word processors and spreadsheets for data analysis) or platforms that allow for content and data to be stored and shared with third parties.

Chart 8. Increase of Users in Other Internet Services

Millions of Users



* 2017 for Cloud Services and Selling; most recent figure for Payments is 2020

Source: Authors' analysis based on INEGI. Endutih 2015, 2016, 2017, 2018, 2019, 2020, 2021.

Internet Use by Mexican Businesses

For businesses, internet appropriation remains very uneven. Although national penetration stands at only 20.7%, this statistic hides stark differences (Chart 9). Of Mexico's 4.78 million "economic units," which we refer to as businesses in this document, only 240,000 have more than 10 employees; in many cases, those with less than 10 employees are either independent workers or family groups working as a single unit.

48. "The main type of interaction is for a government procedure. These figures, which were taken from "Encuesta Nacional de Calidad e Impacto Gubernamental (ENCIG) 2021)", are not comparable with ENDUTIH for methodological reasons.

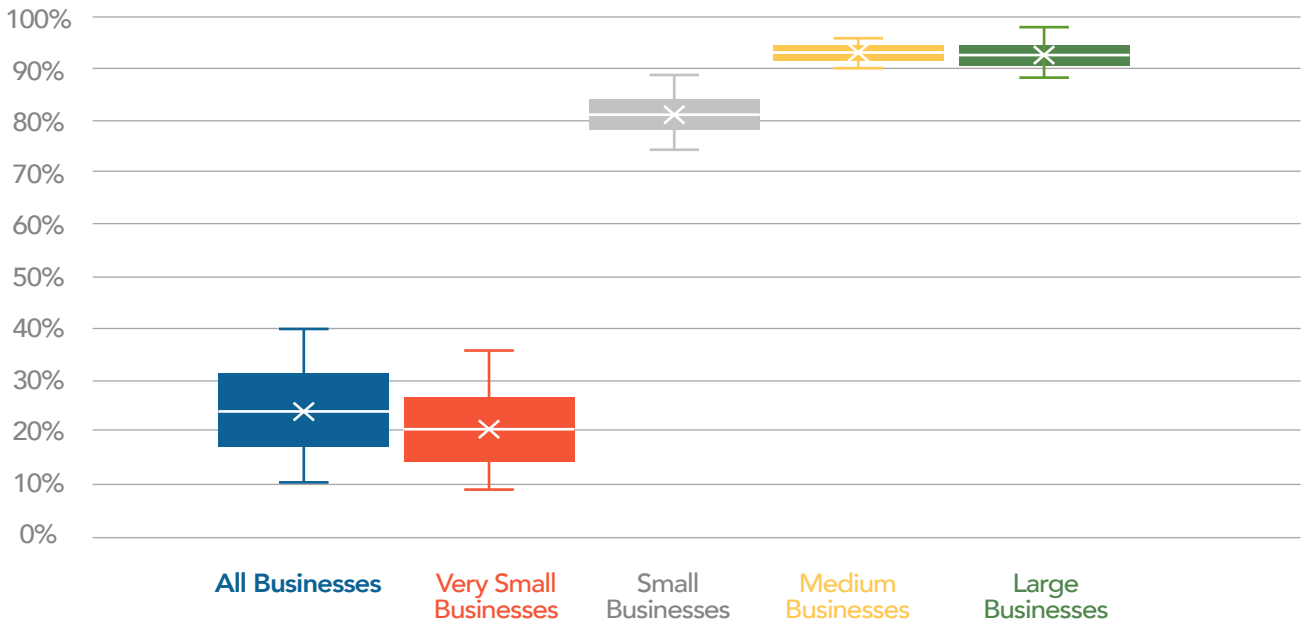
49. INEGI. (May 2022). "Encuesta Nacional de Calidad e Impacto Gubernamental (ENCIG) 2021)".

More than 93% of businesses with more than 50 employees use the internet, but this penetration drops to 81.5% for businesses that have more than 10 but fewer than 50 employees. For very small businesses, with 10 or fewer employees, penetration is a meager 17.4%.[50]

Penetration does not vary significantly by state for businesses with more than 10 employees, but the discrepancies among very small businesses are huge. In Baja California Sur, Baja California, and Quintana Roo, slightly more than 30% of very small businesses are connected to the internet, but it drops to only one in 10 in Guerrero, the State of Mexico, Oaxaca, and Chiapas.

Chart 9. Internet Penetration by Size of Business

Variation by State[51]



Source: Authors' analysis based on IFT. "Anuario estadístico 2021"

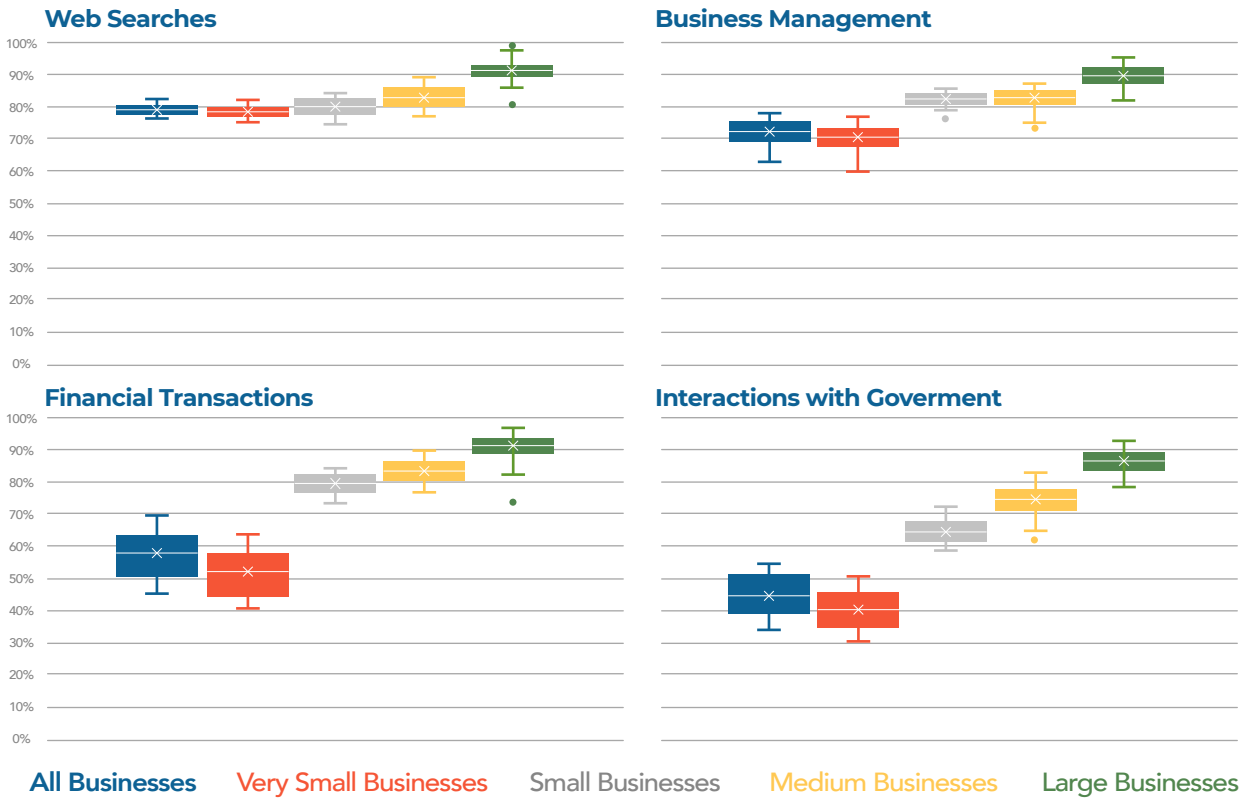
Overall, independent of the state and the size of the business, more than 80% of connected businesses use the internet to search for information. On-line tools to assist in managing the business are also widely used; however, there is a 10-percentage point difference between very small businesses (around 70%) and the rest (over 80%). Conducting on-line financial transactions is also common among businesses with more than 10 employees (more than 81%), with more than 9 out of 10 large businesses using the internet for such purposes. Low banking penetration in Mexico probably explains why conducting financial transactions on-line is low among very small businesses. Where appropriation still lags is in interaction with government institutions. Only 4 in 10 very small businesses use it for such purpose. The gap between small businesses (66.1% penetration) and very large businesses (88.8%) is still large.

50. IFT reports these penetrations on a yearly basis in its Statistical Yearbook (Anuarios Estadísticos | Instituto Federal de Telecomunicaciones - IFT). We have analyzed the data since 2015. According to the published statistics, there has been very little change in penetration in the period 2015-2021. That is, the IFT reports that national penetration has increased from 19.1% to 20.7% in 6 years. For very small businesses it has increased from 16% to 17.4%; for small businesses, from 81.0% to 81.5%; for medium businesses, from 92.0% to 94.0%; for large businesses, it has decreased from 94.0% to 92.7%. We believe there could be an error in these figures, the fault probably arising from the methodology used. Thus, we do not show the evolution nor base our conclusions on such data. For the purposes of this report, we assume the data presented for 2021 is correct.

51. Each boxplot shows the penetration for all 32 states. The range is shown by the extremes of the whiskers of the plot, except when the observation is considered an outlier, such as small businesses in Guerrero (8.8% penetration) and large businesses in Colima (80% penetration).

Chart 10. Use of the Internet by Businesses

By Size of Business and Variations by State



Source: Authors' analysis based on IFT. "Anuario estadístico 2021"

Services currently used by small businesses are less cloud dependent than those used by individuals, but as adoption grows and certain processes become more IT intensive (e.g., payroll, tax compliance, sourcing), together with the growing need to have an own domain and web page, business use of the cloud should become more intensive.

Digital Literacy

The term "literacy" typically refers to reading and writing skills, although on the digital front, it has come to encompasses a broader range of skills. For example, from reading content in a webpage, sending a text or a post on a social media network, to more sophisticated skills to manipulate technology like gauging the validity of a website, creating and sharing digital content, or even developing code. The term has become so broad that some experts prefer to speak more specifically about particular skills at the intersection of technology and literacy. For the purposes of this document, we divide this term into three categories as a way of assessing digital literacy within the Mexican population:

- The basic skills needed to use a computer and the internet in daily life. This includes listening to music online, checking emails, social media messaging, and searching on- line to answer basic questions.

- Skills beyond finding and consuming digital content to creating and manipulating it for more productive purposes. For instance, writing and manipulating basic data in digital formats (word processors, spread sheets) and creating other forms of media such as podcasts, videos, and blogs. Usually, these skills require sufficient reading/ writing, math, and science skills beyond primary school.

- More sophisticated skills and re-skilling over the previous acquired digital skills, for emerging and developing technologies like artificial intelligence and data science. Skills such as programming and writing code, data analysis and machine learning, require an even more comprehensive understanding of the digital world.

As shown in Chart 6, approximately 28.6% of households indicate that they do not have an internet connection because they do not need, do not know how to use it, or do not understand its value. This is an approximate of the number of households that are fully digital illiterate.

About 88 million Mexicans use internet.[52] Of those, data shows that 80% to 90% of them use it for information searching, communications, entertainment, video consumption, and social networking (see Chart 7). So, we can estimate that around 72% of the total Mexican population over 5 years possess at least the basic skills required in category 1 of digital literacy.

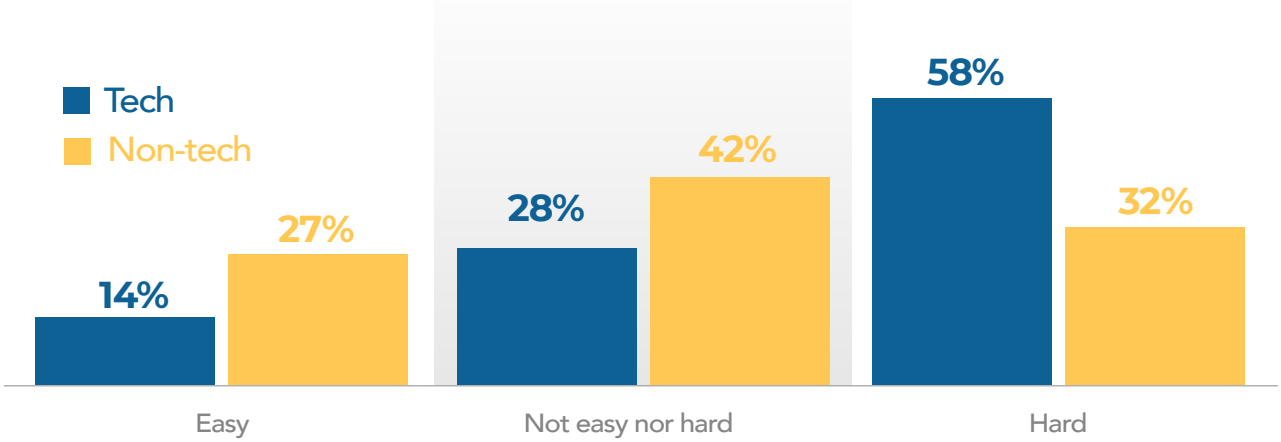
According to PISA, the standardized international test conducted by the OECD to 15-year-old students worldwide, Mexico is lagging with respect to the rest of the world, ranking 54th, 61st, and 57th in reading/ writing, math, and science skills, respectively, out of the 75 countries evaluated in the 2018 edition.[53] If sufficient reading, writing and math skills beyond primary school are needed be digital literate past category 1, this is a structural problem that needs to be addressed urgently.

Finally, it is often-cited that 24,000 engineers graduate every year from Mexico's university system.[54] There are approximately 1.48 million employed engineers,[55] of which 52% are directly linked to the ICT sector.[56] Despite having access to this yearly pool of potential ICT professionals for some of the emerging and developing technologies they still will require extra training. There is no data available or a proxy measure to gauge the level of appropriation of these more sophisticated types of skills in the Mexican population; however, they have (and will have) the highest employment demand. This is especially the case as technologies such as cloud, IoT, and AI become ubiquitous across industries.

In this same line, country managers of digital startup companies in the region describe that(1) hiring local talent is the main challenge for expanding their businesses, and (2) that technology roles are the most difficult to fill. [57, 58]

52. INEGI 2022 , Enduirh 2021.
53. OECD (2018). Program for International Student Assessment (PISA).
54. Universia (www.universia.net) , citing CANIETI (Cámara Nacional de la Industria Electrónica, de Telecomunicaciones y de Tecnologías de la Información).
55. Includes mathematics
56. Secretaría del Trabajo y Presión Social (2022). Observatorio Laboral (OLA). www.observatoriolaboral.gob.mx
57. "Latin America Digital Transformation Report 2021." Atlantico, September 22, 2021.
58. "Soft Landing in Latin America." Endeavor Review, 2022.

Chart 11. Difficulty in Hiring Employees for Technical Roles



Source: Latin America Digital Transformation Report 202i, Atlantico

What is true for these types of more sophisticated skillsets is that only a "small" proportion of the working force will need to obtain them (to program, for example), although it is imperative to understand that in order to fill this growing demand gap, these digital skills cannot be acquired if the more basic ones are not previously met. This takes place in the primary and secondary years of education and get polished and enhanced at university or a technical school.

Fast-growing Digital Start-up Environment

The aforementioned accelerated adoption of digital technologies in Mexico has created new business opportunities for fintech, e-commerce, edtech, SaaS companies, adtech, and other technology-enabled sectors. This, along with an unprecedented growth in venture capital, has created an extraordinary start-up boom in Mexico and in Latin America.

Latin Americans are the number one adopters of social platforms in the world. Smartphone penetration in the region is at nearly 60%, positioning Latin America as the third largest smartphone base globally behind China and India.[59] With the second largest population in the region, Mexico boasts the second biggest market in Latin America behind Brazil. In contrast to Brazil, Mexico stands out as an entryway to the US and shares a common language with the rest of the region.

Indicative of this growing start-up ecosystem, Mexico's venture capital investments were valued at $3.8 billion dollars in 2021, growing more than threefold from the previous year. In 2016, this figure was equivalent to just $56 million.[60] Mexico has since seen the creation of seven tech unicorns. Kavak, Mexico's first unicorn company, is a second-hand car platform that has expanded its operations to Argentina, Brazil, Colombia, Peru, and Chile, as well as outside of the region to Turkey.[61] Additionally, Mexico is a top

59. Social network users as a percentage of internet users: Latin America 88%; Central & Eastern Europe 86%; Asia Pacific 85%; North America 73%. "Latin America Digital Transformation Report 2021", Atlantico, November 2021.
60. "Soft Landing in Latin America." Endeavor Review, 2022.
61. "Unicorn" is defined as a private tech company valued at $1 billion or more. Other Mexican unicorns are Clip (Fintech), Bitso (Fintech/crypto), Konfio (Fintech), Clara (Fintech), Merama (E-commerce), Incode (Biometrics ID and authentication).

destination for expansion from other Latin American startups. The number of unicorns in the region has nearly doubled every year since 2018, from 4 to 26 in 2021.[62] Fintech accounts for 40% of all venture dollars in this territory, although financing has also moved to the e-commerce and delivery space, marketplaces for truck services and other products and services, even real estate. All these startups are commonly powered cloud.

The expansion of diverse new online platforms has also given rise to other tech-based businesses, like logistics companies and digital payments. When evaluating expansion throughout the region, these start-ups evaluate whether the destination country has the inputs and operational partners, such as payment processors, suppliers, and cloud technologies suppliers, that their products and services need.[63] Speed and scalability in their IT capabilities are critical for digital start-ups whose business models depend on their capacity to collect, store, and process data.

The Mexican Government's Digital Agenda and Policies Around Cloud Computing

The main challenge of any government with respect to technological change is how to promote its use in the economy to remain globally competitive. For this to happen, governments need to work on relevant actions to maximize the social and economic potential of ICT, such as a strategy to develop digital inclusion, to promote and ensure the best quality possible of the broadband network infrastructure, and to extend connectivity for both fixed and wireless broadband across the country. Also, governments should implement policies to advance digital skills in the workforce, to accelerate e-government services, and to promote the use technology to offer basic services to the population such as in health and education. Of note is the adaptation of regulatory and legislative frameworks for the new technological trends and the legal backing for these government strategies to be adopted. All these efforts are normally charted in a country's digital agenda.

Last year, Mexico published a document entitled National Digital Strategy ("Estrategia Digital Nacional 2021 -20224"). Its objective is to promote (1) the use of technology by government to offer better services and (2) broadband access. Thus, it consists of two initiatives; one related to federal government IT spending as sourcing of these resources should be centralized, the other related with fostering internet access by using a recently created government company, CFE Internet para Todos, which operates the fiber optic network of the electric utility.[64] This is not really a comprehensive digital agenda. In this sense, a recent analysis from CEPAL indicates that out of the 27 countries in Latin America and the Caribbean, 16 have a standing digital agenda that is being implemented. Meanwhile, there are 11 who need to develop such an agenda or that the latest version should be updated. This is the case of Barbados, Ecuador, Haiti, Honduras, Nicaragua, Venezuela, and Mexico.[65]

62. "Latin America Digital Transformation Report 2021", Atlantico, September 2021.
63. "Soft Landing in Latin America." Endeavor Review, 2022.
64. September 2021, available at https://dof.gob.mx/nota_detalle.php?codigo=5628886&fecha=06/09/2021#gsc.tab=0.
65. "Tecnologías digitales para un nuevo futuro." CEPAL, 2022.

On the other hand, the real success of any digital agenda or strategy depends on several institutional and organizational factors. These are linked to the establishment of strategic priorities, the multisectorial coordination of the policies that are to be implemented, and the financing of projects. Also, it is necessary to establish the mechanisms for measuring and monitoring the plan, as well as a clear definition of who will coordinate and follow through.

In Mexico, the National Digital Strategy Coordination Office in the Office of the Presidency is the federal government agency designated as responsible for the planning process for the development of the national digital strategy, including public policy actions in information technology, telecommunications, and digital government (responsible for preparing the government's digital agenda), although it is not clear that it has the legal and budgetary resources to coordinate such an effort. There is also no known methodology or series of indicators that allow for an objective and transparent measurement of the evolution of the digital economy and the impact of government actions to narrow the digital divide.

With respect to the adoption of cloud computing, several governments have acknowledged that cloud technology is a key enabler in the transition to improved e-government services. With this in mind, they have introduced cloud-first policies (also known as cloud enabled, cloud preferred, and cloud native), that is, a path towards helping direct efforts to the implementation of cloud technology by the government.[66]

As established, the adoption of cloud computing, be it a business or a government agency, is based on a strategic assessment of its costs and benefits. In the case of the public sector, some of the issues that need to be resolved, and which are usually part of the cloud computing government adoption plans, are:[67]

- **Accreditation, compliance, and security in the cloud:** Governments need to ensure the quality of the cloud services that are used. This ties to national and international cloud- accreditation systems to assess potential CSPs. Also, as some governments have put in place restrictive regulations (e.g., data localization), these need to be factored in.

- **Setting data classification standards:** This implies implementing a data classification framework that allows for different types of data to be managed differently. Governments need to mandate the classifying of the different data they handle according to their level of sensitivity, and then provide guidelines for their storage in the cloud.

66. To cite some cases, in the United States in 2019 there was an update in its cloud computing strategy from Cloud First to Cloud Smart, as a "long-term, high-level strategy to drive cloud adoption in Federal agencies", "to drive savings, to improve security, and to deliver mission-serving solutions faster". In the United Kingdom there is Government Cloud First Strategy, for Australia the National Cloud Computing Strategy and Colombia, the Nube Primero policy. A more recent example is the South African Government. In June of 2021 it published the Draft National Data and Cloud Policy in an effort to move "towards a data intensive and data driven South Africa" that ensures social and economic development and inclusivity.

67. More details can be found in Thomas Abell, Arndt Husar, and Lim May-Ann, "Cloud Computing as a Key Enabler for Digital Government across Asia and the Pacific," Asian Development Bank, June 2021, https://www.adb.org/sites/default/files/publication/707786/sdwp-077-cloud-computing-digital-government.pdf.

- **Security issues:** Governments establish and adopt complementary security and data processing and privacy policies, which overlap with existing international standards. This supports a successful transition to the cloud and complements the security efforts of CSPs.

- **Public procurement policies in the cloud:** Governments design and establish new public procurement frameworks, as tender contracts must allow payment models based on usage, which are common in the provision of cloud services. It is a move from a capital single expenditure model to a utility-based expenditure one. Updating such policies may require legislative changes.

- **Adoption plan:** This includes details on their intended migration and implementation approach. For example, the UK and the Australian Cloud First policies state that organizations should evaluate a cloud solution before considering any other option. Other actions involve creating an interoperable ecosystem and the sharing of cloud computing infrastructure among agencies.

Regardless of the pros and cons of the different countries' strategies, Mexico is lagging behind others in the world and in Latin America, as it has not yet implemented any policies focused on "cloud first."

Mexican Regulations Related to IT Outsourcing Services

As previously stated, some countries have introduced data policies that restrict the use of the data collected by third parties for different economic purposes, including where this data is to geographically reside. With the latter, such regulations keep data within defined territorial limits of jurisdictions or even within certain designated facilities. At least partially, the idea behind this is to minimize cybersecurity risks and to establish operational stability and business continuity in the event of a contingency in some regulated sectors.

Mexico is one of the three countries that are signatory to the United States-Mexico-Canada Agreement (USMCA), that came into force on July 1, 2020. The USMCA is a substitute of the North America Free Trade Agreement (NAFTA) of 1994. A key highlight within this new agreement is a chapter on digital trade (Chapter 19). Within said chapter, there is a specific provision that relates to cloud computer services.

For the purpose of the USMCA, a "computing facility" is defined as "a computer server or storage device for processing or storing information for commercial use". Article 19.12 of the agreement establishes that, "no party shall require a covered person to use or locate computing facilities in that party's territory as a condition for conducting business in that territory". In essence, signatory governments cannot impose a local territorial restriction on the data center localization of a company. In terms of Mexican bylaws, the Constitution, together with federal laws and international treaties, are the supreme law. Therefore, the USMCA forms part of domestic law, meaning that it is directly applicable to federal, state and municipal authorities.

At the national level, the transfer, processing, and contracting of cloud computing services is covered by Federal Law on the Protection of Personal Data Held by Private Parties. Article 52 establishes the minimum requirements to be met by those responsible for holding and in charge of processing personal data. These are those individuals (*sujetos obligados* in the law) who collected the information. Cloud Computing service providers are seen as managers of the data.[68] As such, they also have obligations with respect to the handling of personal information that is provided to them under their capacity as managers.

In addition, Mexico's data protection authority (INAI), in conjunction with the Ministry of Commerce, has issued non-binding guidelines for cloud computing migration and risk management regarding data handling, with the objective of establishing the minimum considerations for those responsible for choosing and contracting cloud services, to better guide their individual decisions.[69] This guide recognizes that cloud computing services goes beyond national borders and establishes that the individual responsible for handling the personal data collected ("the client") should choose a cloud computing services provider that operates under equivalent standards to Mexico's data protection regulations, and, where applicable, that complies with international standards on the protection of personal data.

With reference to regulation on whether data is to reside on national territory, only one explicit restriction was found. It relates to the regulation of financial technology institutions (Fintechs or ITF). Internationally, the financial system is regulated to preserve the resilience of its operations and avoid money laundering. In Mexico, the authorities in charge of upholding the stability of the system are the Bank of Mexico and the National Banking and Securities Commission (CNBV).

In accordance with Article 54 of the Fintech Law, ITFs are allowed to come to agreement with third parties nationally or abroad for the provision of services necessary for their operations. Such services could include areas relating to technological infrastructure, such as servers for storage and the processing of information. In such instances, ITFs are obliged to include in contracts or other formalized service documentation an express stipulation that contracted third parties have accepted and are subject to supervisory surveillance by the CNBV or the Bank of Mexico. In January 2021, new provisions that regulate technology companies came into force.[70] They establish additional requirements for cloud storage. Provisions include a series of general obligations for fintech's regarding operational contingencies to ensure business continuity. One such contingency concerns possible interruptions in services provided by third parties. Article 50 of this provision establishes that those who contract an international third-party provider of cloud computing services must include in their business continuity plans a secondary provider in another territory, or else have its own infrastructure to sustain its operations. This obligation only applies to those ITFs that exceed a certain transfer threshold.

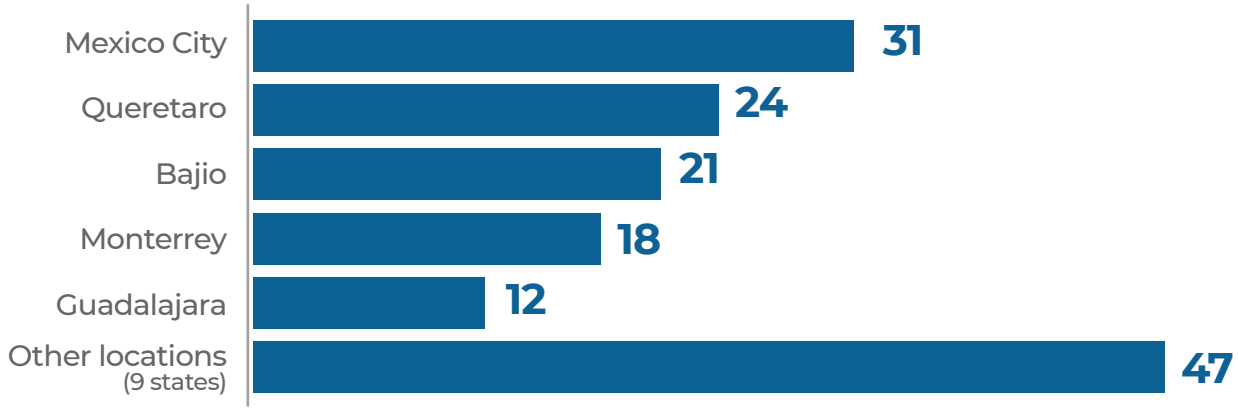
68. Unless the client and the computing service provider are vertically integrated.
69. "Criterios mínimos sugeridos para la contratación de servicios de cómputo en la nube que impliquen el tratamiento de datos personales", available at https://home.inai.org.mx/wp-content/documentos/DocumentosSectorPrivado
70. "Disposiciones aplicables a las instituciones de fondos de pago electrónico a que se refieren los artículos 48, segundo párrafo; 54, primer párrafo, y 56, primer y segundo párrafos de la Ley para regular a las instituciones de tecnología financiera."

This restriction presents a twofold problem of discrimination for certain fintech companies: traditional financial institutions do not have such a restriction nor do smaller fintech's that do not cross the operational threshold established. It could also hinder cloud computing adoption in the Mexican financial sector.

Data Centers

According to CloudScene, there are 153 data centers in Mexico, including very large complexes that host the requirements of more than 23 providers, to single user buildings. At least 10 of them could be considered hyper-scale. These data centers are concentrated in 5 regions within in Mexico: Mexico City, Queretaro, the Bajio region, Monterrey, and Guadalajara. Mexico City and Queretaro are the main locations, but a third of all data centers are spread out throughout other 9 states. Most of them are built to Tier 3 specifications;[71] according to the Uptime Institute, there are only four Tier 4 data centers. The IFT, in its 2020 study on cloud computing in Mexico, notes that the estimated total available data center area is around 250,000 square meters, making it the second largest market in Latin America behind Brazil.[72] According to Arizton,[73] data center revenues reached $632 million dollars in 2021 and could reach $1.1 billion by 2027. More data centers are being built, as reported by public news outlets.

Chart 12. Geographic Location of Data Centers in Mexico



Source: CloudScene

Energy Supply and Electricity Costs

As previously outlined, a reliable power supply is essential for hosting cloud infrastructure. Thus, another challenge is meeting the demand for electricity. In essence, countries that experience intermittent access to electricity will struggle to attract CSPs.

Between 2013 and 2014 Mexico's electricity market underwent relevant modifications. The goal of these modifications were to secure access to sufficient, cheaper, and clean energy in the years to come. This process of transformation, and the opening up of the electricity industry was centered on the introduction of competition into the generation and commercialization of electricity, by allowing for the participation of private

71. Tier 2 data centers have a single path for power and cooling; the expected uptime is 99.741%. Tier 3 data centers multiple paths for power and colling, redundancies in many components and have an expected uptime of 99.982%. Tier 4 data centers are built with redundancies for every component and provide an expected uptime of 99.995% per year. See "Digital Infrastructure Authority: Tier Certification & Training," Uptime Institute, accessed May 25, 2022, https://uptimeinstitute.com/.
72. "Estudio de cloud computing en México." Instituto Federal de Telecomunicaciones, July 2020
73. "Mexico Data Center Market: Size, Growth Forecast 2022-2027," Arizton Advisory & Intelligence, May 2022, https://www.arizton.com/market-reports/mexico-data- center-market-investment-analysis.

companies in these activities. Competition would promote the installation of the most efficient electricity projects, many of which are based on clean energy technologies. Although system operations and ownership of the transmission and distribution electricity networks remained exclusively reserved for the Mexican state, an independent operator was created to administer the national electricity system. Regulation was established so that access to the grid for different power plants was based on economic criteria, to tap electricity from the cheapest plants until demand is satisfied ("dispatch ladder"). From 2016 to 2021, the opening up of the sector, the creation of an electricity market, and investment in technologies such as solar energy and wind power, allowed for total costs in the system to drop by 30%. Investments reached around 12.5 billion dollars.[74]

However, from 2018 to date there have been a number of regulatory changes that have raised obstacles for a competitive electricity market to function, by ruling or de facto eliminating (1) the non-discriminatory access of any power plant to the grid, (2) the rule of economic dispatch, and (3) the independence of the sectoral regulator. A recent study estimates that the impact of this transformation could increase Mexico's electricity system production costs by up to 31%.[75] These recent changes have also halted investments, particularly with new renewal energy projects. These trends could impact the long-term growth of cloud computing services in Mexico because of:

- Outages and intermittent access to electricity in certain regions in Mexico. News local outlets, for example, reported intermittences in the northern state of Nuevo Leon due to a heat wave and growth in demand of electricity for cooling purposes.[76]

- Difficulty in attracting data center investments in Mexico as CSPs attend to their own cloud sustainability policies.[77]

74. "Impactos de la potencial aprobación de la contrarreforma eléctrica." Consejo Coordinador Empresarial, 2022.
75. This cost increase would be the result of de facto establishing that electricity dispatched into the national system comes from state-owned enterprise power plants (those completely owned and of those with which it has joint venture agreements with the private sector), and for the remainder to be determined by the economic dispatch rule within private generators. See Riccardo Bracho et al, "Impacts Analysis of Amendments to Mexico's Unit Commitment and Dispatch Rules." Power Partnership, January 2022.
76. "Entra Monterrey en alerta eléctrica", Newspaper El Norte, May 4, 2022.
77. For example, Amazon Web Services on powering its operations with 100% renewable energy by 2025. See "Sustainability in the Cloud," Amazon, accessed May 25, 2022, https://sustainability.aboutamazon.com/environment/the-cloud?energyType=true#section-nav-id-0.

Chapter 5.

Potential Economic Impact of a Wider Adoption of Cloud Services in Mexico

ICTs are general-purpose technologies (GPT) that affect an entire economy, and with a durable aggregate impact. GPTs are characterized by their pervasiveness as they are used as inputs by many sectors, by their potential of technical improvements and as innovative complementarities throughout the economy. Productivity in downstream sectors increases as a consequence of improvements of the GPT.[78] Cloud computing has all these characteristics as all types of businesses can use it to improve their processes, driving innovation in almost every economic and social activity. Thus, the correct way of measuring the impact of a generalized "move to the cloud" would be through the evaluation of the impact of its appropriation on productivity and GDP.

As cloud is reasonably new, definitions and data are still not consistent nor comparable, and the time series span a short timeline. With this restriction, an econometric model measuring its impact on productivity or GDP would mostly depend on a large number of assumptions. To bypass these issues, the impact of cloud computing has been estimated, for example, through cost savings, or other economic spillovers, such as on SMEs and jobs creation.

Following this, we estimate some of the potential spillovers of a generalized "move to the cloud" for the Mexican context:

Impact from Cost Savings

Switching Capex for Opex is one of the most evident impacts of cloud computing on businesses. From the governmental side, the national budget (PEF)[79] assigned for ICT spending and investment totals $27.9 billion pesos in 2021[80] and $32.3 billion for 2022. This includes PEMEX and CFE, which are the government entities with the largest amount of ICT spending. Of these amounts, 29% and 27% respectively are set for acquiring servers and other computing equipment. That is, the Mexican government spent $7.73 billion pesos in 2021 and is bound to spend $8.73 billion pesos in 2022 on computational infrastructure. Assuming a modest reduction of between 10% and 20% which would be saved by moving some ICT needs to the cloud, and thus, avoiding capital expenditures, savings would be somewhere in the order of $0.900 -1.700 billion pesos. This is between 0.01-0.02% of the total Mexican Federal Budget. This is somewhat a more conservative figure than the estimated savings from the first US Federal Cloud Computing Strategy. [81]

78. Bresnahan, Timothy & Manuel Trajtenberg, (1995). "General Purpose Technologies 'Engines of Growth?'". National Bureau of Economic Research, Working Paper No. W4148, 1995
79. Presupuesto de Egresos de la Federación, www.pef.hacienda.gob.mx
80. It exercised $26.669 billion pesos, equivalent to about 95% of the budgeted amount. Source: PEF 2021
81. Vivek Kundra. U.S. Chief Information Officer, The White House. (February 8, 2011). "Federal Cloud Computing Strategy".

With respect to the private sector, on the aggregate, businesses in Mexico invest just under 2% of their revenues in ICTs (infrastructure and software) which is equivalent to around $588 billion pesos.[82,83,84] Assuming businesses behave similarly in their allocation of ICT budget as the Mexican government, around 28% of this would go into servers and computing equipment. We would expect businesses to be more aggressive than governments in migrating to the cloud, as they have fewer restrictions and tend to be more agile. Nevertheless, even assuming savings stay within the same range of 10% to 20% as in the government, they could secure $16.5 to $33.0 billion pesos in savings, more than ten times the expected amount from that of the public sector.

Impact on SME Creation

To estimate the impact on business creation, we built a simplified version of the model described by Etro.[85] This is based on the role cloud computing has had in fostering business creation and competition due to the reduction of the fixed costs on entry. As stated, cloud computing reduces entry barriers by reducing fixed costs associated with hardware and software adoption and with general ICT investment, turning those costs into variable costs. Assuming a slow reduction of a 1% reduction in the fixed costs of entry, in the medium term (5 years), we estimate that around 35,000 SMEs could be created. [86]

The Value of the Cloud in Innovation

As previously outlined, McKinsey & Company attributes $1.3 trillion as the value of the cloud in EBITDA run-rate impact by 2030 for 487 companies. Of that, $430 billion come from IT cost optimization (cost optimization of application development and maintenance and IT infrastructure), risk reduction (improved business resilience of the organization), and core- operations digitization (implementation of latest technological/digitization achievements in core operations). The other $770 billion come from innovation-driven growth, accelerated product development, and hyper-scalability.[87] IT cost optimization is the immediate value of the cloud, as the migration model is well-proven and the process to adopt it well- understood. How innovation and growth processes are impacted by the cloud is much harder to estimate, as this is different for every company and industry.

For the purposes of this paper, assuming that businesses in Mexico would reap the sort of benefits of cloud computing as those established in their report, then the cloud would bring in between $1.5 and $3.0 billion dollars per year in the near future. The amount is not negligible, but it does depend heavily on their strategy and how they incorporate cloud computing into their business and R&D models.

82. CitiXsys. (2019). "Global Shopping Trends 2019", cited by Netsdtech (https://netsd.mx/empresas-mexicanas-invertir-tecnologia/)
83. According to OECD data, ICT investment in non-residential gross fixed capital formation is generally between 10% and 20%. The organization does not publish figures for Mexico. 2% of total revenues as published by INEGI (Censos Económicos 2019, which is the last available census) would be equivalent to less than 10% of non-residential gross fixed capital formation. These are estimates which are bound to give rough estimates of impact.
84. INEGI (Censos Económicos 2019) reports 29,416.3 billion pesos of accumulated revenues.
85. It is a standard macroeconomic model augmented with endogenous market structures. which simulates the impact of a gradual reduction of the fixed costs of entry.
86. Our estimates are roughly in the ballpark of Etro's estimates. For the EU 25, his estimates in the medium term are in the range of 83,000 to 431,000 new SMEs, with around a million additional jobs in the region. Nevertheless, they differ substantially from the impact estimated by IMCO in 2012 (IMCO. (2012). "Cómputo en la nube": nuevo detonador para la competitividad de México", sponsored by Microsoft. At the time, IMCO estimated between 1,800 and 9,500 new SMEs and between 63,400 and 330,300 new jobs.
87. Op. Cit.

Chapter 6.

Public Policy Recommendations to Promote Cloud Services in Mexico

The digitalization of the economy is a far-reaching phenomenon in Mexico. As seen, as the economy becomes more digital, so will the adoption of cloud services become more widespread. Mexican governments at all levels – federal, state, and municipal – can play an important role in further spurring the use of cloud computing, which brings about several benefits as has been described in the previous sections. Such efforts include promoting the availability of the underlying infrastructure for quality telecommunications networks at reasonable prices, being lead users, removing unnecessary legal barriers, fostering skills, and securing the IT education needed by its population to participate in the digital economy. At the bare minimum, the Mexican government should work simultaneously on the following fronts:

Government appropriation: Governments should widely adopt cloud services for internal use as well as for its interactions with citizens and businesses. This is fundamental at the federal level, but it is also important at the state and municipal level, as well as other branches of government.

The reasons for this are many. Although the budgetary savings from adopting cloud service are relevant, the most important value will come from the opportunity to innovate. Such a move will not only help governments free themselves from outdated, inefficient, and slow technology processes, but also spearhead the modernization of digital services. Cloud services enable access to the latest technology to build citizen-centered platforms that avoid red tape and bureaucracy and encourage paperless processes. Cloud adoption is also a necessary condition for the transformation of cities into smart cities.

Also, government adoption of cloud computing will have important spillover effects. Firstly, it forces the population to become digitally literate in order to interact with it. Secondly, given the scale of government spending, a commitment to cloud computing signals to the private sector that there are investment opportunities in telecommunications networks, in data centers, and in cloud computing services in Mexico.

As it stands, the achievement of cloud migration and cloud adoption is not so straightforward. In governments' case, apart from IT challenges, its success depends on policies on the treatment of data, procurement, and a commitment to an adoption plan. Therefore, a federal Cloud First Policy is imperative.

Universal connectivity: The federal government needs to promote the deployment of the infrastructure required to ensure the best quality possible for the telecommunications network, and to extend connectivity for both fixed and wireless broadband access to all citizens.

As it has been stated, Mexico has never invested enough in telecommunications for a state- of-the-art network, a precursor for cloud technology development and adoption. With the growth of cloud computing, the demand for bandwidth is expected to increase significantly. The quality of internet connections is also an important factor for some cloud powered technologies. It is important for networks to be able to operate at high upload and download speeds and with low latencies.

Policy makers should take steps to help accelerate broadband infrastructure deployment. This is specifically significant for fiber optic, by eliminating roadblocks to foster private investment and competition in local and long-haul markets, as well as in international connectivity. At times these difficulties are from local authorities as is the case for newer telecommunications companies that need to take their fixed networks to clients' homes (i.e. build their own last-mile networks). For a number of reasons local authorities are not incentivized to grant permission for the rights to deploy networks.

The Mexican Antitrust Agency has recommended developing a program with federal budgetary incentives for those states that prepare and put in place plans to promote investment in network deployment. Also, the federal government should use the power of its National Council for Better Regulation to impose improvement and standardization on local rules regarding infrastructure installation.[88]

Digital skills: It is fundamental to develop digital skills in the population. This not only includes basic digital skills, but also promoting policies for education programs that constantly evolve workforce skills to keep up with emerging trends.

Education attainment determines labor market possibilities, as an individual and for a country. If the Mexican population does not have the digital skills needed to manipulate technology for productive activities, the country will not reap the benefits of such a digital trend. Likewise, the country will not be able to fill the shortage of workers and match the required skills with their respective new technology. Thus, these job opportunities will go elsewhere. Finally, it also becomes impossible to further train workers on manipulating emerging technologies. This is a structural problem that needs to be addressed. Digital skills should be part of the education curriculum starting in the early years of primary education.

One way to walk this path is accelerating the digitalization of education, by making more content and learning activities available in the classroom with technology. This could entail significant investment in technology. However, this project could benefit from cloud computing finance schemes in a pay-as-you-go model to finance projects of this type.

88. Article 17, I and 18 of the Ley General de Mejora Regulatoria.

For reskilling and promoting the adoption of the skills needed to manipulate emerging technologies, the public sector should endorse educational programs in collaboration with universities, technical schools, private businesses, and technology providers. Such parties play a role in enhancing skills-development initiatives. These efforts can go from formal education programs on technology-based skills development at public institutions, to subsidizing private skill training programs and certifications. In particular, building advanced skills in areas of artificial intelligence and data science would allow public and private organizations to fully take advantage of cloud technology.

Digital Agenda: All previous recommendations, including cloud first policies, should be part of a Digital Agenda for Mexico.

As developed previously, an agenda of this type should charter the country's commitment to broadband network infrastructure, policies to advance digital skills in the workforce, accelerate e-government services, among other efforts for Mexico to keep up with the new technology developments. Along with a Digital Agenda, the Mexican government must choose and commit - for a long enough time period (20 years) – to an institutional framework to coordinate and oversee such efforts, as well as the mechanisms and indicators for measuring and monitoring advancements.

Energy policies: To attract cloud infrastructure investments, specifically in the installment of data centers in Mexico, it is critical that the Government develops policies to address growing demand in electricity. This can be done by fostering investment in the electric network system, in new green energy generation projects and pursuing a competitive electricity marketplace.

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