THE 360° ON DIGITAL TRANSFORMATION IN FIRMS IN LATIN AMERICA AND THE CARIBBEAN

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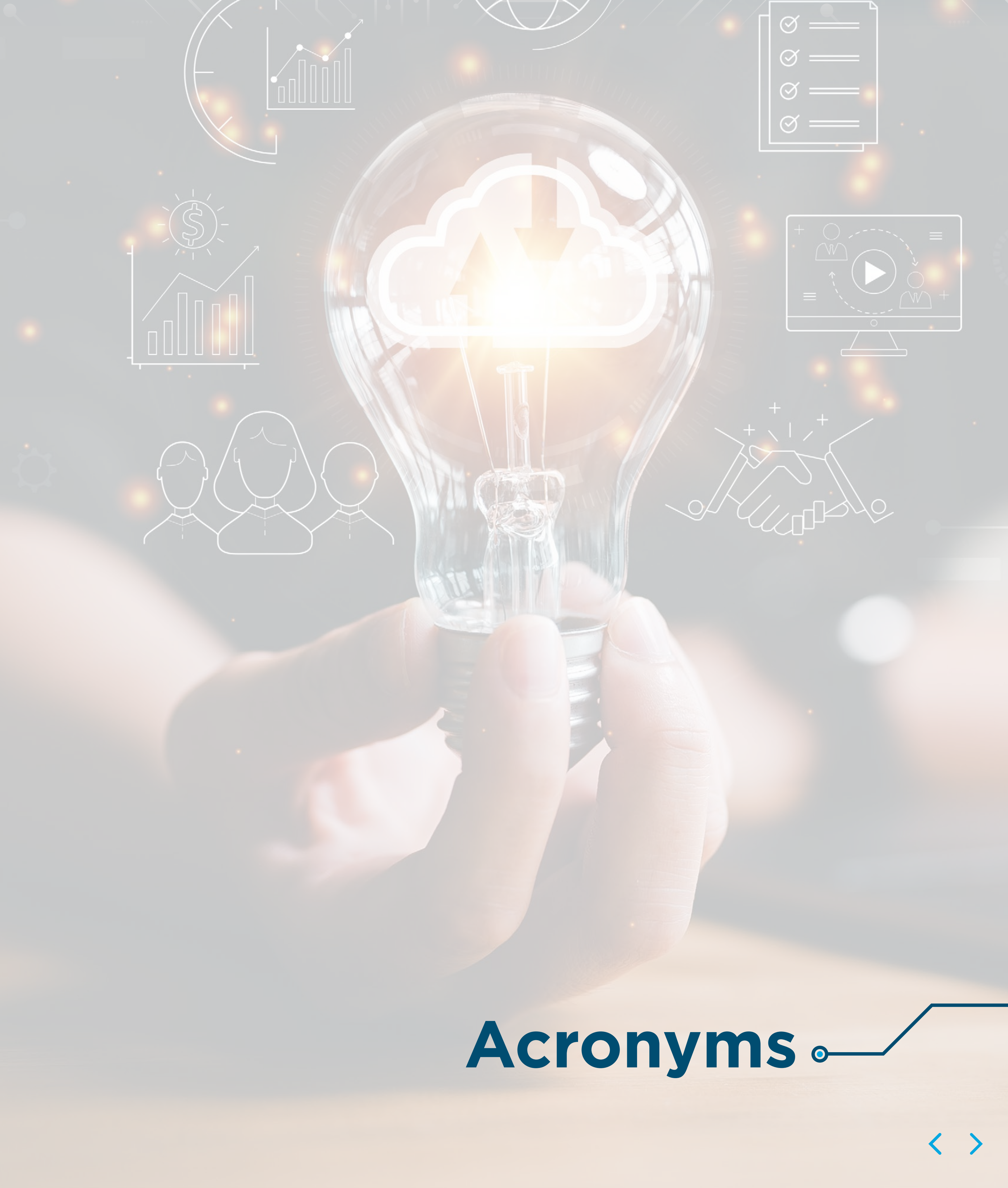

Acronyms

1G	first generation wireless telephone technology
2G	second generation wireless telephone technology
3G	third generation wireless telephone technology
4G	fourth generation wireless telephone technology
5G	fifth generation wireless telephone technology
ADP	advanced digital production
AI	artificial intelligence
B2B	business-to-business
B2C	business-to-consumer
BEA	U.S. Bureau of Economic Analysis
CMM	Cybersecurity Capacity Maturity Model for Nations
DEIE	developing and emerging industrial economies
ECLAC	Economic Commission for Latin America and the Caribbean
EU	European Union
FCC	Federal Communications Commission
GAO	The Government Accountability Office
GDPR	General Data Protection Regulation
GNI	gross national income
GSMA	Global System for Mobile Communications
GVC	global value chains
IDB	Inter-American Development Bank
IDBA	Broadband Development Index
ICT	information and communication technologies
IFPG	Innovation, Firm Performance and Gender survey
IFR	International Federation of Robotics
ILOSTAT	International Labour Organization Statistics
IoT	internet of things
IP	intellectual property
ISCO	International Standard Classification of Occupations

ISO	International Organization for Standardization
ITU	International Telecommunication Union
IXP	internet exchange points
KIBS	Knowledge Intensive Business Services
M2M	machine-to-machine
MSME	micro, small, and medium enterprises
NRI	Network Readiness Index
LAC	Latin America and the Caribbean
OAS	Organization of American States
OECD	Organisation for Economic Co-operation and Development
PCT	Patent Cooperation Treaty
POS	point of sale
PPP	purchasing power parity
SDLC	software development life cycle
SME	small and medium enterprises
STEM	science, technology, engineering and math
TFP	total factor productivity
UASF	universal access and service fund
UIS	UNESCO Institute for Statistics
VC	venture capital

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Introduction

As the world continues to grapple with the COVID-19 pandemic, the role of digital technologies and their potential economic and societal scope only seems to be growing. During this critical period, digital technologies allowed a sizeable portion of the workforce to continue working remotely and they remain instrumental in public health efforts and online education. Similarly, smart automation in large manufacturing companies has allowed workers to keep a greater "distance" from each other, which permits these companies to continue their production, thus limiting disruptions in the supply chain (Hallward-Driemeier et al., 2020).

Digital technologies have become indispensable to firms and people who use them. They lower all kinds of costs, from search (i.e., finding information), to replication (afforded by scanners or photocopy machines), transportation (digital goods travel through cyberspace via digital environments at almost zero cost), tracking (orders, status, and location), and verification costs (i.e., employee vetting processes, consumers online rating systems). In turn, lower costs often translate in substantial economic benefits for producers and consumers (Goldfarb and Tucker, 2019). According to Leinwand and Mani (2021) and to the MIT Center for Digital Business and Capgemini Consulting (2011), digital transformation implies reimagining business models and value creation; it goes beyond simply digitizing business functions or moving from analog (or in-person) to digital transactions.

Despite the growing importance of the digital economy in Latin America and the Caribbean (LAC), including evidence of an impressive uptick in digital technology adoption among firms prompted by the COVID-19 pandemic, there is a widespread belief that the adoption of digital technologies by firms in the region remains far behind compared to advanced economies. Studies have shown that digital technologies helped firms in developing and emerging economies to be more resilient during the pandemic (UNESCO, 2021; UNIDO, 2021). Recent evidence shows that the sophistication of firms' pre-pandemic technology played a significant role in whether firms increased their digital technology usage during the pandemic (Comin et al., 2022). The concern is that as more benefits (productivity, profits, etc.) accrue to firms adopting more and more sophisticated technologies, firms that fall behind in this process will not only struggle to keep up, but they will continue to fall further behind. Recent evidence from countries belonging to the Organisation for Economic Co-operation and Development (OECD) shows that the productivity gaps between frontier and laggard firms are increasing and that this is especially true in digitally intensive sectors (Pisu et al., 2021).

Going forward, one hope is that firms (both large and small) in LAC will embrace the digital momentum brought on by the pandemic and invest further in digital technology adoption and complementary local capabilities (talent and skills) to improve productivity and growth. Yet, charting a path forward is incumbered by lack of a well-documented starting point. And the starting point matters (Comin et al., 2022), not just for resilience in times of crisis, but also because recent evidence suggests a building block pattern (or hierarchy) of increasing technological sophistication (Zolas et al., 2020). This implies that the presence (or absence) of more basic digital technologies may be a determinant of the adoption of more sophisticated digital technologies.

This report provides an initial quantitative and qualitative assessment of the current state of digital technologies in LAC's productive sector. In doing so, it has endeavored to compile the latest resources and indicators available on a range of digital technologies and the enabling conditions that facilitate their adoption, in order to provide a snapshot of where the region stands in terms of the current development and use of digital technology in the productive sector. Drawing upon a variety of sources, including fresh innovative data and benchmarks, the report goes over the adoption of a wide range of digital technologies in LAC, from artificial intelligence (AI), big data and the internet of things (IoT), to "backbone" technologies such as cloud computing, and basic digital technologies (i.e., the percent of firms with websites). In this way, the report intends to complement recent publications on the topic which had a broader focus.[1]

As the OECD aptly describes in its 2019 roadmap for measuring digital transformation, the very nature of the phenomenon of digital transformation presents some challenges to classic statistical measurements. As a result, national account systems and traditional metrics have big blind spots in measuring digital transformation. Following the OECD's (2019) recommendations to build partnerships with the private sector to address some of these blind spots, this report uses data from an initiative by the Inter-American Development Bank (IDB) and the World Bank to form a Development Data Partnership[2] with private sector entities

1. While there are several recently published resources which include a wide range of indicators about connectivity and factors that enable and measure digital technology uptake by citizens and governments, and/or innovation for many countries in the LAC region (for example, the Global Innovation Index (Dutta, Lanvin, and Wunsch-Vincent, 2020); the Latin American Economic Outlook 2020 (OECD et al., 2020); the Network Readiness Index (Portulans Institute and STL, 2021)), information pertinent to digital technology adoption, specifically in firms, remains disperse in different sources. This report does not include digital indicators for the public sector, nor does it attempt to cover indicators on the sharing economy. For one thing, the Economic Commission for Latin America and the Caribbean (ECLAC, 2021) already presents a useful set of indicators on e-government, laws, public policies, and regulation related to digitalization for the LAC region.

2. The iniciative is available via the following link https://datapartnership.org/.

like LinkedIn, who have amassed large amounts of potentially policy relevant data, and a separate IDB initiative to gain access to CB Insights startups data. Thanks to these initiatives, new indicators about digital skills and the digital economy are presented in this report. These indicators are not perfect. In fact, the OECD (2019) warns that such and effort will entail continued and close collaboration between stakeholders to develop the right metrics and data infrastructure. Nevertheless, we present these newly developed indicators as a step in the process of collaboration and as a fruit for thought and invitation to think and discuss how to improve them to better describe the digital status and digital prospective of the firms in the region.

The structure of the report is as follows: Chapter 1 presents a selection of indicators on the enabling conditions for digital technology adoption, touching upon connectivity and human capital specific to information and communication technologies (ICT)—two fundamental factors for paving the way for firms to adopt and effectively implement digital technologies. These indicators set the stage for what will follow. Chapter 2 presents a series of indicators on digital technology adoption. Chapter 3 briefly highlights the challenging issue of cyber-security, which represents an increasingly complex threat to firms, especially smaller ones that may be more vulnerable, have less resources to protect themselves, and may not realize they are potential targets. The report closes with a chapter on the supply side of the digital technology equation by looking at indicators related to the ICT sector. In each chapter, a brief analysis of the gaps between LAC and the OECD is presented for a selection of indicators.

The intention of this report is to be useful for policy makers in the region who are pushing for the deployment of public policies to foster the development and uptake of digital technologies. Going forward, forthcoming publications will put a deeper focus on the "how to" of designing and implementing such policies (see Suaznábar and Henriquez, 2020). We invite you to stay tuned to further developments.

1 Enabling Conditions for Digital Technology Adoption in Firms

There are certain conditions that need to be in place in order to facilitate digital technology adoption in firms. They can be divided into two big categories: i) digital infrastructure, which includes connectivity and data (the foundational services and elements that are necessary for most digital technologies to function); and ii) digital talent, including the human capabilities that are necessary for digital technology implementation and management in firms, and those that are crucial for pushing digital technologies' frontier and inventing new ways to harness their full potential. Figure 1.1 outlines the structure of this chapter and summarises the enabling conditions that will be discussed.

FIGURE 1.1 STRUCTURE OF CHAPTER 1

Enabling Conditions for Digital Technology Adoption in Firms

Source: Authors' elaboration.

Note: For a better visualization of this interactive figure, please download the PDF

Digital Infrastructure

Accessible and affordable digital infrastructure is a necessary condition for digital technology uptake and digital transformation. Traditionally, indicators to measure digital infrastructure focused on the extent to which people were connected to the internet (or phones), and the digital divide between (and within) countries was typically measured in those terms (Vangadia, 2020; UNCTAD, 2021a). Nowadays, this concept has expanded to include the connections of devices to each other in industrial contexts (i.e., IoT), which has implications for data transmition and storage and data value chains (Vangadia, 2020; UNCTAD, 2021a). Broadband remains a fundamental component of digital infrastructure. Access to broadband in LAC continues to lag behind OECD countries, and there is stark heterogeneity among LAC countries. This is evidenced by the Broadband Development Index (IDBA), a tool developed by the IDB, which measures access to broadband and variables related to the development of broadband in LAC and monitors the gap of the region with respect to the OECD countries (García Zaballos, Iglesias Rodríguez, and Puig Gabarró, 2021).

Unequal access to broadband is compounded by the difference in quality. Quality matters not only for the user experience, which influences the utility of digital technology uptake, but it is also essential for determining economic impact (OECD, 2019). Telecommunications, and broadband in particular, have a documented impact on economic growth (see Katz and Jung, 2021a who cite 15 studies conducted between 1980 and 2018 that demonstrate the positive relationship). Specifically in the LAC region, robust empirical evidence of a positive relationship between broadband adoption and labor productivity in firms was documented by Grazzi and Pietrobelli (2016). The speed of broadband is one of the few indicators for digital technologies where quality is relatively easy to observe, document, and assess. Empirical studies have found that faster broadband has a positive impact on gross domestic product (GDP) growth,[3] firm productivity, and employment (see Katz and Jung, 2021b for a recent summary of the literature). The underlying causal mechanism is rather simple, higher quality broadband facilitates greater efficiency in business processes and accelerates adoption of complementary digital technologies and spurs innovation, not just in products and processes, but also in business models (Katz and Jung, 2021b).

3. Studies have shown that an increase in the speed of broadband is associated with an increase in GDP per capita. Specifically, a "1 per cent yields an increase in GDP per capita of 0.147 per cent for a general sample of countries, 0.1 per cent for low-income countries and 0.06 per cent for high income countries" (Kongaut and Bohlin, 2014 as cited by Katz and Jung, 2021a: 39).

For firms and their consumers to be enticed to adopt today's cutting-edge digital technologies, they need connections that allow optimal use of modern digital technologies, such as augmented or virtual reality and the IoT, including wearables and smart home applications, autonomous robot vehicles in warehouses, smart glasses for remote maintenance systems, and drones for remote work site observation. The section on connectivity within this chapter explores the current distribution of generations of mobile technology, from second to fifth generation wireless telephone technology (2G to 5G). The LAC region made impressive progress in expanding fourth generation wireless telephone technology (4G) coverage within just a two-year time span, from 2019 to 2021. But the rate of improvement was slower than other regions such as Europe. This translates to LAC falling further behind Europe, in comparative terms. With an eye toward the future, selected indicators show projections of 5G coverage and describe initiatives to foster the development of applications anticipated to become complementary for more sophisticated digital technologies with vast potential for productivity, such as the IoT, and technologies that are not yet commercialized, such as driverless vehicles.

Without delving deeply into the governance and regulatory issues related to broadband, this section points to the positive correlation between regulation and broadband infrastructure in LAC countries, using data from the IDBA. New analysis from the International Telecommunication Union (ITU) shows rather decisively that ICT regulation had a measurable impact on ICT markets over the last 10 years (Katz and Jung, 2021a). Collaborative regulatory policies in the mobile sector led to an increase in competition and investment, which in turn resulted in more coverage, lower prices, and boosted ICT adoption (Katz and Jung, 2021a). Regulation can contribute to both supply (including coverage) and demand (which is predominantly affected by price) to determine adoption.

Finally, digital data is becoming a fundamental aspect of infrastructure in the digital economy (OECD, 2020a). The capacity for data storage and data processing, and the time it takes for a data packet to be sent and received (latency) are all part of the expanding concept of connectivity. Colocation data center facilities provide space, power, cooling, and connectivity for companies' server, storage, and network equipment (UNCTAD, 2019). While these days, tech companies' business models are typically location independent, this may change. Growth of IoT and 5G will demand low (shorter) latency and may require data to be in closer physical proximity. UNCTAD (2021a) warns that an important consideration concerning colocation data centers is their environmental demands: cooling and energy infrastructures (cost and use of local energy). Local storage, however, may benefit local firms in terms of cost and lower latency and there may be subtle barriers embedded in cross-border data flows that may be important from a development perspective (UNCTAD, 2021a). In some scenarios, if weaker economies do not create (or enforce) domestic rules, the gains from free-flowing data may go to firms, sectors, and markets that are already the most privileged, thus exacerbating the struggle for developing economies to fully realize the potential economic benefits of the digital economy (UNCTAD, 2021a).

Connectivity: quality, coverage, regulation, and the next generation in mobile technology

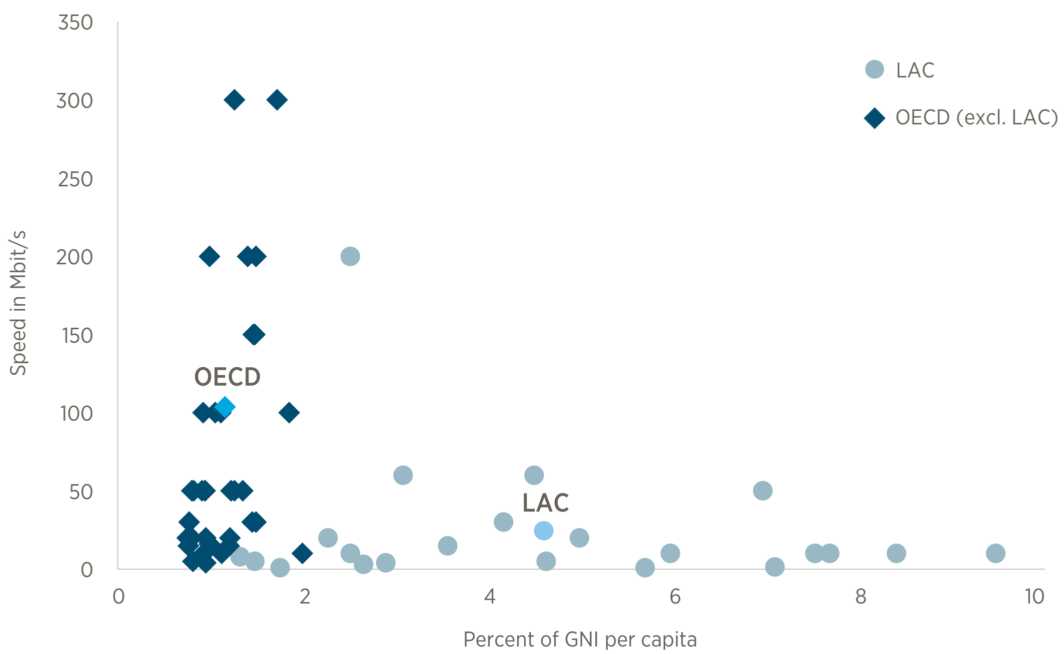
Consumers in LAC countries tend to pay more money for slower broadband service than those pertaining to the OECD. Figure 1.2 shows that, across LAC countries, the average price of fixed broadband represents around 5 percent of the gross national income (GNI) per capita, which excludes the three outliers for which the cost distorts the average. In Haiti, the most extreme case, the price of fixed broadband costs consumers 84 percent of the country's GNI per capita, for a service of only 2 Mbps. In Nicaragua, fixed broadband costs around 27 percent and in Honduras, 14 percent of GNI per capita. These costs are so extreme that they have been suppressed from Figure 1.2 for the sake of visualizing the rest of the data points. In general, for people with income lower than the average per capita in the country, the cost of broadband represents an even larger share of their income. By comparison, across OECD countries (excluding LAC member), consumers never pay a price for fixed broadband that represents more than 2 percent of their county's GNI per capita. On top of relatively high prices, the speed of fixed broadband is much slower in LAC, averaging 24.7 Mbps across countries in 2020. While this figure is a dramatic improvement with respect to LAC average of 8.8 Mbps in 2019, it is still far slower than the average speed of 103.8 Mbps across OECD countries in 2020. OECD countries also saw a dramatic uptick from the average speed of 47.6 Mbps in 2019.

Data from OECD's Going Digital portal[4] shows that in Colombia (the only LAC country for which data are available for this indicator) only 26 percent of businesses have contracted broadband speed of 30 Mbps or more. This pales in comparison with nearly 74 percent of businesses in the OECD, the average across the other 27 OECD countries in the sample, that have broadband speed of 30 Mbps or more. For telecommuting, the Federal Communications Commission (FCC, 2020) in their broadband and speed guide recommend between 5 and 25 Mbps. The Government Accountability Office (GAO) in the United States recently reviewed the evidence and found that 25 Mbps for downloading and 3 Mbps for uploading was too

4. The portal can be accessed via the following link https://goingdigital.oecd.org/indicator/14.

slow for small business needs, suggesting that 50 Mbps is the speed needed for operating point of sale (POS) terminals, inventory management, and coordinating shipping (GAO, 2021). Since these guidelines and findings are based on tasks today's teleworkers, entrepreneurs, and small firms typically execute, they should remain relevant even outside the specific context of the United States. This suggests that 30 Mbps should be the bear minimum, even for smaller firms.

FIGURE 1.2 FIXED BROADBAND VALUE FOR MONEY, 2020



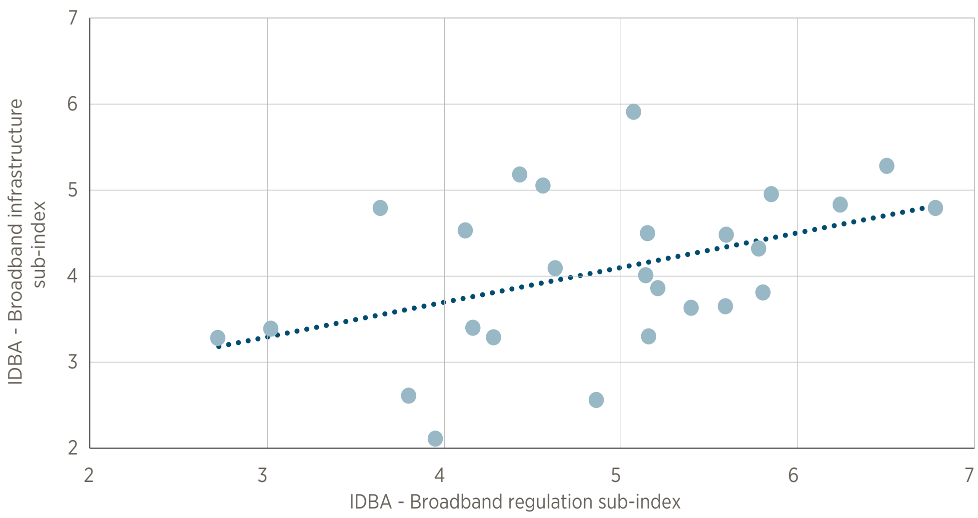
Source: Authors' elaboration based on ITU (2021).
Notes: The following outliers have been suppressed for better visualization: from the OECD, the speed in Japan is 1024 Mbit/s and costs 1 percent of GNI per capita; from LAC, in Haiti, Nicaragua, and Honduras, the cost is 84, 27 and 14 percent of GNI per capita, respectively; there is no data available for Venezuela.

Katz and Jung (2021a) argue that ICT policy and regulation can and does stimulate investment, which can lead to increased mobile network coverage and lower prices (also see the same Katz and Jung (2021a) publication for a detailed model, literature review, and empirical evidence about the impact of policies, regulations, and institutions on ICT performance).[5] Using data

5. Some of the evidence is specifically from Latin American countries.

from the IDBA,[6] in Figure 1.3 we find a positive correlation between broadband infrastructure and regulation. That is to say that when the normalized value of the regulation and competition sub-index is higher, the normalized value for the broadband infrastructure tends to be higher too. In large brush strokes this implies, in a static sense, that LAC countries with better connectivity are those countries where price, competition, and regulatory conditions are more favorable.

FIGURE 1.3. BROADBAND INFRASTRUCTURE AND REGULATION OF 26 LAC COUNTRIES, 2020



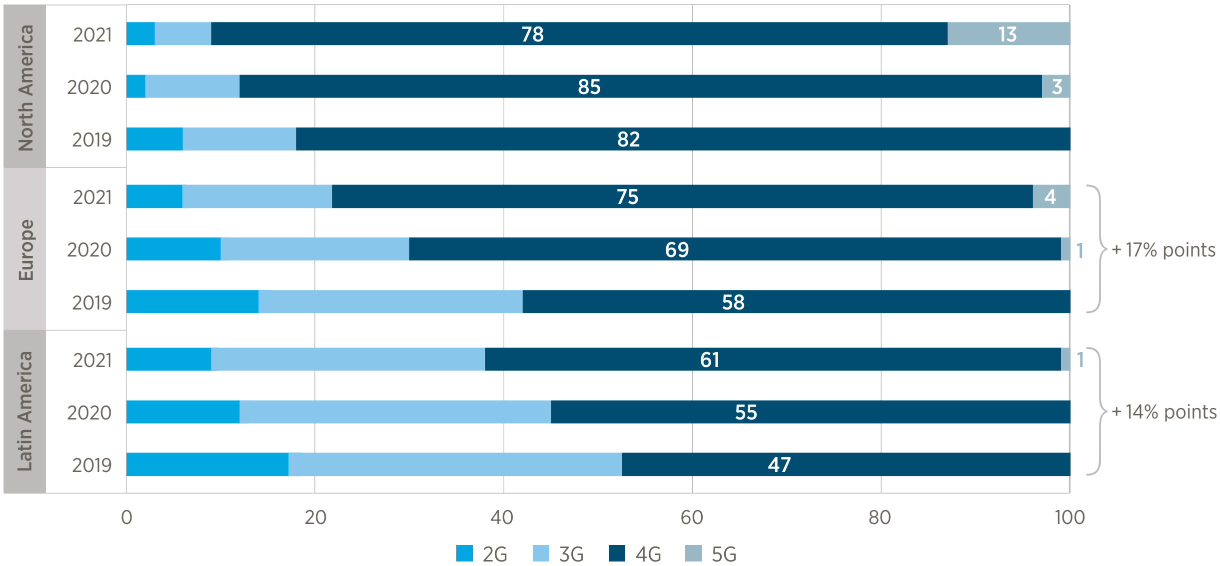
Source: García Zaballos, Iglesias Rodriguez, and Puig Gabarró (2021).
Notes: Indicators included in the IDBA broadband regulation sub-index pillar are as follows: monthly fixed broadband subscription in US$; purchasing power parity (PPP) in $/month; monthly mobile broadband subscription in US$, PPP $/month (based on operators' websites at end of 2019); reports of effectiveness from universal access and service fund (UASF); concentration of fixed broadband operators; concentration of mobile broadband operators (Herfindahl–Hirschman index (HHI) based on reports); assignment of mobile communications spectrum in bands under 3GHz (4G Americas, European Communications Office (ECO), FCC, or GSMA). Indicators included in the IDBA broadband infrastructure sub-index pillar are as follows: proportion of the population with 4G mobile broadband coverage (in percentage); secure internet servers per million inhabitants; percentage of households with personal computers; percentage of households with internet access; fixed broadband lines per 100 inhabitants; mobile broadband lines per 100 inhabitants; broadband lines with fiber optic access per 100 inhabitants; average broadband access speed; average 4G network access speed; international broadband speed in bits/inhabitant; existence of internet exchange providers. (see García Zaballos, Iglesias Rodriguez, and Puig Gabarró, 2021).

6. One of the IDBA measures relates to the extent of broadband penetration along several variables that contribute to broadband infrastructure, including the penetration of fixed and mobile broadband, 4G mobile broadband coverage, secure internet servers per million in the population and internet exchange providers. Another sub-index aims to capture regulation and competition and includes the price of fixed and mobile broadband subscriptions, the effectiveness of UASF, and the concentration of fixed and mobile broadband operators. These variables and more are normalized and combined to form the respective sub-indices (see García Zaballos, Iglesias Rodriguez, and Puig Gabarró, 2021).

Connectivity has been reshaped by mobile penetration and the adoption of smart phones. Penetration of mobile subscriptions and smart phone adoption is quite high in Latin America, but not all mobile technology allows the same quality of connectivity (GSMA, 2020). Different generations of wireless mobile technology are referred to as first generation wireless telephone technology (1G), 2G, third generation wireless telephone technology (3G), 4G, and 5G and allude to technology used by the mobile carrier and device itself: 1G devices supported only voice calls, 2G users can send picture messages and SMS, 3G can handle (low quality) video calling and mobile internet access, and 4G supports mobile web access that demand high speeds like video conferencing and gaming services (Fendelman, 2021). The advancement to the next generation of mobile technology, 5G, is expected to be much more than just an incremental improvement over 4G (see below and Box 1.1 for more details). According to a report by UNCTAD (2021a), 93 percent of the global population with mobile broadband was covered by a signal from at least a 3G network in 2020, whereas only 88 percent of Latin America is covered by 3G and only 12 percent still have a signal from a 2G network (see Figure 1.4).

While the expansion of 4G coverage in LAC has been impressive, it is not keeping pace with the expansion in Europe. Latin America expanded its 4G coverage from less than half to more than 61 percent from 2019 to 2021. But in the same two-year span, Europe expanded from 58 to 75 percent. 5G is the latest generation and while it is still a nascent technology, launched in 2020, it is expected to play a big role in the data-driven digital economy (UNCTAD, 2021a).

FIGURE 1.4 DISTRIBUTION OF TECHNOLOGY MIX (2G, 3G, 4G, 5G) BY REGION, IN 2019, 2020, AND 2021 (IN PERCENTAGES)



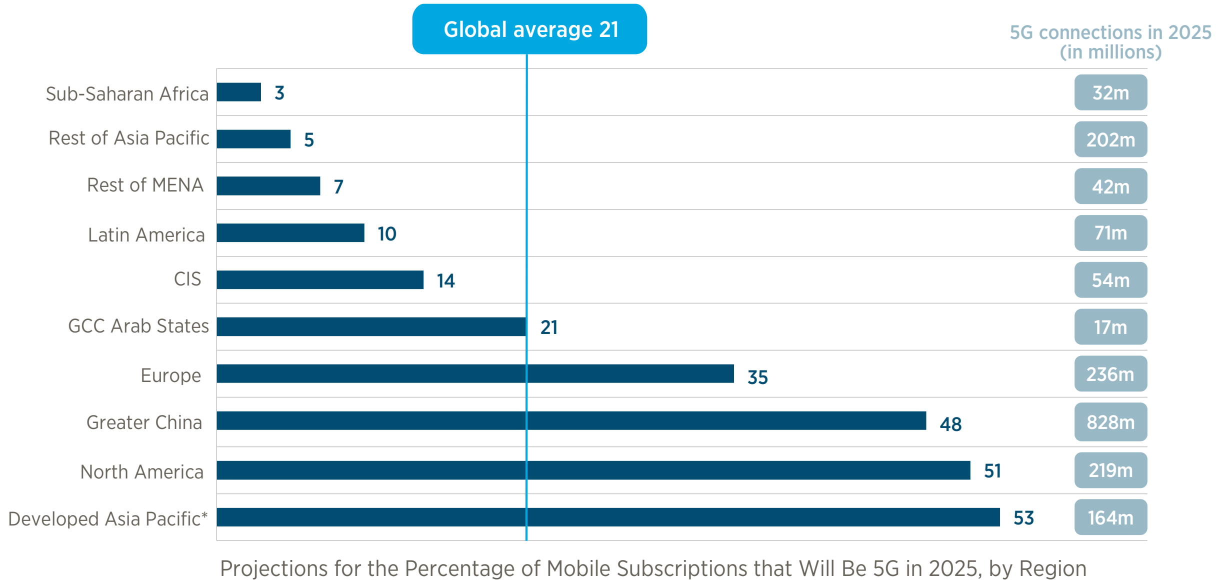
Source: Excerpted from GSMA (2020, 2021).
Note: Regions are defined by the source. The total for Latin America does not reach 100 percent in the report, it is assumed to be a rounding issue.

There are huge expectations for 5G and its applications, since this technology can process one thousand times more data than today's systems, which will be essential for IoT (UNCTAD, 2019). It is also expected that 5G will eventually handle 10 to 100 times more connected devices (up to 1 million) per square kilometer than 4G (Verizon, n.d.).

It is important to note that the development of high speed 4G and 5G connections brings together the need to expand the fiber backbone and backhaul networks. Regions that are not covered by an optical fiber network will face bandwidth scarcity, as users, applications, and devices become more data intensive.

5G networks have only started to be effectively implemented in 2020, but forecasts indicate that by 2026, 5G mobile data traffic will surpass 4G and lower technologies (UNCTAD, 2021a). Figure 1.5 shows the Global System for Mobile Communications' (GSMA) prediction that in Latin America, by 2025 only 10 percent of mobile subscriptions will be using 5G. With 5G technology, desktop devices may become less relevant since the quality of internet connection and data volume on mobile devices will increase. While it may take a long time to develop, if 5G device-to-satellite becomes a reality, it could transform connectivity, providing more remote/rural broadband connectivity and could have important applications in a variety of sectors and industries with many commercial implications for businesses (UNCTAD, 2021a).

FIGURE 1.5 PROJECTIONS FOR THE PORTION OF MOBILE SUBSCRIPTIONS BY REGION THAT WILL USE 5G IN 2025 (IN PERCENTAGES)



Source: Excerpted from GSMA (2021).
Notes: Regions are defined by the source. MENA stands for Middle East and North Africa. GCC Arab States refers to the Co-operation Council for the Arab States of the Gulf (GCC). Developed Asia Pacific refers to Australia, Japan, Singapore and South Korea. The numbers next to the bars represent the projected percentage of each region's Mobile subscriptions that will be 5G in 2025. The numbers in the boxes to the right, are the corresponding number of projected 5G connections in each region in 2025.

The developmental trajectory of a digital technology and its applications are partly shaped by successful uptake in firms. Firms often need to undergo a long phase of trial and error before the implementation of a new technology succeeds and the learning process may not be the same for every technology (Lee and Lim, 2001). Testbeds can provide an interesting space to accelerate the development of key technologies and new use cases so that firms can experiment and see the value of adopting new digital technologies. In Box 1.1. we have an example of how 5G testbeds are doing just this in the LAC region.

BOX 1.1 5G TESTBEDS

5G is way more than 4G + 1 as it merges communications with computing and it has major implications for IoT, robotics, drones, self-driving cars, augmented virtual reality, and mobile broadband (Azcorra, 2019). 5G merges communications with computing.

What are 5G testbeds?

A 5G testbed typically provides a place to support technology research and trials (development of prototypes and deployment pilots) to spur 5G use cases and business models. Some testbeds, such as 5G-VINNI, 5G-EVE, or 5GENESIS in Europe explicitly support inter-connectivity, inter-operability, and vertical industries, and aim to be an end-to-end 5G facility. Other testbeds, such as 5G-MOBIX, focus specifically on testing automated vehicle functionalities using 5G core technologies (Azcorra, 2019).

Why are 5G testbeds important?

To explain the importance of the 5G enabled testbed/accelerator within the Cambridge Science Park, Simon Mead, the CEO of Cambridge Wireless, describes 5G as the glue that will hold together all the key technologies for the next phase of automation (i.e., AI, robotics, sensor technology, big data, and virtual reality). 5G testbeds give early access to companies and allows them the opportunity to prove that 5G applications will work and add value. Testbeds can give companies digital infrastructure (i.e., access to indoor and outdoor 5G networks and latest 5G-enabled devices), physical infrastructure (i.e., project rooms and other spaces), and guidance (i.e., technical support, project coaching, and mentorship). 5G testbeds are instrumental in developing the actual 5G technologies (research centers), training in 5G (network management, application development, etc.), developing 5G applications, defining use cases for demonstration effects (showcase), and supporting startups and spinoff companies engaging with 5G technologies and applications.

Are there international initiatives in 5G development and testbeds?

As of February 2022, commercial 5G services are available in all 27 European Union (EU) countries.

As of 2019, based on Azcorra (2019) the listed 5G testbeds were active in the following cities in Europe and United States:

COUNTRY	CITY
Finland	Espoo, Helsinki, Oulu, Tampere
France	Burdeos, Châtillon, Douai, Lille, Linas-Monthléry, Lyon, Marsella, Nantes, Paris, Toulouse
Germany	Berlin
Greece	Atenas, Demokritos, Egaleo, Trikala
Italy	Bari, L'Aquila, Matera, Milán, Prato, Roma
Netherlands	Amsterdam, Drendhe, Eindhoven, Groningen, Pernis, Rotterdam
Spain	Barcelona, Madrid
United Kingdom	Birmingham, Bath and Bristol, Coventry, Cumbria, Inverness-shire, Liverpool, Northumberland, North Yorkshire Shropshire, Orkney, Perthshire and Monmouthshire, Somerset, Wolverhampton, Worcestershire
USA	New York, Salt Lake City

What's happening in LAC?

In LAC, to date, the development of 5G testbeds has been slow. A few initiatives have been launched or are in an incipient stage, mostly as private sector efforts, in Argentina, Costa Rica, and Uruguay. An example of an initiative put forward as a private sector effort, is the case of the "Observatorio Nacional 5G" in Valparaiso, Chile, by SUBTEL with the support of Ministry of Transportation and Telecommunications (MTT). Considering the expected impacts of 5G technology on all sectors, governments in the region should consider setting up financial mechanisms to support the establishment of testbeds that facilitate the experimentation and capacity building of private firms with 5G technology and its wide range of potential applications. Both Finland and the United Kingdom, for instance, have set up public support to establish 5G testbeds with positive results.

Source: Authors' elaboration based on Azcorra (2019).
Notes: More information about the Observatorio Nacional 5G is available via the following link https://www.pucv.cl/pucv/inauguran-primer-campus-5g-regional-del-pais-en-la-catolica-de-valparaiso.

Data as part of digital infrastructure and connectivity

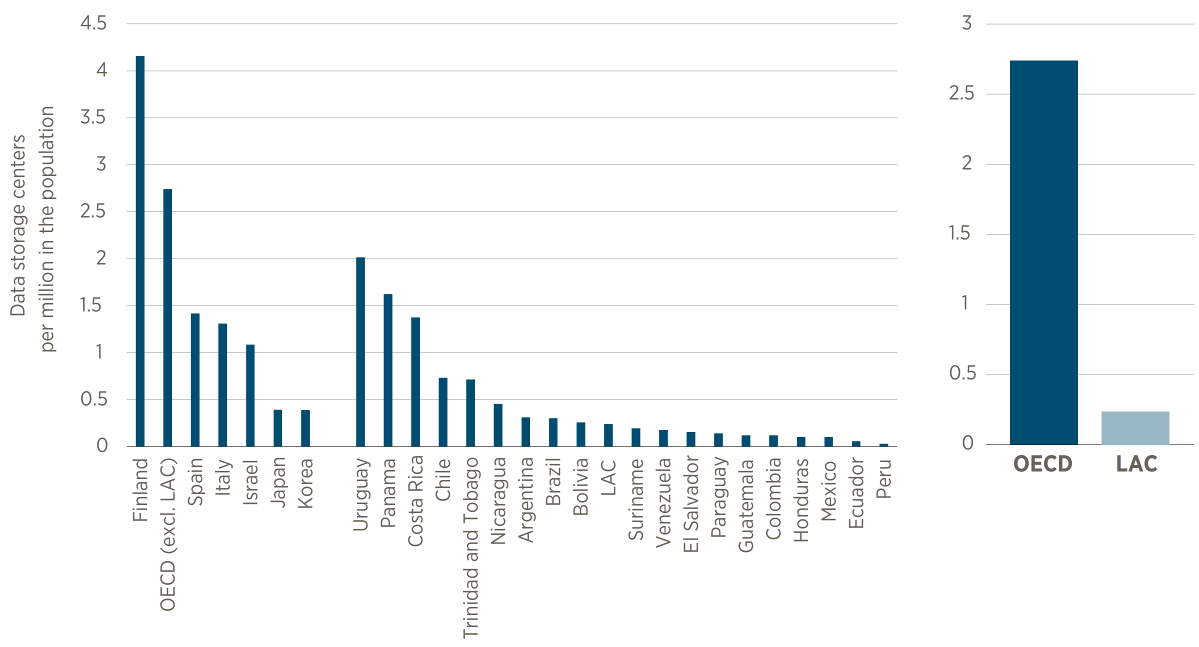
Data is currency in the digital economy. The volume of data is growing, pushing every boundary of data storage. In addition, the increasing prominence of data analytics has contributed to the growth in numbers and importance of colocation data centers, or physical facilities, which enable data storage and remote computing (OECD, 2020a). Colocated data centers offer many advantages, such as reliability (power, cooling, and security) and potential for scale. These centers lease space to network and cloud providers, as well as to firms that can then connect for business purposes, allowing them to centralize information technology (IT) operations and potentially reduce costs (see, for example, CORESITE, n.d.). For firms whose own data centers are outdated, colocation data centers offer a viable alternative to investment in continuous upgrading. In fact, in 2019, Gartner (as cited by Moore, 2019) estimated that 10 percent of companies had already shut down their traditional data centers in favor of colocation and hyperscale data centers. Gartner also predicted that the majority of firms will do the same by 2025.

This does not necessarily mean that colocation data centers need to be close by. In fact, one feature of data that technology companies have traditionally exploited is location independence. As digital technologies evolve and become more demanding in terms of data and latency requirements, this may change. In the future, digital technologies such as IoT and 5G may require data to be in closer proximity (UNCTAD, 2021a). Despite potential advantages for economies to have their own colocation data center facilities, there are environmental considerations, such as the cooling and electricity requirements of data centers (UNCTAD, 2021a), which may concern particularly LAC countries with warmer climates and weaker electric infrastructure. There are different views about today's concentration of colocation data centers in advanced economies. The OECD posits that cross-border data flows may be aided by data centers (OECD, 2020a) and several international organizations including the OECD, the World Bank and the World Economic Forum maintain that international cooperation can facilitate efficient data flows, especially trade data (UNCTAD, 2021a). Recent work by the IDB, aims to provide policy makers with a holistic and deeper understanding of implications of data protection and sharing in global value chains (GVCs) in specific contexts, as it is the case of Mexico's automotive and electronics industry (see Stankovic and Filippo, 2021) Acknowledging potential downsides to creating a national data storage industry such as the environmental considerations already mentioned, plus vulnerability to natural disasters or hackers (if cybersecurity is less sophisticated), the UNCTAD (2021a) raises the issue of distributional considerations. Gains from free data flows may go predominately to economies with a developed data infrastructure and discussion is complicated by distinct types of data (trade, business, and personal) and the fact that the definitions and measurement of cross-border data flows remain elusive (UNCTAD, 2021a).

Nevertheless, organizations seem to agree that awareness of data as part of the digital infrastructure and efforts to measure and collect information on related indicators, such as the location and presence of data centers, is important. These indicators can serve as a basis for policy makers to engage in active planning deemed necessary for the evolving and extensive data requirements of more sophisticated digital technologies (OECD, 2020a; UNCTAD, 2021a).

Figure 1.6 shows the number of colocation data centers in each country (or region), weighted by population. With a handful of exceptions—Costa Rica, Panama, and Uruguay—there are fewer than one data center per million in the population in LAC countries. In the OECD, there are typically more data centers per million in the population, but there is also a lot of heterogeneity within the OECD, with some members accounting for most of the data centers and other members having very few.

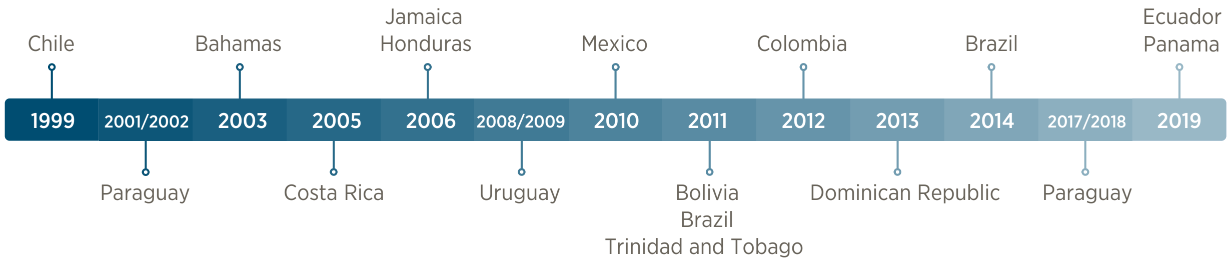
FIGURE 1.6 COLOCATION DATA CENTERS PER MILLION IN THE POPULATION



Source: Authors' elaboration based on the number of colocation data centers indicated in the Data Center Map, available at https://www.datacentermap.com/datacenters.html, and population data from the World Bank's development indicators, available at https://databank.worldbank.org/source/world-development-indicators.

As the economic value of data and its integration in value chains increases, countries have begun to enact legislation regarding data ownership. The most famous example is the General Data Protection Regulation (GDPR) within the EU, which contains a set of guidelines for the collection, ownership, and handling of personal data (OECD, 2020a). These regulatory guidelines can be seen as a limitation since they may constrain how firms are able to use the data they collect, but they may also be useful. For example, the GDPR makes consumers more aware of the potential uses of their personal data and they are routinely asked to give or deny permission for such use. Thus, these personal data protection regulations may help businesses, since consumers cannot be blindsided by the kinds of data being collected when they visit a company's website, for example.[7]

FIGURE 1.7 DATA PROTECTION AND PRIVACY LEGISLATION



Source: UNCTAD's data protection and privacy legislation worldwide, available at https://unctad.org/page/data-protection-and-privacy-legislation-worldwide.
Notes: There are some countries for which UNCTAD lists data protection and privacy legislation without a date affiliated. For example, Argentina's Law 25.326 that protects personal data; Brazil's General Data Privacy Law; Mexico's Ley general de protección de datos personales en posesión de sujetos obligados; Peru's Law No. 29733, or Ley de Protección de Datos Personales; and the Constitution of Trinidad and Tobago. There is also undated draft legislation in El Salvador and in 2019 there was draft legislation in Barbados. For the complete list and the Title of legislation/draft Legislation, please see Appendix 1.

7. Appendix 1 shows a list compiled by the United Nations (UN) on data protection regulations in LAC countries. Highlighted in bold are countries for which the only entry on the table is more than 10 years old. This indicates that these regulations may be quite outdated. In some cases, no dates are provided. The rollout of data protection and privacy legislation is summarized in the timeline presented in Figure 1.7.

Key Digital Talent/Human Capital Indicators

Digital technologies require unique skills to facilitate adoption, since successful implementation can require firms to reorganize themselves, coordinate via new digital channels with buyers and suppliers, and even reassigning tasks to reconfigure division of labor (Ciarli et al., 2021). Simultaneously, firms innovating in digital technology require frontier knowledge of digital technologies and their potential commercial applications. Further adding to the complexity, digital skills need to be in constant evolution in order to match the rapid pace at which digital technologies evolve, both in terms of development and/or adoption of technologies (Ciarli et al., 2021).

As Ciarli et al. (2021) point out, ideally human capital and talent should interact with digital technologies in ways similar to those traditionally understood as emblematic of a strong innovation system. Differences in the relationship stem from the pace at which skills need to upgrade and evolve and how digital skills and digital technologies may shape each other concurrently. In this context, universities play a role in developing a critical mass of highly skilled human capital with specialized knowledge. Falck, Heimisch-Roecker, and Wiederhold (2021) demonstrate a positive wage return to ICT skills, indicating their market value and perhaps also their short supply. Furthermore, recent studies show that there is a positive and significant relationship between the proportion of employees highly skilled in ICT (measured by tertiary education in the field) and the intensity of innovation in ICT in European firms (see Falk and Hagsten, 2021). As with typical technological innovation, universities and research centers are linked with local innovative capacity, because of their role in developing new knowledge or adapting knowledge from the frontier to local contexts which is one of the ways in which universities typically contribute to innovation and stimulate economic performance (Valero and Van Reenen, 2019).

Somewhat worryingly, both the OECD and LAC have a relatively low percentage of tertiary graduates in ICT and ICT professionals as a percentage of the workforce. Both regions also suffer from low percentages of female participation in ICT occupations. However, the OECD has managed to grow its professionals in ICT relative to the workforce faster than LAC. For some countries with strong education systems, now is the time to increase the formation of advanced human capital in this area.

ICTs are raising the attractiveness of skills that are complementary[8] and diminishing the value of skills that may be substituted, perhaps tethering a country's economic growth prospects to its people's ability to work with new (digital) technologies (Falck, Heimisch-Roecker, and Wiederhold, 2021). Taking it even a step further, digital technologies may shape demand for digital and related skills within talent profiles, which in turn may influence growth (or contraction) trajectories of particular occupations and industries. Cirillo et al. (2021) find that while occupations that earn high marks on routine task intensity indices seem to be the most vulnerable to anticipated negative employment effects, there are sectoral differences when it comes to advanced digital skills and employment growth. And a growing body of literature is showing that workers' skills[9] and management practices are crucial and causally related to increased productivity in firms that adopt cutting edge technologies (Brynjolfsson, Jin, and McElheran, 2021).

The main difference is that digital technologies, more so than other technologies, require the ability to continuously reskill (adapt existing skills) or upskill (acquire new skills) and apply these new capabilities as necessitated by changes in the digital technologies (Ciarli et al. 2021). This concept, commonly referred to as lifelong learning, has recently been identified as one of the most fundamental aspects of spurring growth and closing gaps via digitalization (Pisu et al., 2021). Evidence from the United States shows that over the past 10 to 15 years, occupations that require digital know-how have steadily risen, and across industries and sectors the typical workday includes a good deal of interaction with tools that require digital skills (Muro et al., 2017). In fact, labor experts from ManpowerGroup argue that digital transformation is more about people than it is about technology (Frankiewicz and Chamorro-Premuzic, 2020).

Possibly to address the widespread need for digital technology related upskilling, or simply to address a shortage of advanced digital talent, new types of training programs have appeared. Unconventional and disruptive, these new players are offering trainings to develop advanced digital skills in areas such as computer and software programming, data science and data analytics, machine learning, and AI. In the realm of education, these new players may be more apt to suit the notion of lifelong learning, because the duration of their courses are typically much shorter than formal higher education programs. Coding bootcamps, corporate courses (Google, Amazon, CISCO, or Microsoft certifications), and MOOCs (Coursera, EdX)

8. Skills that are considered complementary to ICT skills range from high levels of numeracy and problem-solving skills to soft skills, such as the ability to work in a team, creativity, and adaptability/flexibility. See, for example, OECD (2016a).

9. In Brynjolfsson, Jin and McElheran (2021) study, higher education is used as a proxy for workers' skills; digital skills and use of digital technologies (i.e., the internet) are correlated with education.

are on the rise, globally and in LAC. Graduates of these trainings appear to be well received by employers in dire need of advanced digital skills (Nichols and Holper, 2021; Triulzi, unpublished manuscript).

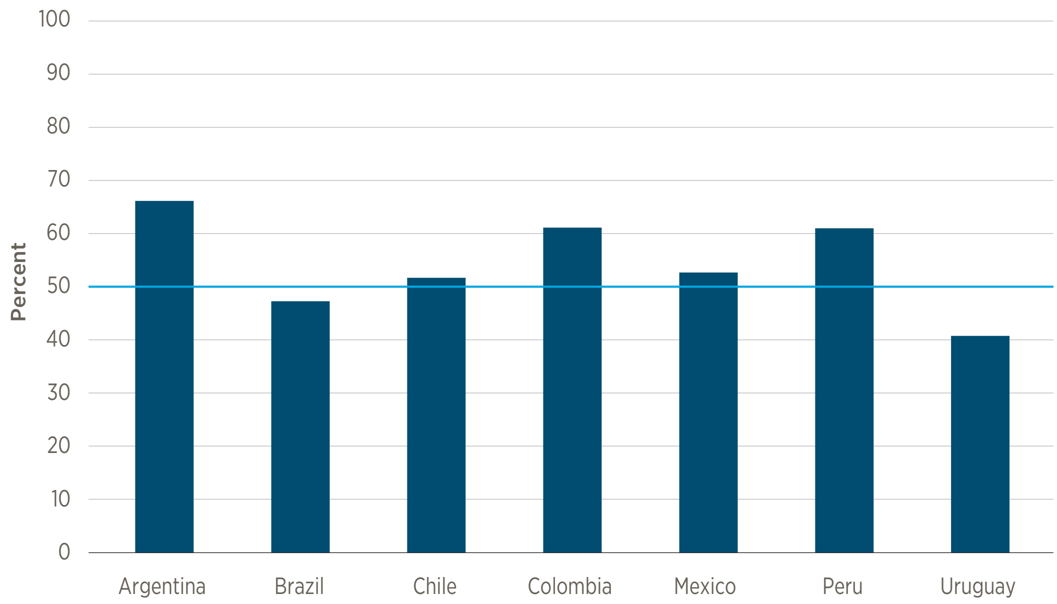
The following section looks at indicators to describe the supply of digital technology programs in higher education institutions in LAC and their output in terms of the portion of graduates with a degree related to ICT. Given the rapid expansion in alternative educational pathways around the world, and in LAC in particular, the section also includes a discussion about the growing presence of coding bootcamps and online courses. It then delves into the availability of ICT professionals in the workforce and examines the gender dimension—aspects that have only been briefly touched upon so far. There is an entire sub-section dedicated to the penetration of disruptive tech skills and tech skills in LAC countries by selected sectors of the economy, making use of LinkedIn data accessed via the Development Data Partnership (see Box 1.2). The section closes by reviewing a few indicators that show that the LAC region is not yet competitive when it comes to knowledge at the frontier for particularly sophisticated digital technologies, such as AI.

Universities: programs for digital technologies and graduates in ICT in LAC

Katz (2018) argues that there are three main stages in any technology's development lifecycle, namely development, adoption, and economic impact. The author also explains that to properly assess gaps in human capital, it is necessary to differentiate between the predominant type of human capital needed in each stage. According to Katz (2018), when a digital technology is being developed, it is appropriate to measure gaps in higher education (bachelor's degrees) and perhaps more importantly in graduate degrees (master's and doctorates), because these are the credentials needed by researchers involved in the creation of new products and services. Katz (2018) also asserts that professionals dedicated to digital technology adoption or assimilation into the production processes can have a bachelor's, perhaps a master's degree, and may also be qualified with a short-term degree.

To understand the supply of programs that offer trainings in careers associated with digitalization, the author determined the total number of universities, tertiary institutes, and non-universities in each LAC country covered in the study (Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Uruguay) and based on the data obtained determined which institutions offered degrees in computer science, electrical/electronic engineering, statistics, or similar programs linked to advanced digital technologies. In the LAC countries for which Katz (2018) conducted this analysis, between 41 percent (as in the case of Uruguay) to 66 percent (in reference to Argentina) of universities offer degree programs in digital technologies (see Figure 1.8).

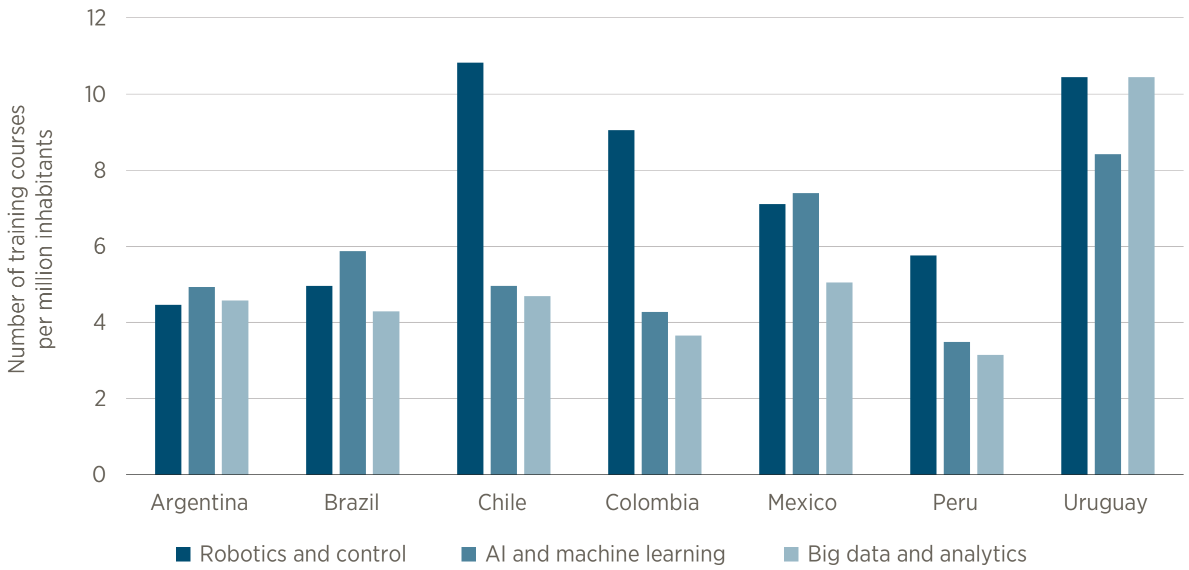
FIGURE 1.8 PORTION OF UNIVERSITIES THAT OFFER PROGRAMS IN DIGITAL TECHNOLOGIES IN LAC, 2018



Source: Authors' elaboration based on Katz (2018:28).
Notes: The programs considered are computing, electrical and electronic engineering, information systems, or similar.

Katz (2018) further classified the disciplines of the courses and identified the supply of courses in robotics/control, AI/machine learning, and big data/analytics. Since institutions typically offer more than one program in digital technologies and short courses (technical diplomas/degrees) were also identified, the 2018 report by ECLAC normalized the number of courses per million in the population. Figure 1.9 shows that Chile, Colombia and Uruguay have the largest number of courses per million in the population available in robotics and control.

FIGURE 1.9 NUMBER OF UNIVERSITY LEVEL COURSES IN ADVANCED DIGITAL TECHNOLOGIES (BY AREA), 2018

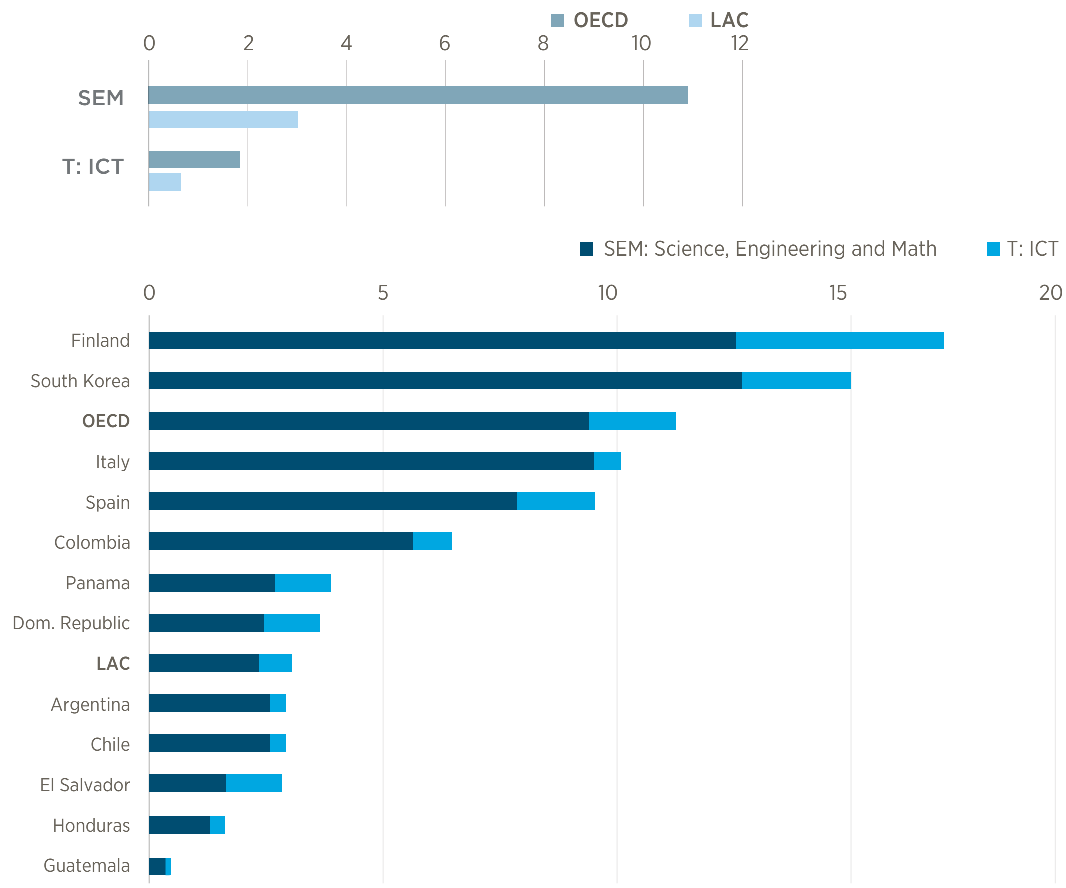


Source: ECLAC (2018), based on Katz (2018).
Note: Numbers include short courses.

In comparison to courses, there are far fewer postgraduate programs available. The total number of postgraduate programs (master's degrees and doctorates) in digital technologies per million in each country are as follows: Argentina, 1.64; Brazil, 1.08; Chile, 2.57; Colombia, 1.66; Mexico, 1.99; Peru, 1.98; and Uruguay, 4.07 (ECLAC, 2018: 104, based on Katz, 2018).

Firms that are higher in technological intensity tend to employ greater shares of workers with an educational background in Science, Technology, Engineering, and Math (STEM) and these skills are also important for advanced digital production (ADP) technologies, but ICT skills are particularly vital (UNIDO, 2020). The lack of STEM tertiary graduates in LAC is already a concern from an innovation perspective, since this kind of highly specialized talent is crucial for innovation systems, both from the perspective of developing new products and processes and for technology transfer and application of technological innovation to local contexts (IDB, 2010). Figure 1.10 shows that tertiary graduates in ICT are a relatively small portion of STEM graduates. These skills are therefore in even shorter supply than overall STEM skills. Beyond these measures of the kinds of technical skills that are needed to work with ADP technologies, complementary soft skills are also needed and in high demand (Basco et al., 2020; UNIDO, 2020).

FIGURE 1.10 TERTIARY GRADUATES FROM SELECTED FIELDS OF STUDY RELATIVE TO THE COUNTRY'S POPULATION AT THE THEORETICAL GRADUATION AGE, 2019 OR LATEST YEAR AVAILABLE



Source: Authors' elaboration based on UNESCO Institute for Statistics (UIS) database, available at http://data.uis.unesco.org/.
Notes: Regional averages are simple averages of countries percentages for which data are available. The LAC average includes data from Argentina, Chile, Colombia, the Dominican Republic, El Salvador, Guatemala, Honduras, and Panama. The OECD average excludes LAC countries that are OECD members and the following countries for which data were not available: Estonia, Ireland, Israel, Japan, and the United States. The indicator presented in this figure is calculated as the percentage of tertiary graduates in selected fields of study by the "Gross graduation ratio from first degrees programme (ISCED 6 and 7) in tertiary education", defined as: the number of graduates from first degree programmes (at ISCED 6 and 7) expressed as a percentage of the population of the theoretical graduation age of the most common first degree programme (see http://uis.unesco.org/en/glossary-term/gross-graduation-ratio-first-degrees-programme-isced-6-and-7-tertiary-education). Fields of study included in UIS STEM include: (05) natural sciences, mathematics and statistics; (06) ICTs; and (07) engineering, manufacturing, and construction. ICTs includes: (0611) computer use, (0612) database and network design and administration, and (0613) software and applications development and analysis, as per the Manual to accompany the International Standard Classification of Education (2011), available at http://uis.unesco.org/sites/default/files/documents/isced-fields-of-education-and-training-2013-en.pdf.

Growth of alternative educational pathways for advanced digital skills

Given the relative short supply of people with ICT skills and the increasing demand for computer programmers, IT professionals, and software developers,[10] it is not entirely surprising that new educational pathways have arisen to address this market need. Coding bootcamps have emerged as a new player, offering short intensive training programs (i.e., skill accelerators) that teach practical computer programming skills and screen applicants for particular soft skills and sometimes coach soft skills during the program (Cathles and Navarro, 2019). A recent analysis based on coding bootcamps in the United States using data from Burning Glass Technologies[11] have found that in-field employment rates from top coding bootcamps are comparable with computer science degrees from highly respected universities (Nichols and Holpler, 2021). Analysis using data from LinkedIn found that graduates from the top coding bootcamps in the United States have similar chances of landing a job at one of the top five big tech companies as graduates from traditional universities (Rhee, 2021). In early 2021, Digital House (the largest coding bootcamp born and operating in Latin America) received US$50 million in new funding and investors cited an estimated shortage of 25,000 IT professionals a year in Brazil alone, as part of their drive to invest in tech talent (Azevedo, 2021).

The stunning growth in the number of bootcamp providers around the world in the last decade is mirrored by a large increase in the number of providers in the LAC region. Ten years ago, there were no bootcamps in LAC (or anywhere). Today, there are around 50 bootcamps operating in over 100 different locations in LAC (see Map 1.1).

10. MercadoLibre made plans to double its workforce by the end of 2021 due to the exponential growth of online sales during the pandemic, and the company projected that a quarter of new jobs will be in technology and software development roles (see Millan, 2021).

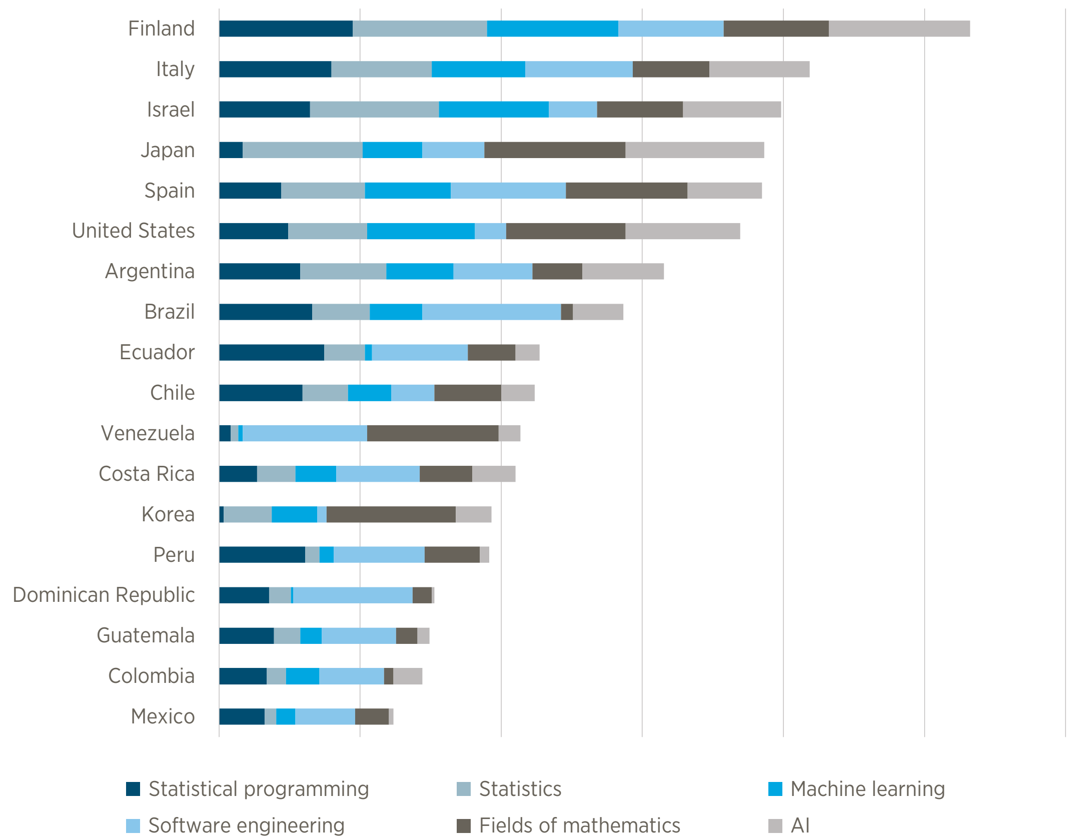
11. Burning Glass Technologies was an IT Services and IT Consulting company that developed job market analytics. It has recently merged with Emsi (see information on Emsi's website, available at https://www.economicmodeling.com/.).

MAP 1.1 BOOTCAMPS OVER THE LAST DECADE IN LAC: FROM ZERO TO 50

Source: IDB (forthcoming).

Coding bootcamps are not the only alternative educational pathways available to prospective students interested in shorter and often less expensive means of learning and acquiring digital skills that are relevant for the workplace. There are many online courses that offer from introductory to very advanced knowledge on topics closely related with AI, such as statistical programming and machine learning. Figure 1.11 shows the uptake of AI-related online Coursera courses in 2019 by country. Data are standardized for each type of course.

FIGURE 1.11 AI-RELATED ONLINE COURSES BASED ON DATA FROM COURSERA, 2019

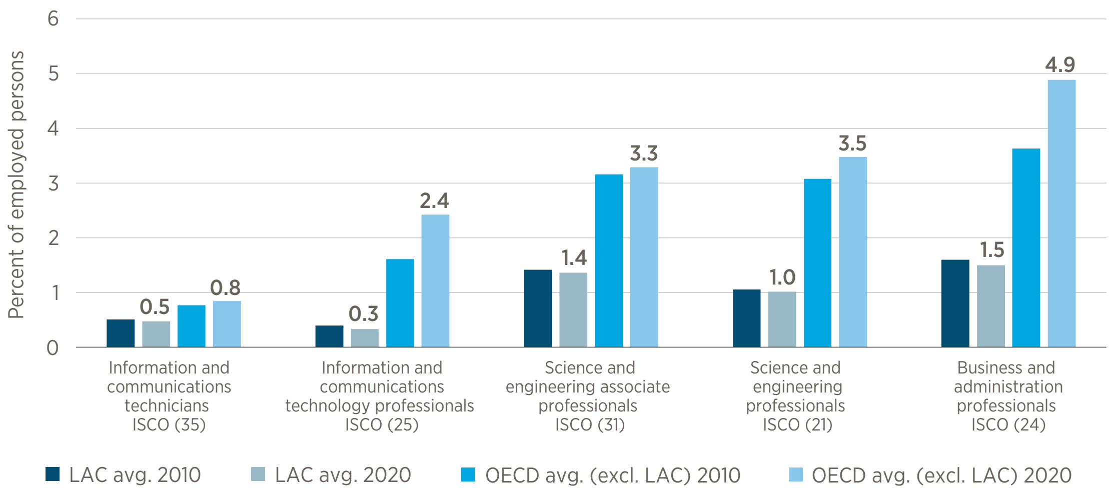


Source: Data were originally extracted from OECD.AI Policy Observatory, available at https://oecd.ai/en/data?selectedArea=ai-jobs-and-skills&selectedVisualization=ai-related-online-course. This site has been updated and the data is no longer available. Please refer to the underlying source of data: Coursera, available at https://oecd.ai/en/coursera.
Notes: The country with the lowest proportion of people enrolled in an AI, for example, receives a value of 0 for that category and the country with the highest proportion received a 1. Values between 0 and 1 are assigned accordingly to the rest of the countries.

Workforce: technicians and professionals in ICT

Pisu et al. (2021) claim that a comprehensive set of skills are needed to maximize the potential benefits to digital technologies. The authors group skill sets into three broad categories: i) generic skills to use basic digital technologies, ii) technical and professional skills (ICT specialists), and iii) managerial skills and other complementary soft skills such as communication and teamwork. Figure 1.12 shows the portion of the workforce that has a job as an ICT technician, ICT professional, science and engineering associate professional, and business and administration professionals. Since the data are by occupation, the people employed as ICT technicians, for example, could be employed in any sector throughout the economy, not just in the ICT sector. Over the last decade, the portion of the workforce employed as an ICT professional grew in the OECD while it remained stagnant in LAC. Yet, there is a very small portion of the workforce employed as an ICT technician in both regions. The stagnation in LAC may reflect the small portion of the population with a tertiary degree in a closely related field of study.

FIGURE 1.12 PERCENT OF EMPLOYED PERSONS WORKING AS ICT TECHNICIANS OR PROFESSIONALS AND OTHER SELECTED OCCUPATIONS, 2010 (OR EARLIEST YEAR AVAILABLE) AND 2020 (OR LATEST YEAR AVAILABLE)

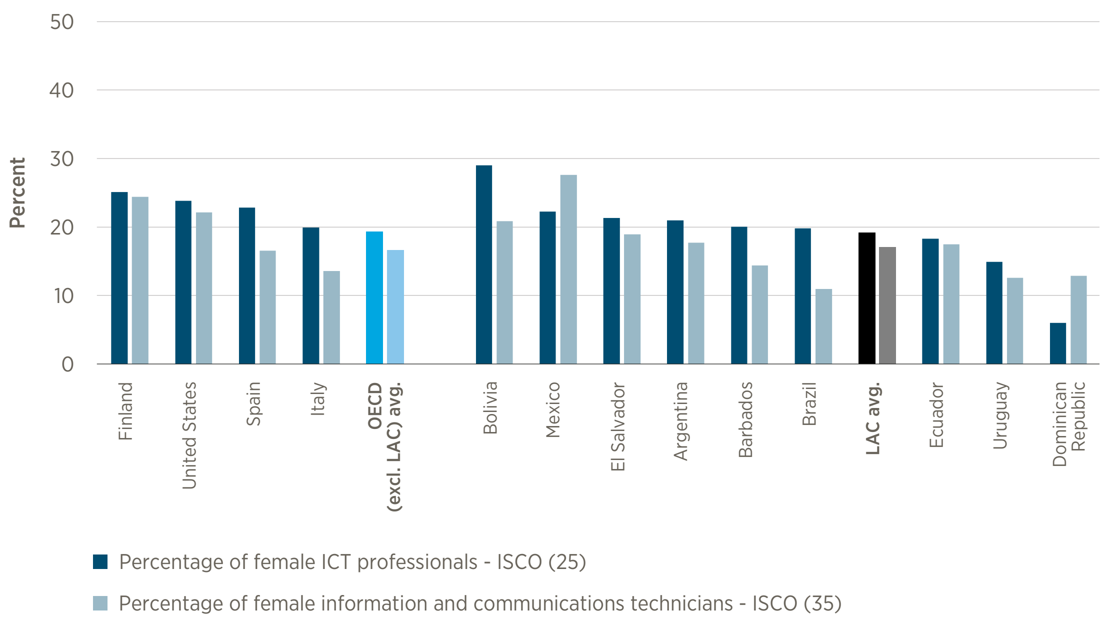


Source: Calculations based on data from the International Labour Organization Statistics (ILOSTAT) database, available at https://ilostat.ilo.org/.

Notes: The indicator "employment by sex and occupation"—International Standard Classification of Occupations (ISCO) level 2 (thousands)—is defined by the International Labour Organisation (ILO) as follows: "The employed comprise all persons of working age who, during a specified brief period, were in one of the following categories: a) paid employment (whether at work or with a job but not at work); or b) self-employment (whether at work or with an enterprise but not at work). Data are disaggregated by occupation according to the latest version of the International Standard Classification of Occupations (ISCO) available for that year and presented for a selection of categories at the 2-digit level of the classification." (Extracted from https://www.ilo.org/shinyapps/bulkexplorer52/?lang=en&segment=indicator&id=EMP_TEMP_SEX_OC2_NB_A). At the 2-digit level, the occupational classification spans by sectors. So, ICT technicians or professionals could be employed in sectors throughout the economy, not just in the ICT sector. For example, production and specialized services managers characterized by ISCO-08 at the 2-digit level as 13 can be further broken down into the three digit level as: 131 production managers in agriculture, forestry and fisheries, 132 manufacturing, mining, construction, and distribution managers, 133 ICT service managers, and 134 professional services managers. Countries were excluded if the sum of the employed in the different occupations was off by more than 3,000 when compared with the total provided by the ILO. Regional averages are based on countries for which data were available. The OECD average excludes LAC member countries.

There have long been gender imbalances in all STEM fields of study and the technology industry is notoriously male dominant. Figure 1.13 shows that the percentage of employed ICT technicians and professionals who are female is well below 50 percent in both LAC and OECD countries. In this respect, the issue is not that the LAC region underperforms with respect to another region with a greater portion of advanced economics, the issue is global and difficult (although, not impossible) to address. A recent study has shown that exposing female bachelor's students in an introductory course to charismatic, successful, and inspiring women (role models) who graduated from the same university in a major typically male dominated, increased the chances that they would choose to major in that field of study (Porter and Serra, 2020).

FIGURE 1.13 PERCENT OF ICT PROFESSIONALS AND TECHNICIANS WHO ARE FEMALE, 2020 (OR LATEST YEAR AVAILABLE)

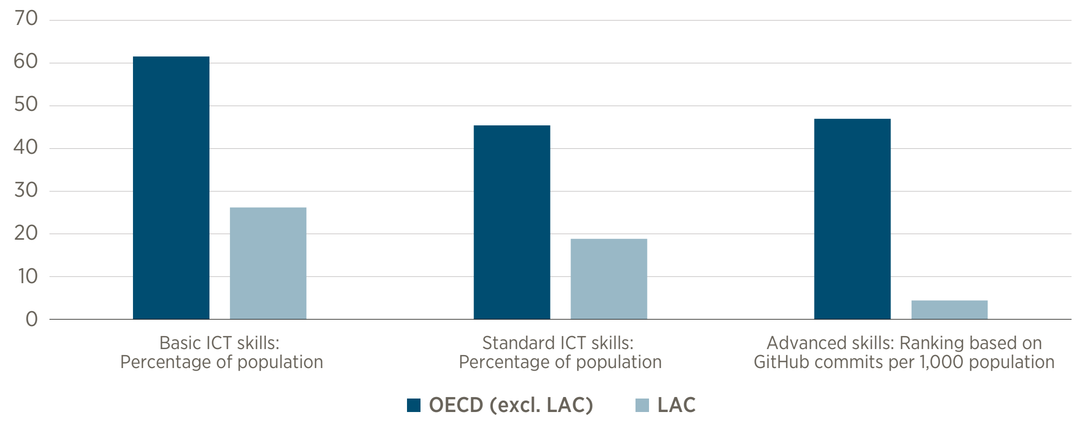


Source: Calculations based on data from ILOSTAT, available at https://ilostat.ilo.org/.
Notes: It follows the same description for the indicator "employment by sex and occupation – ISCO level 2 (thousands)" by the ILO described in Figure 1.12. Regional averages are based on countries for which data were available. The OECD average excludes LAC member countries.

Digital/tech skills penetration

As pointed out by Pisu et al. (2021) a strong set of basic digital skills across an economy are very important for supporting further uptake of digital technologies. Figure 1.14 shows that there is a gap between the OECD and LAC at every level of digital skill (basic, standard, and advanced), although the gaps tend to increase as the skill level also increases. This remains a challenge for firms that would like to adopt the most advanced digital technologies.

FIGURE 1.14 DIGITAL TALENT GAPS BETWEEN THE OECD AND LAC, SELECTED SKILLS



Sources: For the basic and standard ICT skills, the authors used data from the ITU ICT SDG indicators, available at https://www.itu.int/en/ITU-D/Statistics/Pages/SDGs-ITU-ICT-indicators.aspx. In the case of advanced skills, data from the Portulans Institute and STL (2021) also commonly referred to as the Network Readiness Index (NRI) were used.

Notes: For the ITU data, the LAC countries included in the average when data are available are: Brazil (2020), Chile (2017), Colombia (2019), Costa Rica (2018), Ecuador (2020, Jamaica (2018), Mexico (2020), and Peru (2019). The OECD is missing data for Australia, Canada, Israel, New Zealand, and the United States. The OECD average excludes LAC countries. The latest year for which the data are available is used. For the ITU data the cut-off is 2015. Average of selected ICT skills (when data are available) from ITU, by level are as follows: i) basic ICT skill: copying or moving a file or folder; sending emails with attached files (e.g. document, picture, video); using copy and paste tools to duplicate or move information within a document; transferring files between a computer and other devices; ii) standard ICT skill: finding, downloading, installing and configuring software; connecting and installing new devices (e.g., a modem, camera, printer); using basic arithmetic formulae in a spreadsheet; creating electronic presentations with presentation software (including text, images, sound, video, or charts). For the Portulans Institute and STL (2021) data, the advanced digital skills is based on GitHub[12] commits and is the simple average of the rankings for LAC countries, except for countries that are missing data, that is, Bahamas, Barbados, Belize, Guyana, Haiti, Nicaragua, and Suriname. The most recent year for which data are available is 2018. The "rank" is the normalized score in the NRI dataset, available at https://networkreadinessindex.org/.

12. GitHub is the world's largest host of source code, and a commit is the term used for a saved change on this platform. Thus, "GitHub commits" refers to the number of commits on the GitHub website that are publicly available. One limitation of the data is that only a minority of GitHub users are geolocated, and therefore the indicator does not concern all commits. However, as pointed out by Ojanperä, Graham, and Zook (2019), this limitation probably does not entail any geographic bias, and the indicator is therefore "an appropriate, if imperfect, proxy for otherwise hard to measure programming skills." (Portulans Institute and STL, 2021: 229).

LinkedIn Data

These days, data held by private sector companies can offer cost-effective and timely alternatives to complement official statistics, and public institutions can benefit from modernizing approaches to data resources and management (Domeyer et al., 2021; European Commission, n.d.). In their Toolkit for Measuring the Digital Economy, the OECD (2018: 10) specifically suggests that the public and private sector should collaborate to, "identify and anticipate the demand for skills and competencies''. In an exciting opportunity provided by a Development DataPartnership formed by the IDB, the World Bank, and private sector actors our successful application granted us access to LinkedIn data on the penetration of digital skills in different industries in LAC countries. The section on digital tech skills and disruptive digital tech skills in selected industries in LAC within this document is based on data provided by LinkedIn and analyzed by us to take a first look at some meaningful dimensions as proxies for the relative availability (or absence) of digital skills.

The advantage of large-scale platform data is that, so long as LinkedIn users are diligent about updating and accurate about reporting the skills they possess, the data are updated in real time. Survey data and their underlying ontological frameworks tend to take longer to collect, update, and process before they can be analyzed. There are, however, several caveats to bear in mind. For instance, LinkedIn coverage of the total workforce in LAC ranges from 1 to 10 percent, depending on the age group (see Figure 3.3 in Zhu, Fritzler, and Orlowski, 2018: 32), and there are differences in the coverage among industries, with notably low coverage in the manufacturing sector. LinkedIn data are self-reported by platform users and while there are some features, such as skill endorsements, there is no truly objective assessment of skill proficiency on a platform where users are often trying to put their best foot forward to advertise themselves to potential employers. Furthermore social desirability bias in self-reported data can vary across cultures (ITU, 2018). An advantage of the LinkedIn data is that, in LAC, it covers more countries and digital skill groups than other sources of data. The analysis of the LinkedIn data presents a foray into a new way to measure and assess the supply of digital skills for more countries and sectors in the region than virtually any other source of data allow. Although limited by specific characteristics of the data, still more aggregate than would be ideal, the fervent hope is that initiatives like this one can be further developed to gain even more meaningful insights from LinkedIn (or other) large-scale platform data.

BOX 1.2 LINKEDIN METHODOLOGY

There are a few things that need to be described in some detail to understand how LinkedIn converted data from its platform into data that can be used to form the graphs in this section to gain insights about digital skills penetration in different countries and sectors. To form digital (and other) skills groups, LinkedIn extracts detailed individual skills from members' profiles and classifies them into more meaningful skills groups, based on likelihood of co-occurrence within profiles (Zhu, Fritzler, and Orlowski, 2018). Digital skills have been grouped by LinkedIn into two very aggregate groups: i) disruptive tech skills and ii) digital tech skills. See the notes below the graphs for details about skills groups and Appendices 2 and 3 for the LinkedIn definitions for each skill group.

LinkedIn ascertains the global average penetration of the skill group and the relative skill group penetration by country and industry. This allows a simple comparison about whether skills penetration is above or below the global average. In the data shown here, a black line has been added to Figures 1.15 to 1.17 to denote visually when the penetration of tech or disruptive tech skills is above the global average (that is, when they are greater than 1). It is important to note that the relative skill group penetration rate is computed by dividing country penetration rates by global average penetration rates for only overlapping occupations. This means that the global penetration rate can vary by country, therefore the relative penetration rate is not always taking a consistent comparison.[13]

The following section presents the relative skill penetration of tech and disruptive tech skills for selected industries/sectors[14] in 18 LAC countries. In the following graphs, we used the LinkedIn data to analyze the presence of digital skills in the industrial sector, in selected traditional services, and in knowledge intensive based services. Distinct patterns of digital skill penetration across the different industry groups are notable. Appendix 4 presents disruptive tech skills and tech skills by country.

13. This is noted in the LinkedIn skills penetration methodology section under the Development Data Partnership page, available at https://docs.datapartnership.org/. Note that it is required to log in to see the methodology.

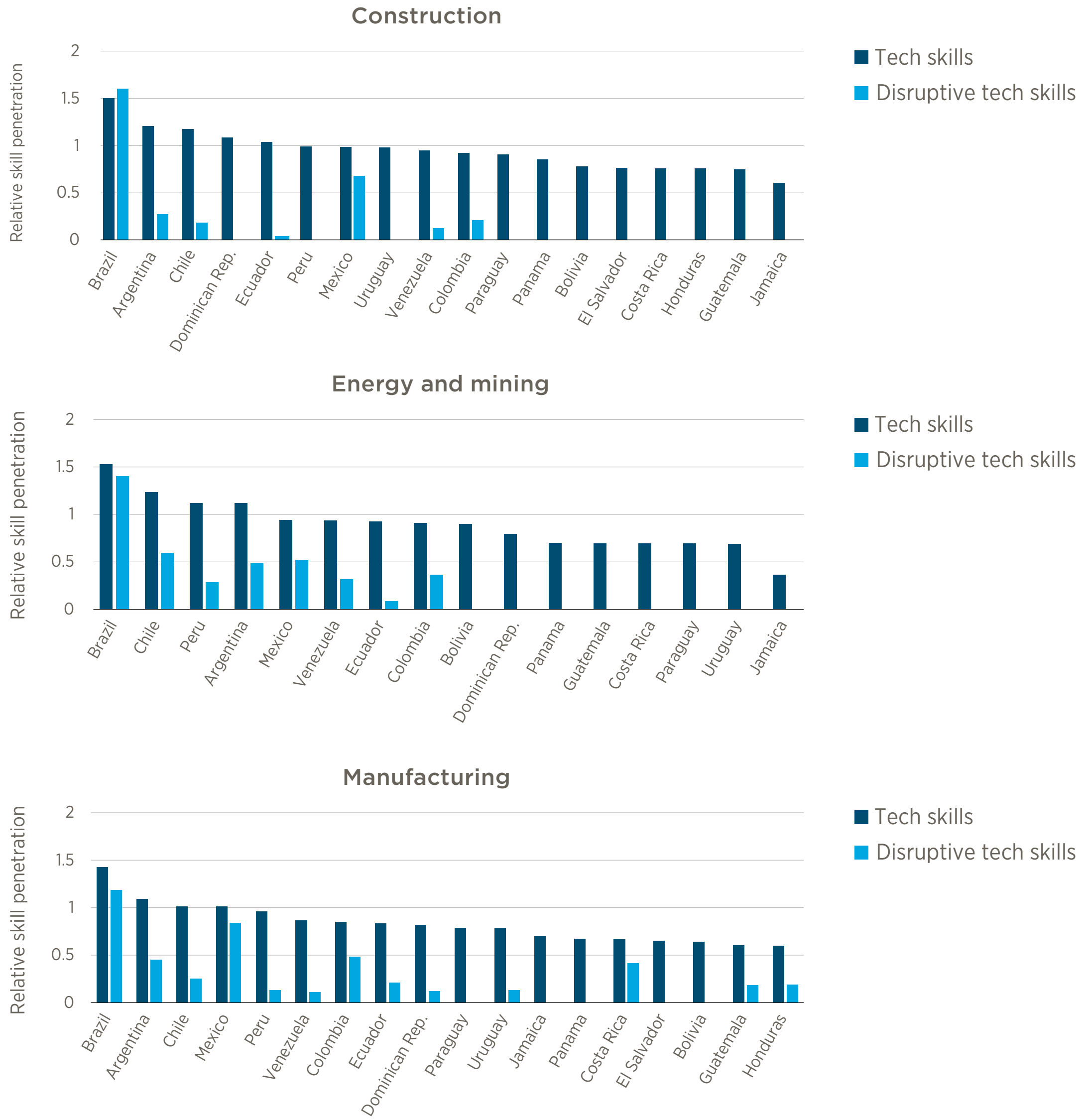
14. Industries have been defined by LinkedIn and may not be consistent with other statistical classifications for industries.

Digital tech skills and disruptive tech skills in selected industries in LAC

Firms furthest from the frontier of best practices, report insufficient financing and lack of human resources (to a lesser extent than insufficient finance) as some of the main obstacles to integrating new digital tools (Basco and Lavena, 2021). Based on the LinkedIn data on tech skills and disruptive tech skills we can observe in Figure 1.15 that Brazil is the only country in the LAC region with both tech and disruptive tech skills above the global average in each of the selected industrial sector (i.e., construction, energy and mining, and manufacturing). Several countries in the region do not appear to have disruptive tech skills in the selected industrial sectors.

The presence of tech skills and disruptive tech skills in the services sector is quite heterogeneous, as expected. Figure 1.16 shows that in industries that were crucial during the pandemic, such as the health care industry, no country in the region appears to have disruptive tech skills penetration above the global average. In the education sector, which often had to be held remotely and in virtual digital settings during the pandemic, even the penetration of tech skills is typically below the global average, with the exception of Brazil. Tech skills and disruptive tech skills are often below the global average in recreation and travel in LAC countries, where tourism is an important part of the economy, and a similar story plays out in retail.

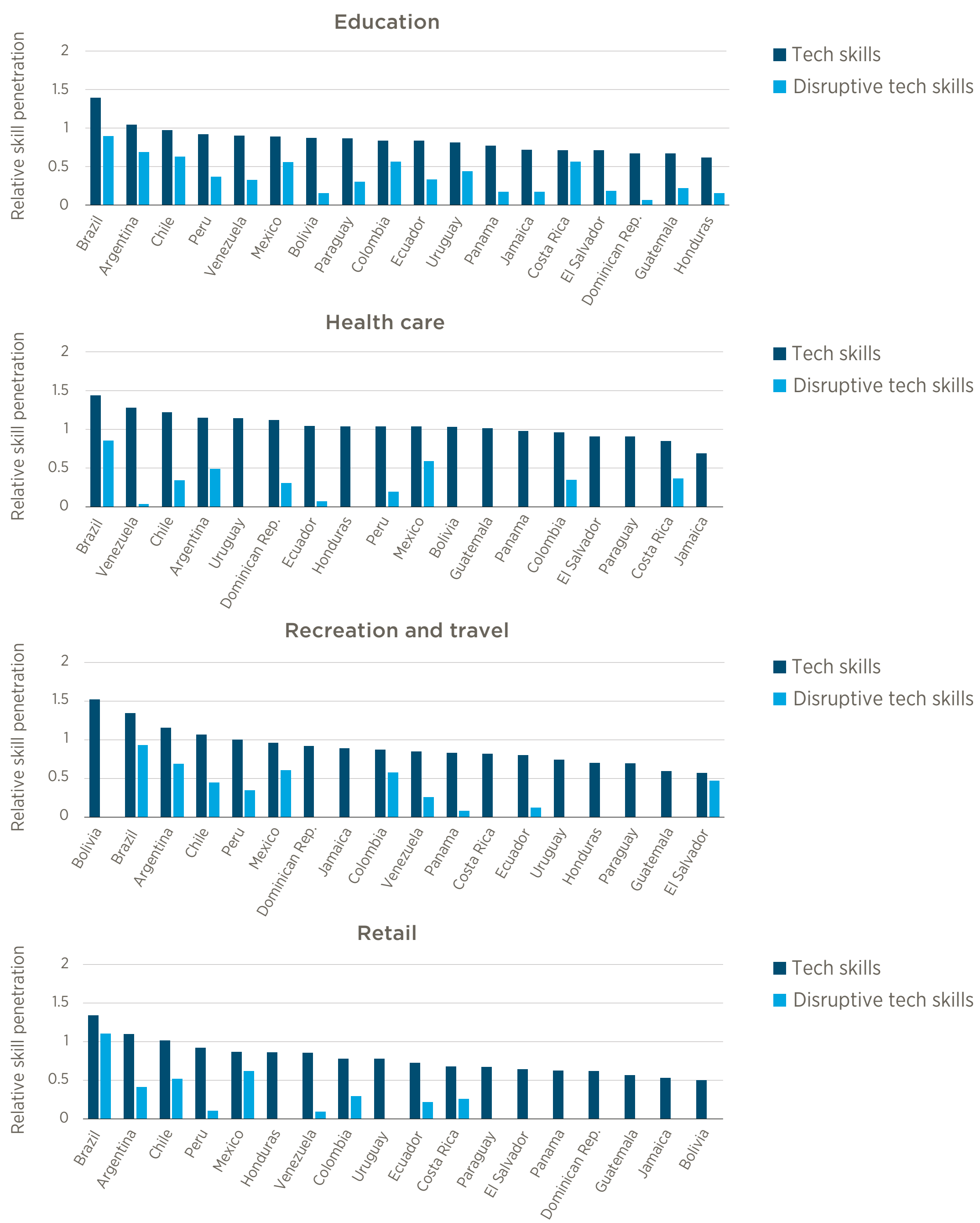
FIGURE 1.15 TECH SKILLS AND DISRUPTIVE TECH SKILLS IN SELECTED INDUSTRIAL SECTORS IN LAC



Source: LinkedIn skills penetration data obtained via the Development DataPartnership, available at https://datapartnership.org/. All data have been processed, analyzed, or graphed, so it does not share original data.

Notes: Disruptive tech skills include the following skills groups: aerospace, engineering, AI, data science, development tools, fintech, genetic engineering, human computer interaction, materials science, and nanotechnology and robotics (see Appendix 2 for the exact LinkedIn definitions of terms in each disruptive tech skill group). Tech skills include the following skills groups: animation, computer graphics, computer hardware, computer networking, data storage technologies, data-driven decision making, digital literacy, enterprise software, game development, graphic design, information management, mobile application development, scientific computing, signal processing, social media, software development life cycle (SDLC), software testing, system administration, technical support, web development, web hosting (see Appendix 3 for the exact LinkedIn definitions of terms in each digital tech skill group).

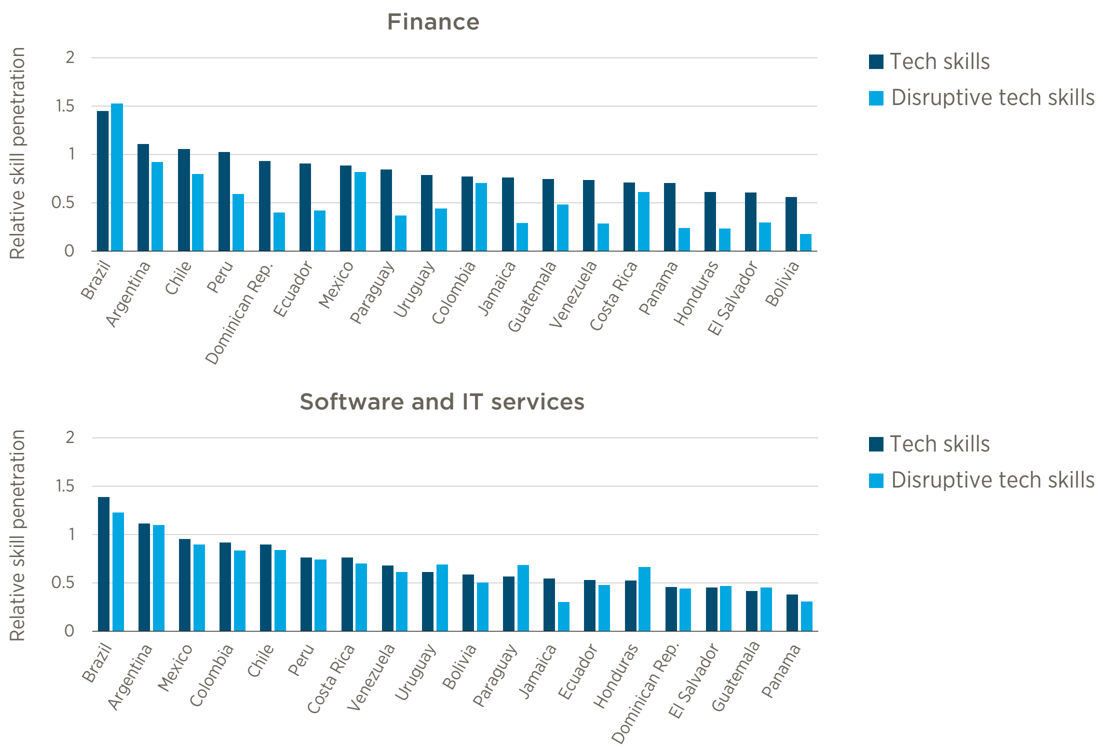
FIGURE 1.16 TECH SKILLS AND DISRUPTIVE TECH SKILLS IN SELECTED SERVICE INDUSTRIES IN LAC



Source: LinkedIn skills penetration data obtained via the Development DataPartnership, available at https://datapartnership.org/. All data have been processed, analyzed, or graphed, so it does not share original data.
Notes: This figure follows the same skill groups for tech skills and disruptive tech skills described in Figure 1.15.

Only in Figure 1.17, which presents the services industries that would be considered part of Knowledge Intensive Business Services (KIBS), we see that there is a consistent presence of disruptive tech skills in countries throughout the region. Yet, for most countries, the penetration of these types of skills still tends to be below the global average.

FIGURE 1.17 TECH SKILLS AND DISRUPTIVE TECH SKILLS IN SELECTED KIBS IN LAC

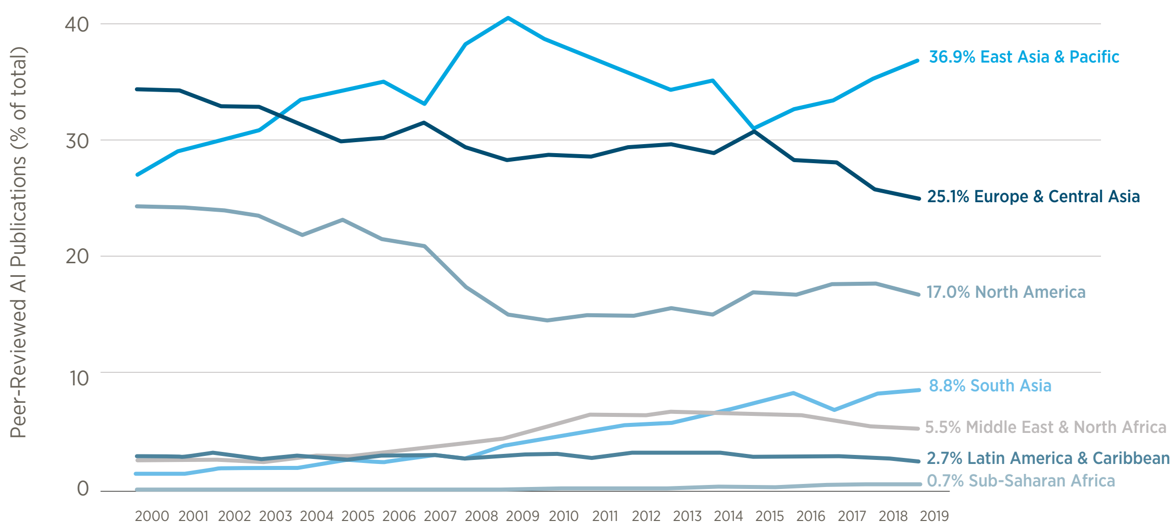


Source: LinkedIn skills penetration data obtained via the Development DataPartnership, available at https://datapartnership.org/. All data have been processed, analyzed, or graphed, so it does not share original data.
Notes: This figure follows the same skill groups for tech skills and disruptive tech skills described in Figure 1.16.

Frontier knowledge: publications and patents

One way to assess knowledge and contribution to knowledge at the frontier is via scientific publications. Partly because AI is a technology with potentially very wide applications and implications in health, transport, and the environment (just to name a few), the OECD includes a measure of citations of AI publications in its roadmap to measuring the digital economy (OECD, 2020a). Figure 1.18 shows that less than 3 percent of the world's peer-reviewed AI publications are from LAC, and that the region's relative contribution over the last 20 years was flat. South Asia and East Asia and the Pacific made strides in their relative contributions to knowledge at the frontier of AI.

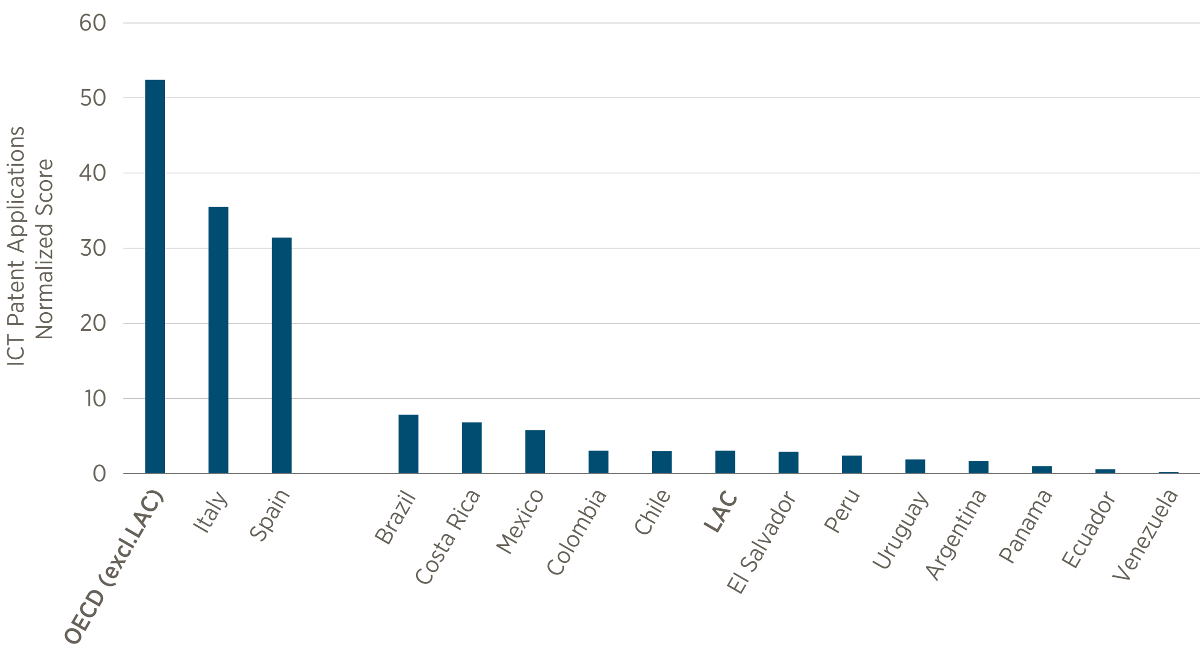
FIGURE 1.18 PEER-REVIEWED AI PUBLICATIONS (PERCENTAGE OF TOTAL) BY REGION, 2000–19



Source: Excepted from Zhang et al. (2021).

The OECD's roadmap to measuring the digital economy similarly includes and indicator on ICT patents, because competing in ICT requires innovation (OECD, 2020a). Patents have long been a marker to stake out intellectual property rights and claims over particular innovations. The OECD (2020a) notes that with respect to ICT in particular, many countries are starting to bundle their intellectual property (IP), so for example, trademarks (indicators of design IP) are also important in this realm. The NRI normalized scores for ICT Patent Cooperation Treaty (PCT) patent applications, and the LAC region's normalized patent applications fall well short of benchmark regions, such as the OECD (see Figure 1.19).

FIGURE 1.19 ICT PCT PATENT APPLICATIONS, NORMALIZED SCORE



Source: Portulans Institute and STL (2021).

Notes: Normalized scores are based on the following original sources: World Intellectual Property Organization (WIPO) PCT data, sourced from https://www.oecd.org/sti/inno/intellectual-property-statistics-and-analysis.htm; population data was sourced from the World Bank's development indicators, available at https://databank.worldbank.org/source/world-development-indicators. The International Patent Classification (IPC) classification is discussed in Inaba, and Squicciarini (2017).

2 Digital Technology Adoption in Firms

In the context of the COVID-19 pandemic, digital technology adoption is increasing. But many obstacles, including lack of quality connectivity and sufficient digital talent, still hamper their wider adoption and effective use (Pisu et al., 2021). Monitoring the adoption and use of digital technologies in firms is crucial to identify digital technology adoption gaps between frontier firms and other firms, and surmounting these gaps is key to releasing productivity gains in many economies today (OECD, 2020a). There is a documented pattern of positive relationships between ICT adoption and productivity in academic literature (Goldfarb and Tucker, 2019). Based on an analysis of data from 20 European countries and 22 industries over the period from 2010 to 2015, Gal et al. (2019) identified that greater digital technology adoption in an industry is associated with higher multi-factor productivity growth for the average firm. In OECD countries, use of platforms is associated with increased productivity and the effect appears to be the greatest for small firms with fewer than 10 employees (Costa et al., 2020 as cited by OECD, 2021). Among European countries, there is a correlation between a higher portion of firms adopting ICT services (i.e., cloud computing and business management software) and smaller gaps in labor productivity between small and large firms (Hallward-Driemeier et al., 2020).

This chapter presents a series of indicators on digital technology, ranging from the more basic to the most advanced and cutting-edge technologies. Typically, as digital technologies get more advanced, the gaps between the LAC and OECD countries widen. Furthermore, among advanced digital technologies gaps between LAC and the OECD in the development of platform technologies (i.e., Mobile App development) are smaller than for advanced robotics which are typically operational technologies used in the manufacturing industry. This may have to do with the productive structure of some LAC countries, since their economies do not have large manufacturing industries.

While the selection of indicators attempts to cover advanced and up-and-coming technologies such as the IoT[15] and augmented virtual reality, some digital technologies are easier

15. Even though we have alluded to IoT before, it is central to the present chapter and as such it seems timely to define it. Following the OECD (2020a: 21) IoT refers to “an ecosystem in which applications and services are driven by data collected from devices that act as sensors and interface with the physical world.” IoT is expected to become a central element of the infrastructure of the digital economy, powering innovations such as telemedicine and autonomous vehicles (OECD, 2020a).

to proxy via indicators that suggest adoption in firms without a direct measure. While it is not possible to observe adoption of IoT for most firms in the region, IoT penetration can be indirectly observed by measuring counts of subscriptions (e.g., SIM cards) enabling machine-to-machine (M2M) connections, which are part of the underlying infrastructure of IoT. Other digital technologies, such as augmented virtual reality, are harder to proxy. Figure 2.1 outlines the structure of this chapter on digital technology in firms.

FIGURE 2.1 STRUCTURE OF CHAPTER 2

Digital Technology Adoption in Firms

Source: Authors' elaboration.

Note: For a better visualization of this interactive figure, please download the PDF

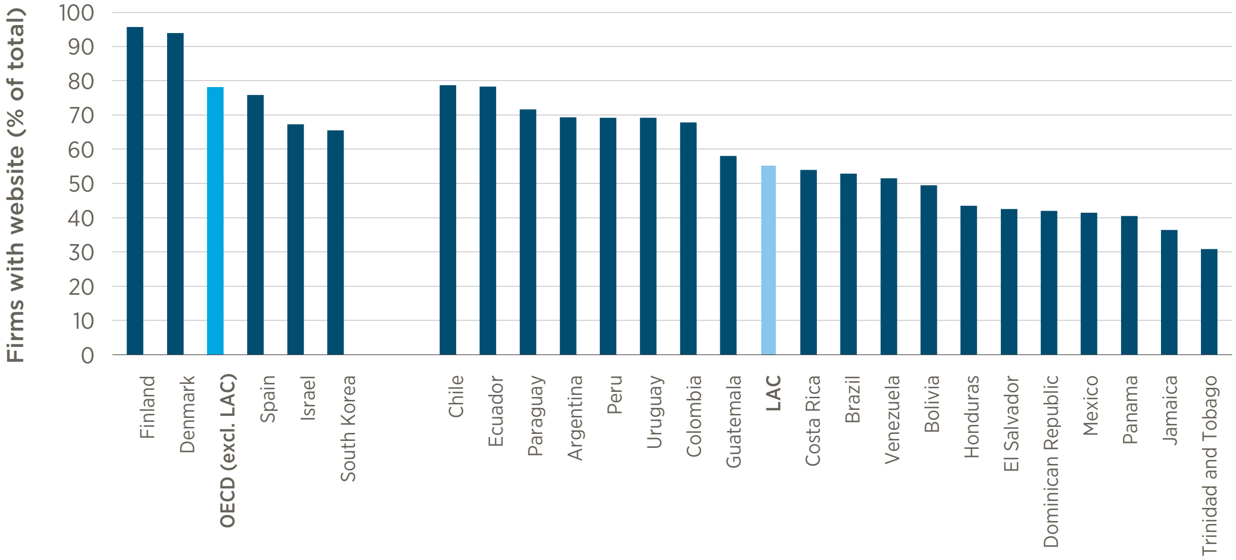
Before proceding it is worth noting that for many countries in the region, there is insufficient data to be able to ascertain the true levels of digital technology adoption such as the digital technology uptake by sector or firm size. When the data have been vetted and are housed in a comparable international database, there are often few LAC countries for which data are available and the data are sometimes outdated. This highlights the importance of data collection efforts in the region. Therefore, Boxes 2.1, 2.2, and 2.3 within the current chapter highlight some of the IDB's own efforts to collect data on digital technology adoption in firms in the LAC region. While these data are often not drawn from representative samples, they provide useful information about different dimensions of digital technology adoption.

Basic Technology Adoption Indicators

Monitoring the uptake of digital technologies in firms helps structure policymaking in closely related areas to gauge priorities and stimulate enabling conditions conducive to supporting firms in their efforts to adopt digital technologies, such as skill development (OECD, 2020a). In the immediate aftermath of the pandemic, year-on-year comparisons (April 2019 to April 2020) showed large surges in the presence of e-commerce websites in Brazil, Chile, Colombia, and Mexico (ECLAC, 2020). In Latin America, more generally, 28 percent of closed micro, small, and medium enterprises (MSMEs) reported that they set up an online presence or website, which was higher than any other region, the next highest being Europe with 27 percent.[16] This digital progress was prompted by the conditions of the pandemic. Firms were essentially forced by the circumstances to digitalize in order to reach customers to sell products and/or services. In Figure 2.2, which present the data pre-pandemic, it can be observed that just over half (55 percent) of firms in LAC had their own website, compared to nearly 80 percent of firms in the OECD. Several sources now show that firms that were digital before the pandemic were more resilient along a number of dimensions, for example, they had less dramatic losses in sales and layoffs (see UNIDO, 2021; IDB, 2022).

16. Based on data collected via a survey conducted jointly by Facebook, OECD, and World Bank (2020).

FIGURE 2.2 FIRMS WITH A WEBSITE (PERCENTAGE OF TOTAL), 2018

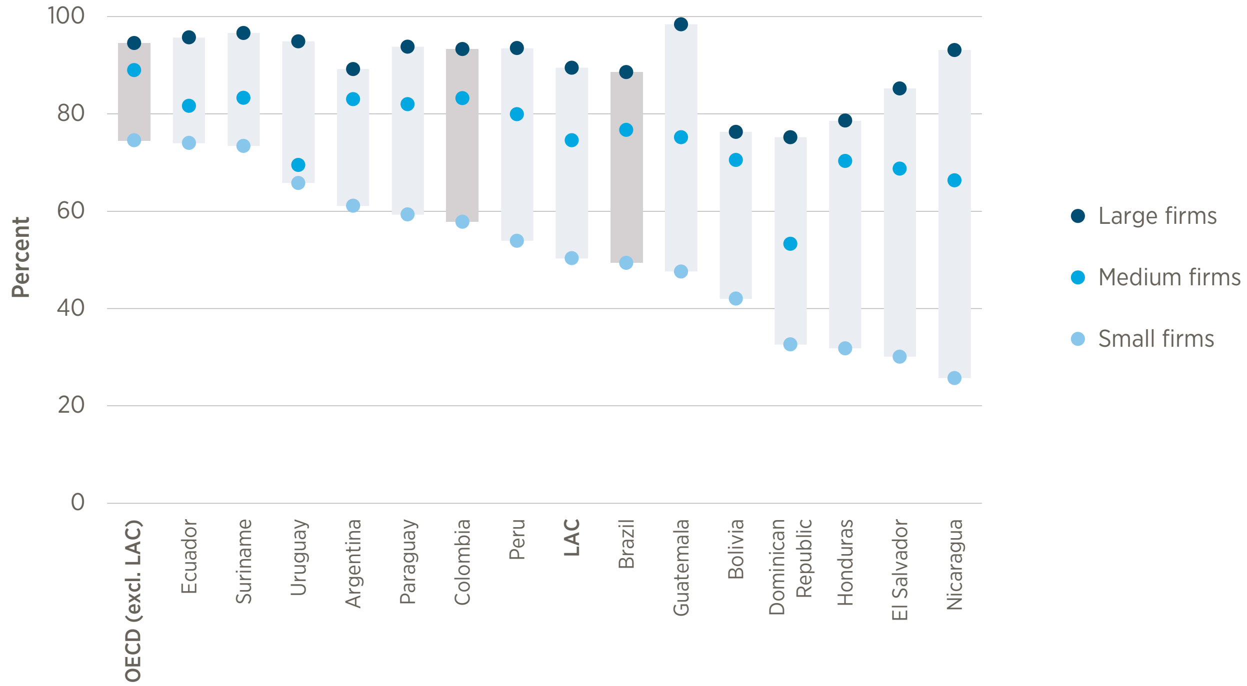


Source: Dutta and Lanvin (2020).
Notes: Original data sources include the OECD Telecommunications and Internet Statistics, available at https://www.oecd-ilibrary.org/science-and-technology/data/oecd-telecommunications-and-internet-statistics/ict-access-and-use-by-businesses_9d-2cb97b-en; and the World Bank Enterprise Surveys, available at https://www.enterprisesurveys.org/en/enterprisesurveys. Data is taken from 2018 or the latest year for which there is data available. In the case of the NRI, 2009 was used as the cut-off year.

Figure 2.3 illustrates the difference between large, medium and small firms in the adoption of even relatively basic digital technologies. Large and medium firms in the LAC region are on par (in most cases) with average adoption rates in the OECD. It is the small firms in LAC that are dragging the averages shown in Figure 2.3[17] down. Often, it is not possible to parse the data by firm size (or for other dimensions, such as rural/urban) and so it is important to bear in mind that this type of heterogeneity likely persists for all digital adoption indicators.

17. The original sources used by the NRI for the data that populate Figure 2.2 were consulted to ascertain data disaggregated by firm size to populate Figure 2.3.

FIGURE 2.3 PERCENT OF FIRMS HAVING THEIR OWN WEBSITE, BY FIRM SIZE, 2019 OR LATEST YEAR AVAILABLE



Sources: The World Bank Enterprise Surveys (available at https://www.enterprisesurveys.org/en/enterprisesurveys) were used for the following LAC countries and years: Argentina (2017), Bolivia (2017), Dominican Republic (2016), Ecuador (2017), El Salvador (2016), Guatemala (2017), Honduras (2016), Nicaragua (2016), Paraguay (2017), Peru (2017), Suriname (2018), and Uruguay (2017). The OECD Telecommunications and Internet Statistics (available at https://www.oecd-ilibrary.org/science-and-technology/data/oecd-telecommunications-and-internet-statistics/ict-access-and-use-by-businesses_9d2cb97b-en) were used for Brazil (2019), Colombia (2018), and the OECD average, which excludes LAC countries and the following countries for which data are missing for 2019: Australia, Canada, Finland, Iceland, Japan, South Korea, New Zealand, Switzerland, and the United States.
Notes: The World Bank Enterprise Surveys define firm size as small (5–19), medium (20–99), and large (100+). In contrast, the OECD defines firm size as small (10–49), medium (50-249), and large (250+).

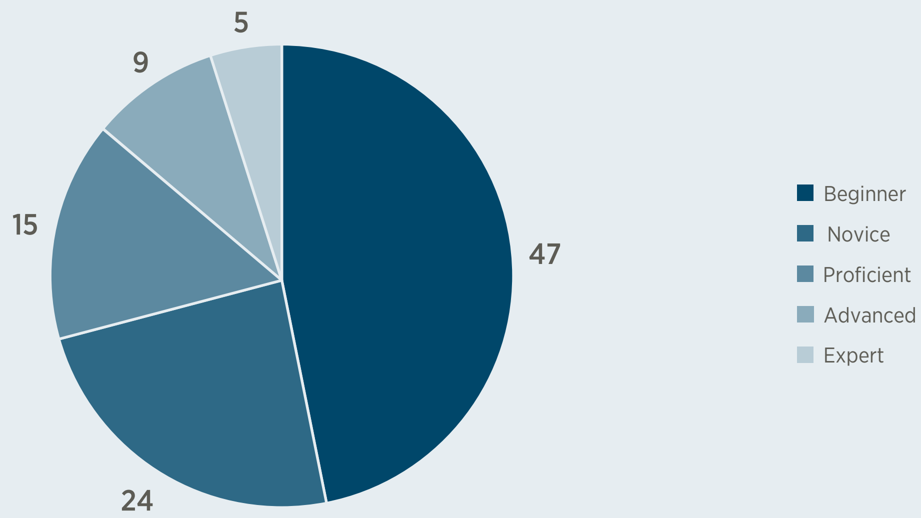
BOX 2.1 CHEQUEO DIGITAL: A DIGITAL MATURITY SELF-DIAGNOSTIC TOOL FOR MICRO SMALL AND MEDIUM ENTERPRISES (MSMEs)

First developed in Chile, the digital maturity self-diagnostic tool "Chequeo Digital" helps MSMEs gauge their digital maturity and then directs them to appropriate support services. With support from the IDB, Chequeo Digital was replicated in 12 LAC countries and in two distinct regions in Argentina. As of April 2022, the tool is available in 13 countries in the region, with three more about to launch it.

The digital maturity self-diagnostic tool is based on a questionnaire that asks MSMEs about adoption of digital technologies and digital skills; digital business strategies and plans for transformation; how/which digital technologies they use in communication channels; the extent of digital integration in business processes, its organization and people/talent; and about the use of data and analytics. The vast majority of MSMEs that have already participated in Chequeo Digital and received digital maturity assessment are from Chile (more than 14,800 MSMEs have participated). There are more than 5,000 MSMEs from other 12 LAC countries (Argentina, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, and Venezuela) who have participated. Figures 2.4 and 2.5 below include data from all 13 countries. Chequeo Digital is also being piloted in Brazil, Colombia, and Uruguay but data collected from firms in these countries have not been included in the mentioned figures.

Digital maturity assessment tools are a useful resource for firms in their digital transformation journey. They are also useful mechanisms to collect data which allow policy makers to design more targeted interventions. For example, the Digital Europe program has just mandated a similar digital maturity assessment tool for SMEs serviced by European Digital Innovation Hubs (EDIH) which are publicly funded networks designed to facilitate digital transformation of European SMES.

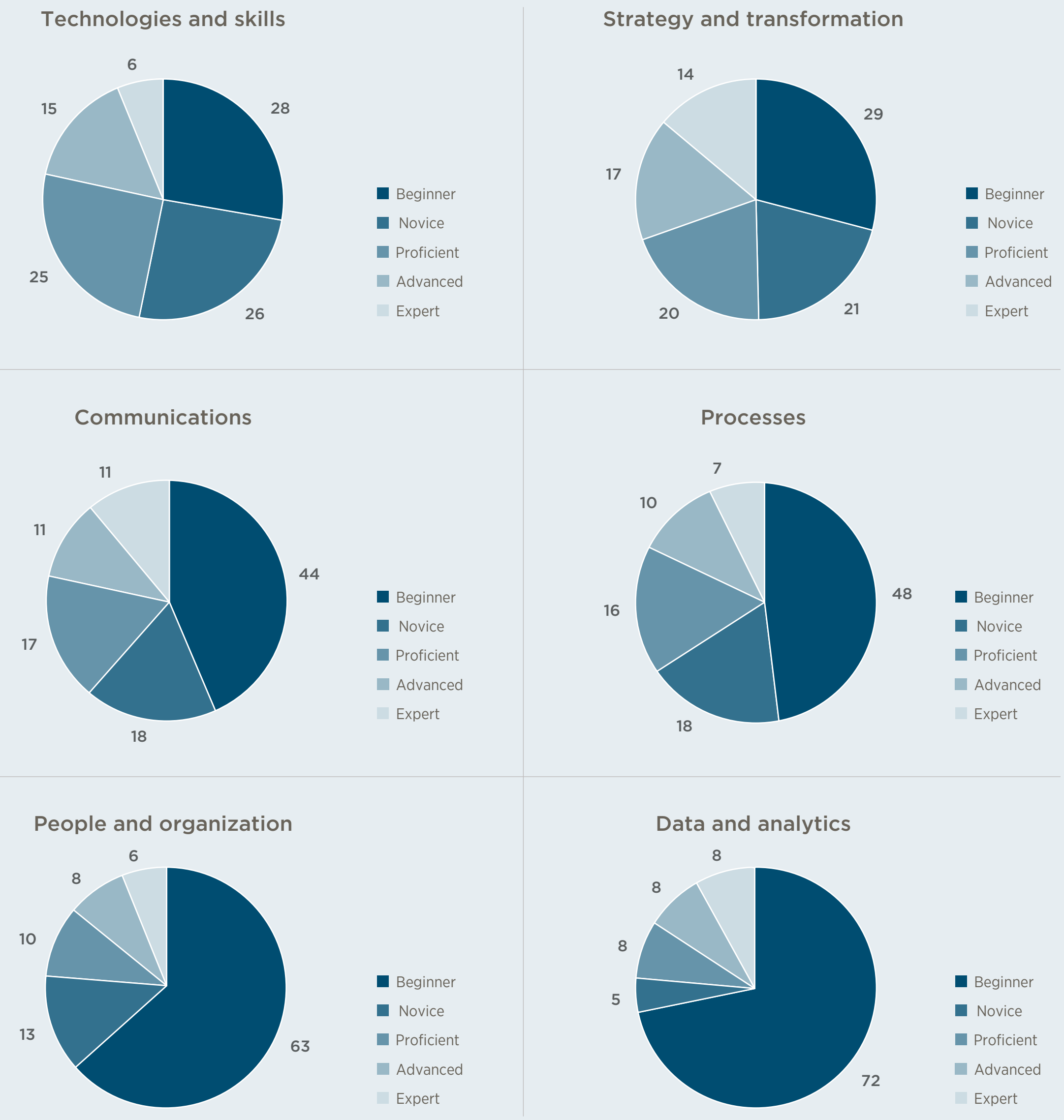
FIGURE 2.4 DIGITAL MATURITY LEVELS OF MSMEs USING CHEQUEO DIGITAL (IN PERCENTAGES)



Source: Chequeo Digital, updated April 2022.

Almost half of the MSMEs that have used Chequeo Digital are in initial stages of digitalization. That means that their digital maturity is very low or, in some cases, virtually non-existent. When we zoom into specific dimensions in terms of digital sophistication and integration of digital technologies into processes and the business model, we can see that a greater percentage of MSMEs are in the initial phases of digital maturity compared to other dimensions such as technology and skills. For example, 63 percent and 72 percent of MSMEs that have used Chequeo Digital are in the initial stages of digital maturity when it comes to the dimensions of people and organizations and data and analytics, respectively.

FIGURE 2.5 DIGITAL MATURITY OF MSMES USING CHEQUEO DIGITAL, BY DIMENSION (IN PERCENTAGES)



Source: Chequeo Digital, updated April 2022.

Source: Authors' elaboration based on data from Chequeo Digital. The instrument is available at https://chequeodigital.net/.

Investment in ICT for innovation in LAC firms

A key driver of digital technology adoption and use in firms is their investment in ICTs, including both physical assets (i.e., ICT equipment and hardware) and intangible assets (i.e., software and databases) (OECD, 2020a). A growing body of literature concludes that digital technology adoption enhances firm productivity, although a variety of factors can mitigate the relationship (see Goldfarb and Tucker, 2019). Intangible assets, which include but are not limited to research and development (R&D) investments, databases, software, and designs are considered key complements to digital technologies and productivity dispersion is growing among firms, especially firms in both digitally intensive and intangible intensive industries (Pisu et al., 2021). This is a concern for nearly all economies, but especially for those that are already dominated by smaller firms with lower levels of productivity. ICT and complementary investments by firms are therefore a key indication of the extent to which firms are adopting digital technologies, which has substantial implications for productivity.

Considering differences in methodological approaches across studies, Cardona, Kretschmer, and Strobel (2013) highlight that an ICT measure (adoption or expenditure) ought to include computing hardware, telecommunications hardware and software, as well as software development and consulting services. Wide ranges in returns to ICT expenditure have been documented, with some firms reaping massive returns while others spending a lot with very little return. Nevertheless, Van Reenen et al. (2010) show that a 10 percent increase in ICT capital is associated with a 0.23 percent increase in firm productivity. The authors describe that firms in the top quintiles of ICT intensity grow faster and are less likely to close and exit the market. Brynjolfsson and Hitt (2003) found that the correlation between ICT investment and productivity is stronger when investment is modeled with a time-lag. Dhyne et al. (2018) found that IT investment explains roughly 10 percent of productivity dispersion across firms in Belgium. Large firms obtain better (more productive) returns to their investment in IT than small firms do. They also found that manufacturing firms typically benefit more from IT investment than service sector firms.

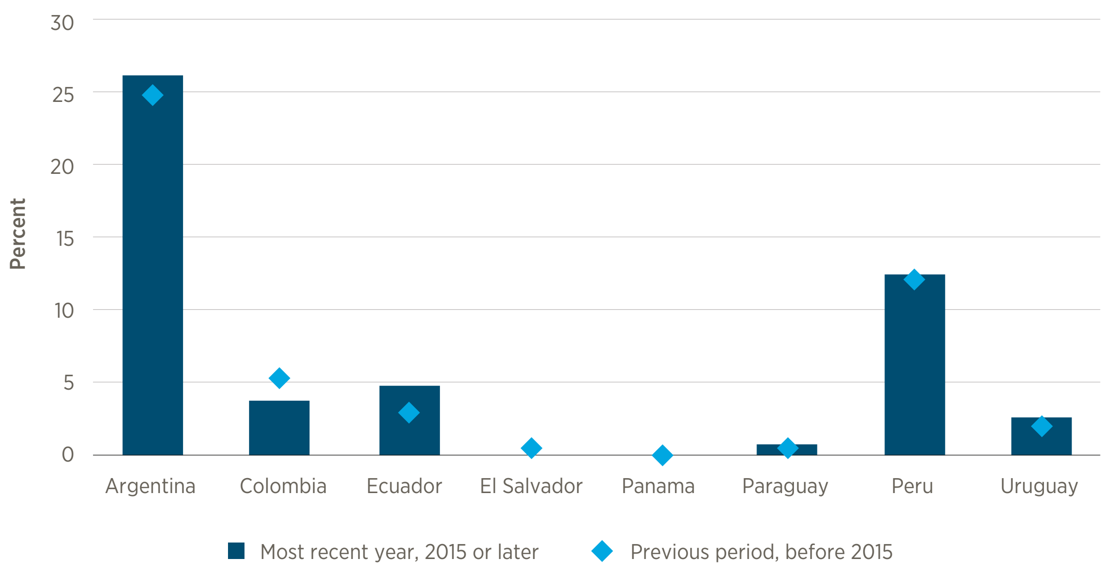
In the case of LAC countries, some similar patterns between ICT expenditure and firm productivity are identified. Brambilla and Tortarolo (2018) find that ICT adoption (which is measured as ICT investment) in manufacturing firms in Argentina, leads to an increase in labor productivity and wages. The effect is heterogenous across firms with larger labor productivity gains for firms that are initially more productive (additional 23 percent) and high-skill firms with a greater presence of advanced human capital (additional 12 percent). Innovation survey data from Uruguay show that ICT investment is associated with higher levels of productivity.

However, in this case, the link between investment in ICT, innovation, and productivity seems to be stronger in the services sector (Aboal and Tacsir, 2017).

Whereas the majority of the studies described above observe the investment in ICT at the firm level, the data presented for LAC countries in Figure 2.4 are from firm level innovation surveys, which measure predominantly innovation expenditure, but tend to break this expenditure into various categories, including but not limited to ICT, R&D, machinery, and equipment.

The portion of manufacturing firms investing in ICT for innovation typically appears to be quite small, except in Argentina and Peru. In Ecuador, the portion of firms investing in ICT for innovation increased over time, but in Colombia the portion decreased. Firms may face financial constraints to investment in ICT for innovation. Given the body of evidence that ICT investments are linked with productivity gains, it would be useful to consider how to support a greater portion of manufacturing firms in LAC in undertaking ICT investment.

FIGURE 2.6 PORTION OF FIRMS INVESTING IN HARDWARE AND SOFTWARE FOR INNOVATION AND MANUFACTURING FIRMS ONLY

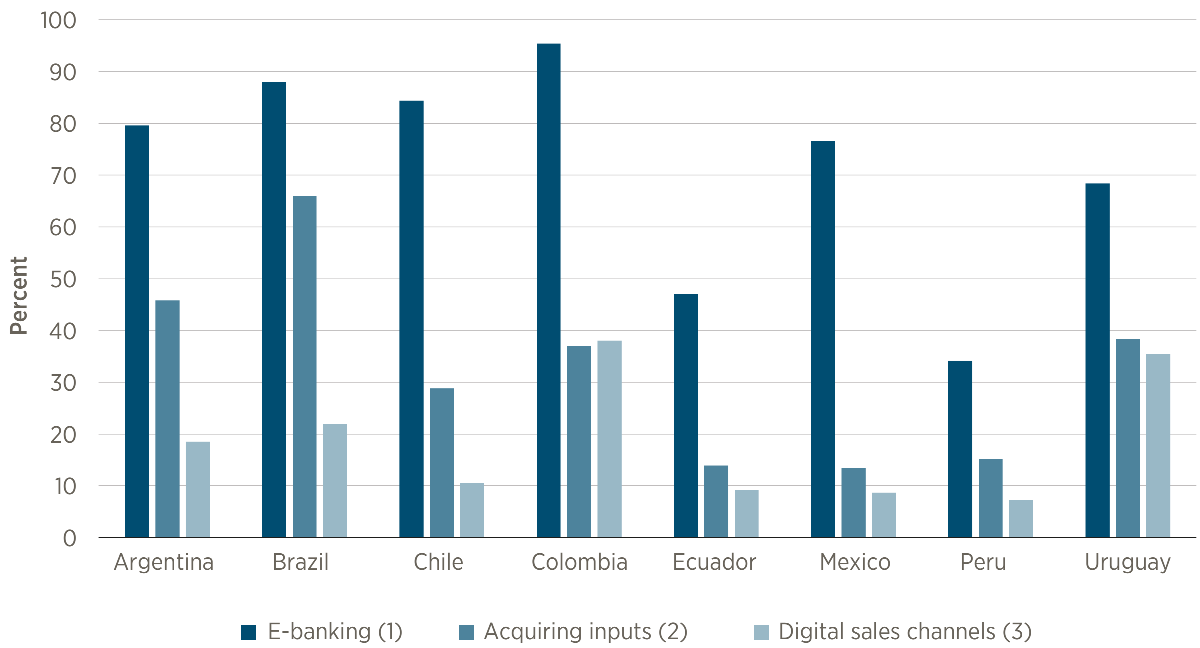


Source: Crespi et al. (2022).
Notes: Survey years are as follows: Argentina, 2013 and 2017; Colombia, 2013 and 2015; Ecuador, 2013 and 2015; El Salvador, 2013; Panama, 2014; Paraguay, 2013 and 2016; Peru, 2012 and 2016; and Uruguay, 2013 and 2016.

Mid-Range Technology Adoption Indicators

The digitalization of firms' productive processes, channels of communication within their supply chains and logistics (i.e., financial transactions), processing and distribution channels, are important measures of digital technology uptake that can indicate advancement in a firm's digital journey (CAF, 2020). This highlights an important issue in terms of the LAC region's data available for measuring digital technology uptake. While there are many countries that measure numerous aspects of national (and sometimes subnational) digital technology uptake, resulting statistics and data are often difficult to compare across countries within the region and also internationally, because different national surveys cover different subsets of firms (i.e., just manufacturing, or just services, or just SMEs), challenging comparability. The IDB is working on another project to identify and document comparable indicators from national sources.

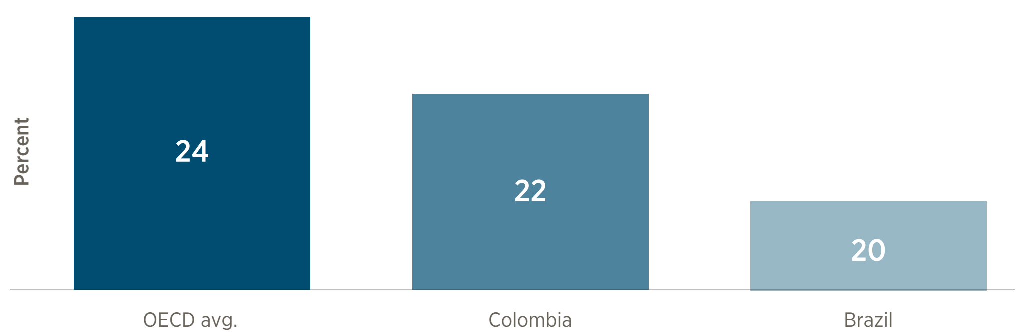
FIGURE 2.7 PERCENT OF FIRMS THAT USE THE INTERNET FOR E-BANKING OR ACQUIRING INPUTS AND THE PERCENT OF FIRMS THAT HAVE DEPLOYED DIGITAL SALES CHANNELS



Source: CAF (2020).
Note: CAF (2020) compiled data drawing on national surveys (for banking and use of internet to acquire inputs). They note that differences between countries may be partly due to the extent to which SMEs are included in the sample.

In 2019, before the pandemic, less than a quarter of small businesses in the OECD and in Latin America made e-commerce sales.[18] While there are very few LAC countries in this dataset, it is worth highlighting the case of Brazil, where only one out of every five small businesses made e-commerce sales in 2019. Even before the pandemic, in 2019, the worldwide value of e-commerce sales from business-to-business (B2B) and business-to-consumer (B2C) was approximately US$26.7 trillion—about a third of global GDP—with B2B representing the overwhelming majority of e-commerce (82 percent) (UNCTAD, 2021b). Despite a spike in e-commerce (growth in commercial websites and online sales) prompted by the pandemic as consumers changed habits, many firms (especially MSMEs) in LAC were not well equipped to adapt, thus suffering high learning costs for which the net effect is still uncertain (ECLAC and IDB, 2021).

FIGURE 2.8 SHARE OF SMALL BUSINESSES MAKING E-COMMERCE SALES IN THE LAST 12 MONTHS, 2019 OR LATEST AVAILABLE



Source: Data from the OECD Going Digital Toolkit, available at https://goingdigital.oecd.org/.
Notes: The OECD average is the sample average for this indicator, based on 31 OECD member countries.

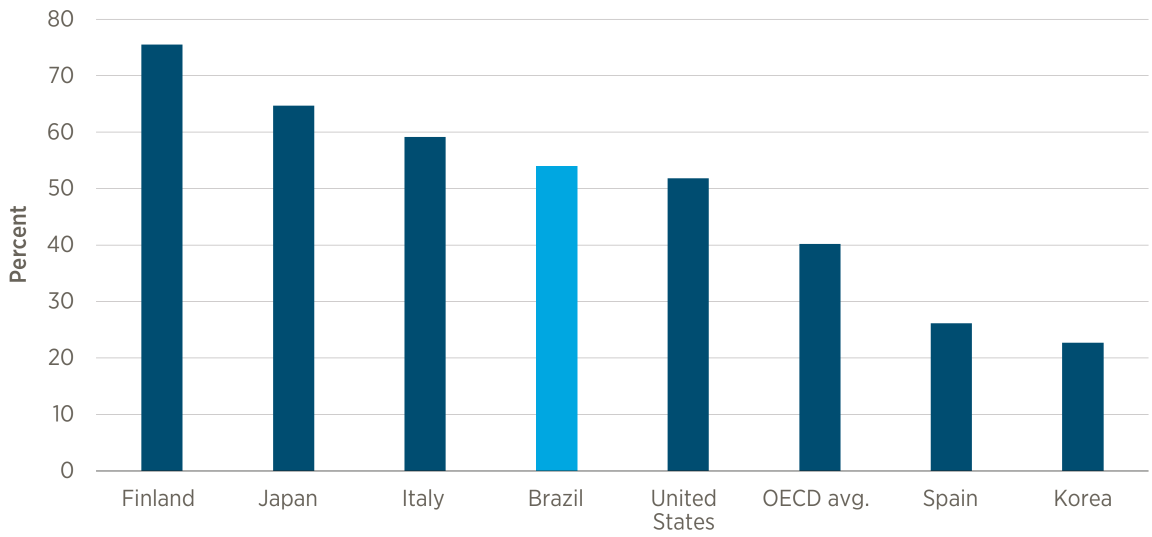
Generally speaking, cloud computing is a unique technology that makes it possible to divorce machinery and equipment from a physical location, thus allowing access to sophisticated technological services without building in-house capabilities (Coyle and Nguyen, 2019). Determinants of successful adoption and implementation of the cloud include managerial capabilities (Garrison, Wakefield, and Kim, 2015 based on a survey of 302 Korean firms), access to

18. E-commerce sales refers to sales transactions enabled by electronic data interchange (EDI) or online platforms.

high-speed broadband (DeStefano, Kneller, and Timmis, 2019) based on data from the United Kingdom), as well as firm size and technological readiness (Oliveira, Thomas, and Espadanal, 2014 based on 369 firms in Portugal).[19]

According to DeStefano, Kneller, and Timmis (2019), the cloud is associated with rather impressive employment increases in young firms,[20] but not necessarily with productivity gains. Bloom and Pierri (2018) find that the youngest firms in the United States have the highest cloud computing adoption rates. The authors contend that cloud computing is a unique technology (compared to computers and e-commerce) because of its appeal to the smallest and youngest firms. Regarding adoption, Figure 2.9 shows that Brazil is competitive with the OECD average in terms of the share of businesses purchasing cloud computing.

FIGURE 2.9 SHARE OF BUSINESSES PURCHASING CLOUD SERVICES, 2020 OR LATEST AVAILABLE



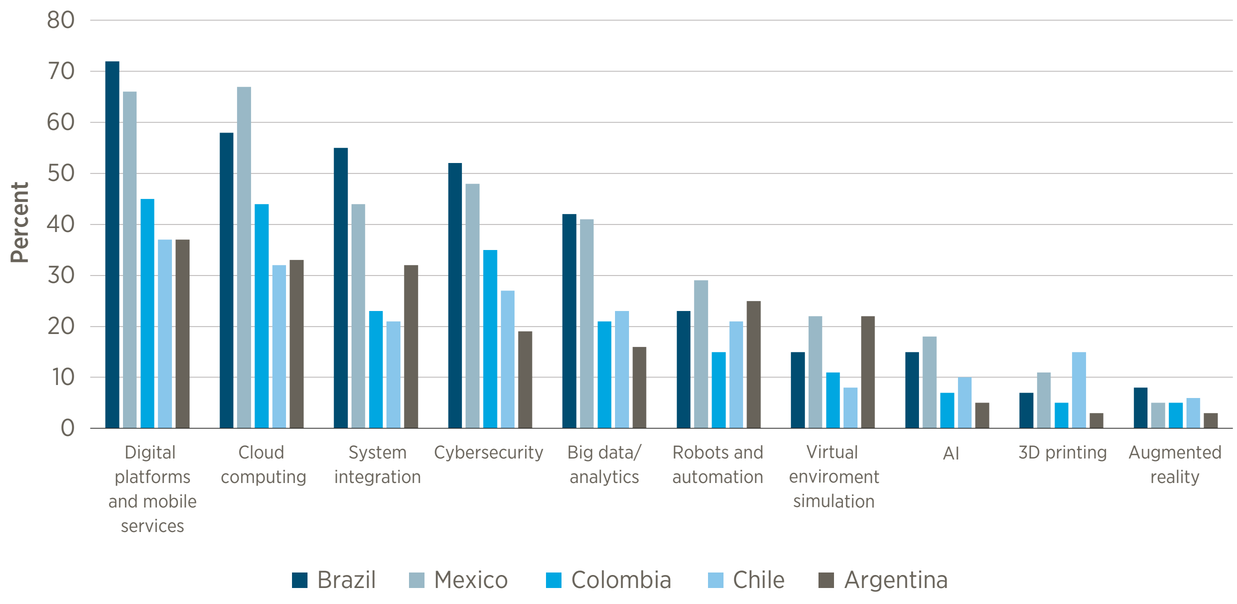
Source: Data taken from the OECD Going Digital Toolkit, available at https://goingdigital.oecd.org/.
Notes: The OECD average is the sample average for this indicator, based on 32 OECD member countries. Data from Brazil and Japan are for 2019; data from Korea and the United States are for 2018.

19. The study by Oliveira, Thomas, and Espadanal (2014), based on 369 firms in Portugal, found that there were sectoral differences with respect to whether support from top management is significant in explaining cloud computing adoption. The authors found that in the services sub-sample the support was significant. This was not the case in the manufacturing sub-sample.
20. To the tune of 13 percent annually between 2008 and 2015 (DeStefano, Kneller, and Timmis, 2019)

Advanced Technology Adoption Indicators

A familiar pattern can be observed in Figure 2.10, which shows how as the sophistication of digital technologies increase, the portion of firms in the LAC region adopting them tends to decrease. These data were collected by an initiative of the IDB's International Trade Unit. The survey sample is not representative, rather it targets firms in sectors most relevant for regional trade integration. As such, the adoption rates in Figure 2.10 should likely be considered upper bounds of digital technology adoption rates in the five LAC countries whose firms were surveyed.

FIGURE 2.10 ADOPTION OF ADVANCED DIGITAL TECHNOLOGIES IN FIRMS OPERATING IN SECTORS RELEVANT FOR REGIONAL TRADE IN FIVE LAC COUNTRIES, 2020

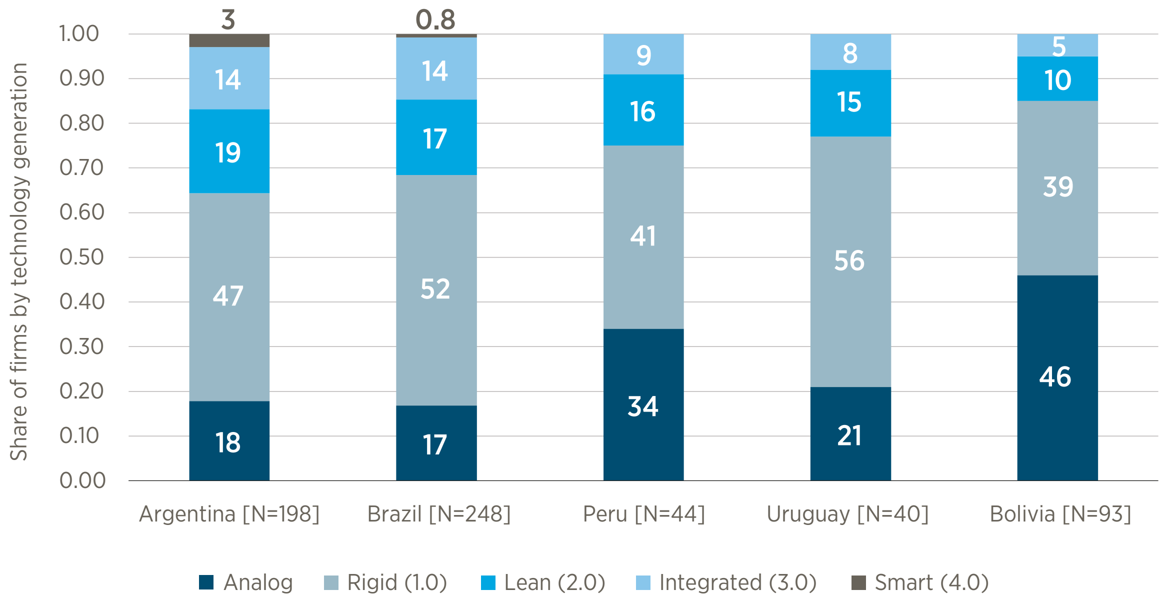


Source: Data are excerpted from Basco et al. (2020: 51).
Notes: Data are from the Technological Adoption, Employment and International Trade (EATEC) survey carried out between 2018 and 2019 at more than 1,100 companies in Argentina, Brazil, Chile, Colombia, and Mexico (between 200 and 250 companies per country) in the most relevant sectors for regional trade integration. The distribution of size among survey respondents is as follows: 72 percent are small or micro enterprises (they have less than 50 employees), 19 percent have between 50 and 200 employees, and only 9 percent have more than 200 employees (Basco et al., 2020).

UNIDO (2021: xvi) defines ADP technologies as those "that result from the combination of hardware (advanced robots and 3D printers), software (big data analytics, cloud computing, and AI), and connectivity (the IoT)". When applied together to manufacturing production, they give rise to the concept of smart production—also referred to as the smart factory, or Industry 4.0 (UNIDO, 2021)

In a survey of firms in developing and emerging economies, UNIDO (2021) found that a very small fraction (just over 1 percent) of surveyed manufacturing firms in Latin America are using what they define as "Fourth Generation–smart production 4.0" digital technologies. Taken together, nearly 30 percent of firms are using integrated (3.0) digital technologies and lean production (2.0) digital technologies (UNIDO, 2021). The sample sizes for individual countries in the LAC region are small but when disaggregating by country it is clear that only firms surveyed in Argentina and Brazil enter into the fourth generation of smart production technologies (see Figure 2.11).

FIGURE 2.11 A SMALL PORTION OF SURVEYED MANUFACTURING FIRMS IN LAC USING INDUSTRY 4.0 TECHNOLOGIES, 2021 (IN PERCENTAGES)

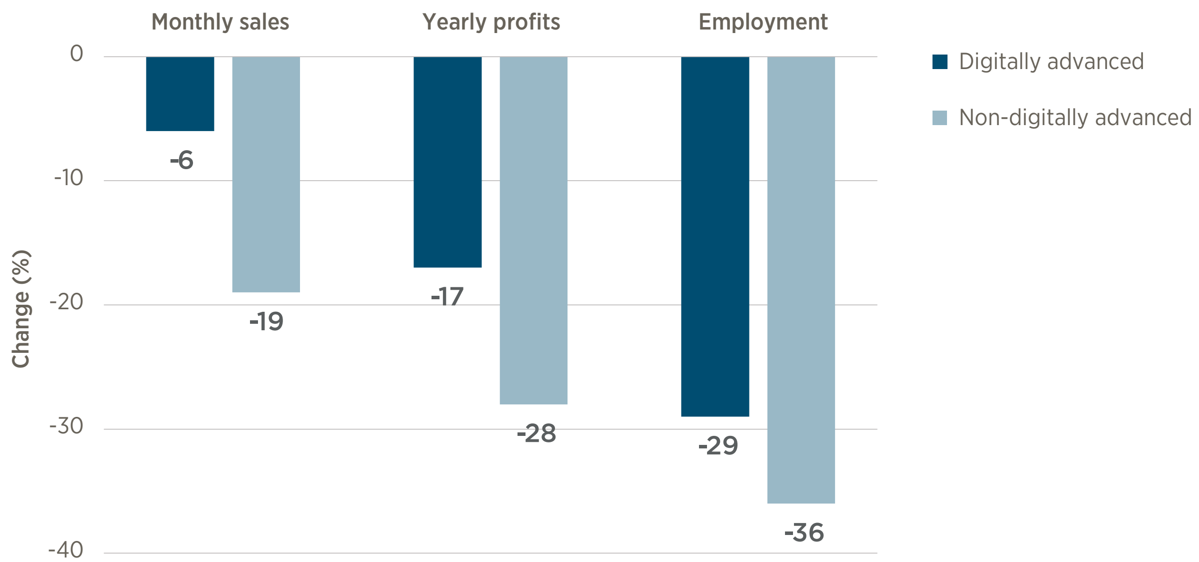


Source: Excerpted from Calza, Lavopa, and Zagato, (2022: 43), based on data collected by UNIDO (2021).
Notes: The sample covers 26 developing and emerging industrial economies (DEIE), seven of which are in Latin America, specifically in Argentina, Bolivia, Brazil, Ecuador, Mexico, Peru, and Uruguay. LAC countries with at least 40 valid responses are presented in the figure. UNIDO (2021) classifies technological generations as analog, rigid, lean, integrated, and smart. The definons of each classification provided by this institution (UNIDO, 2021: 175) are the following: analog "no digital technologies are used during any stage of the production process (e.g., in-person contact with suppliers or via phone: use of machinery that is not micro-electronic based)"; rigid (1.0) "the use of digital technologies is limited to a specific purpose in a specific function and activity (e.g. use of Computer Aided Design (CAD) only in product development, use of non-integrated machines operating in isolation)"; lean (2.0) "Digital technologies involve and connect different functions and activities within the firm (e.g. use of CAD/Computer-aided manufacturing (CAM) linking up product development and production processes; basic automation)"; integrated (3.0) "Digital technologies are integrated across different activities and functions, allowing for the interconnection of the whole production process (e.g. use of Enterprise Resource Planning (ERP) systems; full 'paperless' electronic production control systems; industrial and service robots)"; smart (4.0) "Digital technologies allow for fully integrated, connected and smart production processes, where information flows across operations and generates real-time feedback to support decision-making processes (e.g., digital twins; real-time sensors and M2M communication; collaborative robots (cobots); management decision making supported by big data and artificial intelligence)".

Figure 2.12 is a visual representation of what several studies have found: digital technologies aided firm resilience when facing the pandemic. Surveyed firms in the developing and emerging economies that were more digitally advanced were more resilient, saw smaller drops in sales and profits, and had to let go of fewer workers (UNIDO, 2021). Basco and Lavena (2021) found a surge in the uptake of advanced digital technologies in a subset of firms in a few

Latin American countries (see Box 2.2.). Acknowledging several studies that have revealed increased use of digital technologies and implicit returns, Comin et al. (2022) wanted to find out why some firms implemented digital technologies and others did not. The authors used sophisticated econometric techniques and data from Brazil, Senegal, and Vietnam. They found that firms' technological sophistication before the pandemic influenced the increased use of technologies. In turn, variation in technology adoption during the pandemic itself is related to firm resilience. One implication of these findings could be the self-reinforcing virtuous cycle, whereby firms that "get their foot in the door" will perpetually be advantaged in terms of digital technology adoption.

FIGURE 2.12 DROPS IN SALES, PROFITS AND EMPLOYMENT OF DIGITALLY AND NON-DIGITALLY ADVANCED FIRMS IN DEIES DURING THE PANDEMIC, 2021

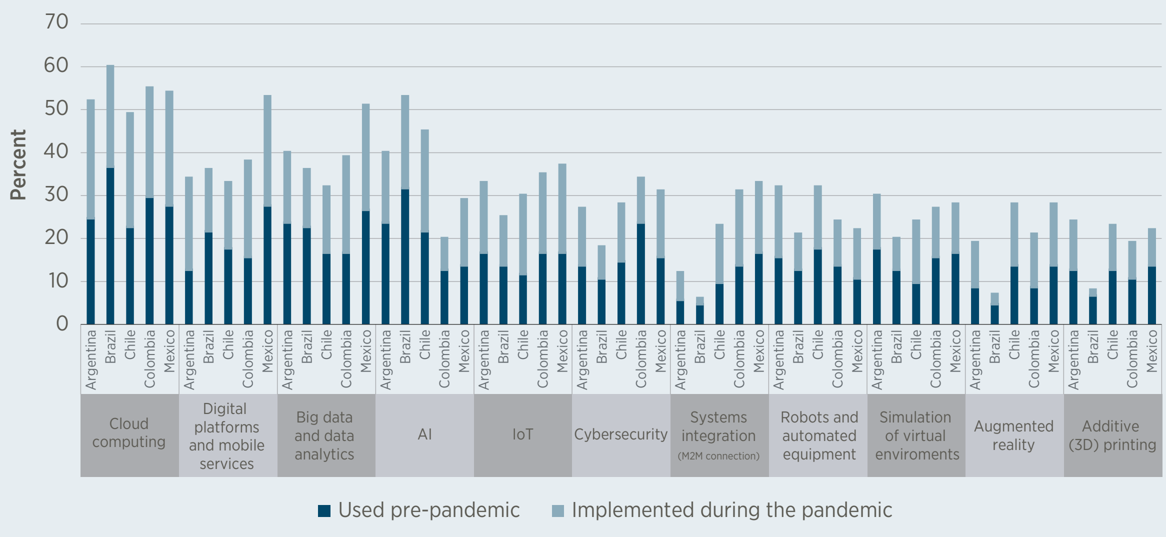


Source: UNIDO (2021: 84).
Notes: Manufacturing firms adopting ADP technologies are considered digitally advanced and non-ADP adopters are considered non-digitally advanced. Change in yearly profits refers to the value of profits in 2020 compared to 2019 (N = 2,303). The change in monthly sales refers to the value of monthly sales the month before the survey with respect to the same month one year before (N = 2,301). The figure also shows the average drop in employment, corresponding to the average share of laid-off workers over the total number of workers in December 2019, considering only firms that declared they have laid off workers since the beginning of the pandemic (N = 1,183). The change in employment refers to total workers who have been laid off due to the COVID-19 pandemic. The sample covers 26 DEIEs, seven of which are in Latin America (Argentina, Bolivia, Brazil, Ecuador, Mexico, Peru, and Uruguay). Only manufacturing firms have been considered (UNIDO, 2021: 84)

BOX 2.2 ADVANCED DIGITAL TECHNOLOGIES IN FIRMS OPERATING IN SECTORS RELEVANT FOR REGIONAL TRADE IN FIVE LATIN AMERICAN COUNTRIES, 2021

Basco and Lavena (2021) document the dramatic surge in the use of several advanced digital technologies in firms in five countries in Latin America (Argentina, Brazil, Chile, Colombia, and Mexico). The EATEC survey conducted by the Institute for the Integration of Latin America and the Caribbean (INTAL at the IDB) in 2019, was adapted for 2020. From June to October 2020, 100 responses were received from each of the five Latin American countries surveyed, for a total of 500 responses. In both years, the survey focused on firms that operate in sectors that are most relevant for international trade. Given the countries and sectors of focus, the results are most likely indicative of the upper bound of firms' technology use in Latin America. Many firms in other sectors and in other countries in the region may have lower levels of technology adoption before and in response to the pandemic. Compared with the use of these technologies pre-pandemic, implementation during the pandemic roughly doubled (Basco and Lavena 2021: 18). While accelerated adoption was notable across all technologies and firms, new advanced technology adoption in small firms was below average in the sample of firms that were surveyed (Basco and Lavena 2021: 19).

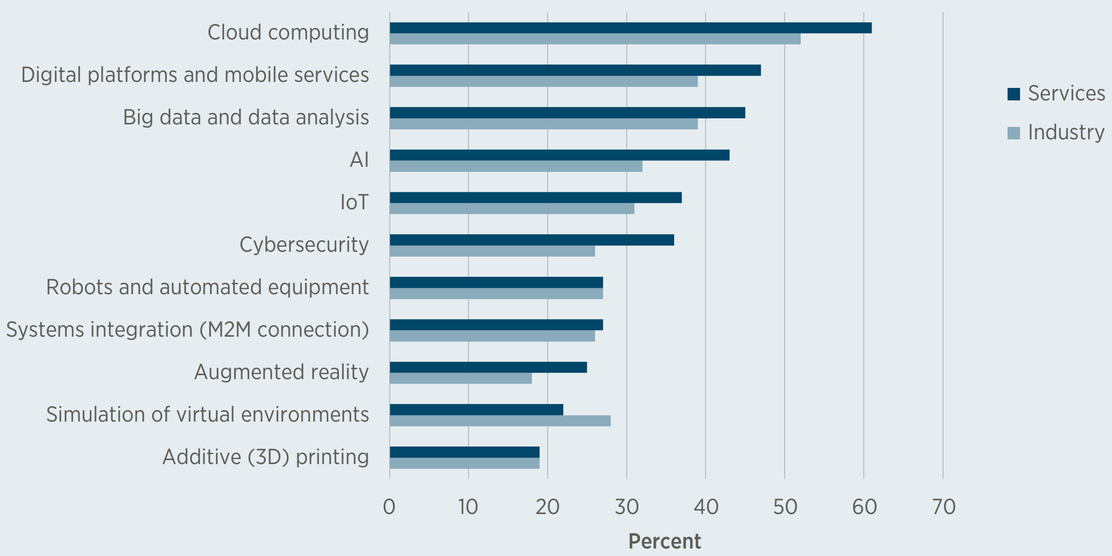
FIGURE 2.13 DRAMATIC SURGE IN ADVANCED DIGITAL TECHNOLOGY ADOPTION IN FIRMS OPERATING IN SECTORS RELEVANT FOR REGIONAL TRADE IN FIVE LAC COUNTRIES, 2021



Source: Data are from Basco and Lavena (2021).

Interestingly, advanced digital technology uptake seems to be slightly higher in responding firms operating in the services sector than respondents operating in industry. A higher portion of responses come from firms in industry. The exact breakdown is as follows: 70 percent of firms were from industries that produce goods (agroindustry; automotive industry; chemical, petrochemical and pharmaceutical; machinery and tools; mining and metalliferous; and optical and medical instruments), and 30 percent of the responses came from firms in knowledge-based services (professionals and consultants in business administration, and computer science and telecommunications). These are quite similar to the services industries for which LAC has the greatest penetration of disruptive digital skills, according to the LinkedIn data presented in Chapter 1. In fact, the analysis shows that in industrial sectors, disruptive digital skills often fall below the global penetration rate or seem to be altogether absent. While there is no way to show causality with the data that we have, it certainly seems plausible that where advanced digital skills are vacuous, advanced digital technology adoption will lag.

FIGURE 2.14 ADVANCED DIGITAL TECHNOLOGY UPTAKE IN FIRMS OPERATING IN SECTORS RELEVANT FOR REGIONAL TRADE BY 2021, BY SECTOR

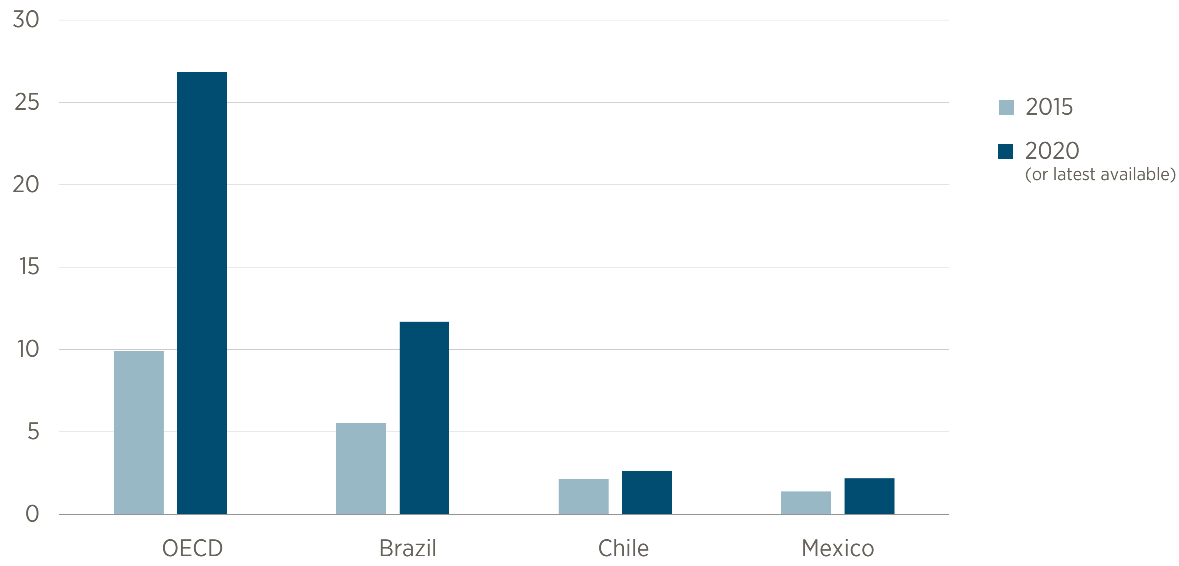


Source: Extracted from Basco and Lavena (2021: 41).
Notes: Data are based on the EATEC survey conducted in 2020. The survey is focused on sectors with greater exporting potential. There are 500 responses (100 firms from each country). Of the total responses, 89 percent of the firms are small (less than 50 employees) or medium (50-200 employees).

Source: Authors' elaboration based on Basco and Lavena (2021).

Direct measurement and observation of the adoption of the IoT is challenging, but a proxy that is commonly used is the number of M2M subscriptions. While incomplete, because M2M is only one element of IoT, it is a helpful indication. M2M is defined as "a communication technology where data can be transferred in an automated way with little or no human interaction between devices and applications." (OECD, 2016b: 9). Regarding the expected impact of this technology for firms, the complementary nature of sophisticated digital technologies may increase as diffusion proliferates.[21] Figure 2.15 shows that M2M subscriptions per 100 inhabitants has grown markedly over the years in the OECD[22] and in Brazil. Nevertheless, the proxy for IoT shows that takeoff in Brazil remains far behind the OECD average and suggests that it is still very nascent in Chile and Mexico.

FIGURE 2.15 M2M: PROXY FOR IoT (M2M SUBSCRIPTIONS PER 100 INHABITANTS)



Source: Data from the OECD Going Digital Toolkit, available at https://goingdigital.oecd.org/.
Notes: Latest data for Brazil are from 2019.

21. For instance, Craglia (2018) speculates that IoT will have an exponential effect on the application of AI technologies to make the most of the potentially explosive amount of data generated through the deployment of sensors. As per the publication, the diffusion of image recognition, machine translation, and natural language processing is really just beginning.

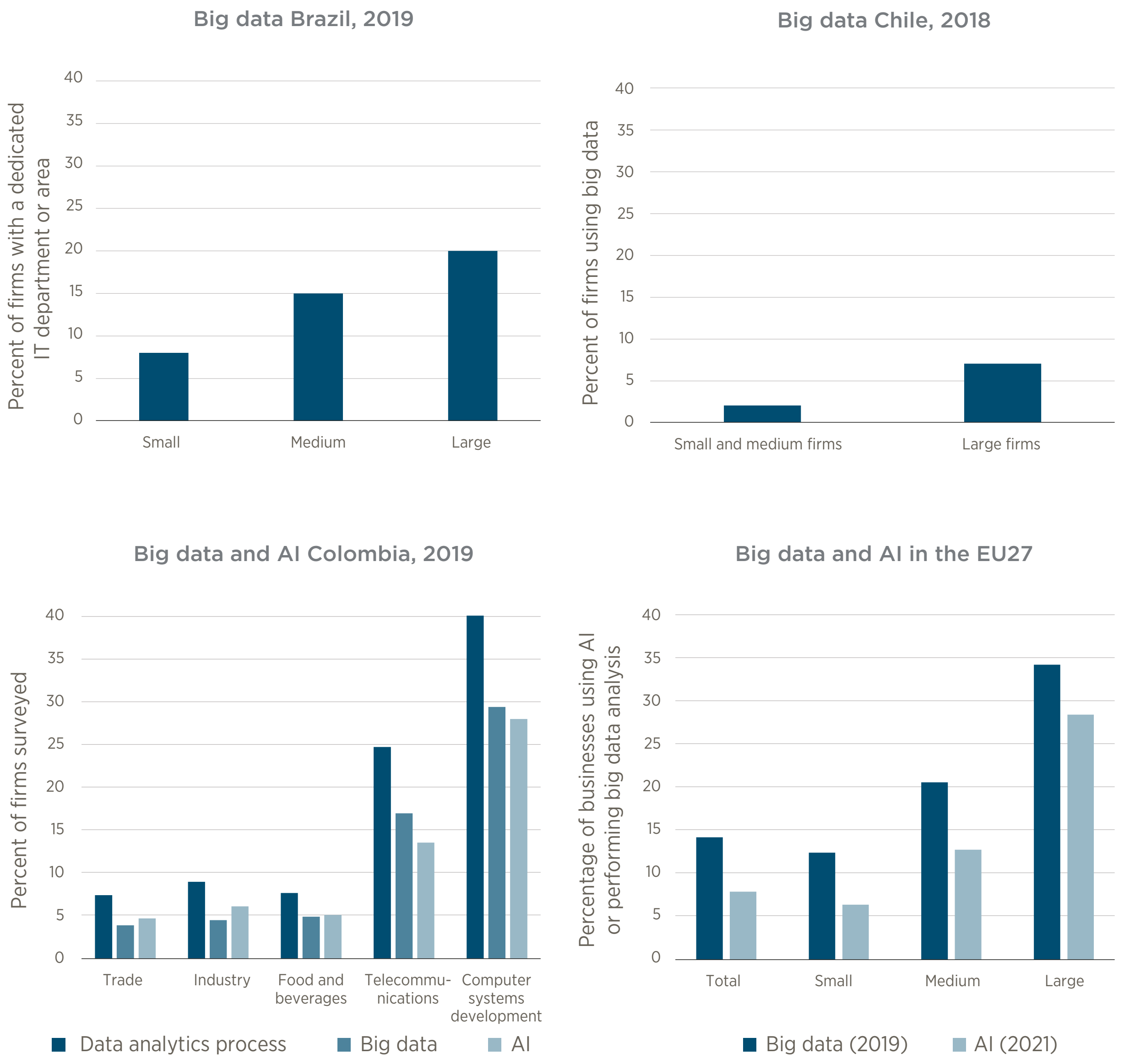
22. The European Commission (2019) found that public support efforts were important in creating the enabling conditions for IoT cluster formation in European countries, and while this support was critical at the beginning, the sustainability of the cluster lies outside the scope of public influence.

Figure 2.16 compiles information from national surveys about the use of big data, data analytics processes, and AI in firms in the LAC region. Data from the EU27[23] are provided as a point of comparison, but it is important to note that the data are from different sources and so they are not easily comparable. For example, firm size in Chile is determined by annual sales, rather than number of employees, and small and medium firms are grouped together. In Brazil, the portion of firms engaging in big data analysis is out of firms that have a designated IT department or area. Clearly, firms with a dedicated IT department (or area) are more likely to have greater digital resources at their disposal than firms that do not. The survey on Information and Communication Technologies in Firms (ENTIC) in Colombia presents the data by industry or sector. In this country, only a selection of services are presented.[24] This serves to highlight that while in the industry sector, for example, use of big data and AI is relatively rare, in firms that belong to the service sector such as computer systems and data processing, the use of these digital technologies is much more frequent, although still less than half of the firms surveyed.

23. The 27 countries that comprise the EU since February 2020.

24. There are more data from other services available in DANE (2021).

FIGURE 2.16 FIRMS USING BIG DATA AND AI IN SELECT LAC COUNTRIES AND THE EU27

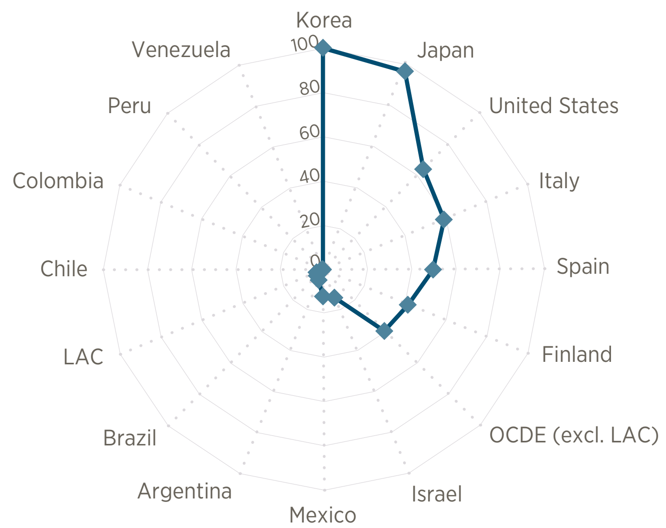


Sources: For Brazil, data is obtained from CETIC.BR available at https://cetic.br/pt/pesquisa/empresas/indicadores/; in the case of Chile, data come froma Survey of Access and Use of ICT in Firms conducted by the Ministerio de Economía, Fomento y Turismo (2020), based on data from 2018; for Colombia, we used data from DANE's ENTIC (2019); and for the EU, we draw data from the OECD.Stat website regarding ICT Access and Usage by Businesses, which is available at https://stats.oecd.org/Index.aspx?DataSetCode=ICT_BUS

Notes: Firm size in Brazil and the EU is defined as follows: small firms are between 10 and 49 employees; medium firms are between 50 and 249 employees; and large firms are those with 250 and more employees. Firm size in Chile is defined as follows: small and medium firms have between 2,400.01 and 100,000 in Chile's unit of account, or Unidad de Fomento (UF), in annual sales. In the case of Colombia, selected services sub-industries are presented.

Much of the discussion surrounding industrial robots and automation focuses on a debate about the potential tradeoffs between productivity gains and employment losses. Some scholars worry about the distribution of productivity gains. Freeman (2015), for example, foresees increased inequality and that the biggest rents will go to the people who own the capital (robots). There is some evidence that the density of industrial robots is associated with increased total factor productivity (TFP). For instance, Autor and Salomons (2018) found that, on average, one additional robot per 1,000 workers is associated with a statistically significant increase in TFP. With regard employment, there are contrasting findings. Acemoglu and Restrepo (2017) found fairly substantial job loss in the United States due to the introduction of robots, but in the German context (robot producer), jobs lost in manufacturing were fully offset by jobs gained in the service sector (Dauth et al., 2017). According to Leigh and Kraft (2018) the global production of industrial robots is highly geographically concentrated and, since software technologies are increasingly relevant for robotics, colocation of firms that develop and produce robots near knowledge and innovation hubs may not be accidental. According to the NRI (Portulans Institute and STL, 2021) the industrial robot density in most LAC economies is virtually non-existent (see Figure 2.17).

FIGURE 2.17 ROBOT DENSITY (RANKED SCORE): NUMBER OF ROBOTS IN OPERATION PER 10,000 EMPLOYEES IN THE MANUFACTURING INDUSTRY, 2019



Source: Portulans Institute and STL (2021).
Notes: The NRI ranked scores are based on data from the International Federation of Robotics (IFR) on the operational stock of industrial robots for 2019, available at https://ifr.org/. For the countries for which IFR has not computed robot densities, data on employment in manufacturing is obtained from the ILOSTAT database, available at https://ilostat.ilo.org/.

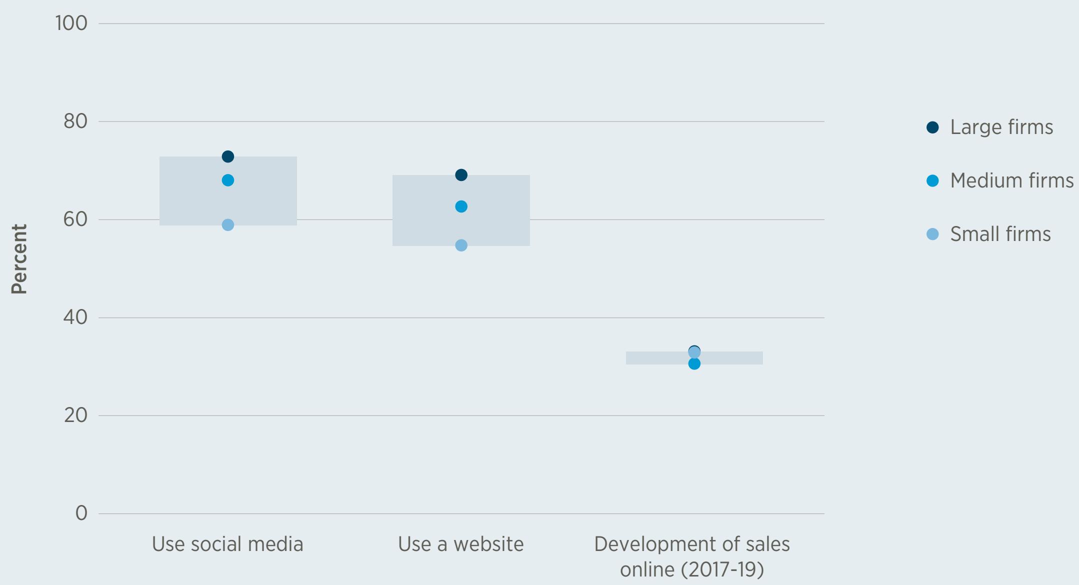
BOX 2.3 DIGITAL UPTAKE IN CARIBBEAN FIRMS

Many small Caribbean economies experienced poor productivity performance for decades, and the global pandemic with its severe consequences for travel and tourism, set some of their economies even further back (Mooney, Rosenblatt, and García Zaballos, 2021). It is estimated that economic activity in the Caribbean fell by almost 10 percent in 2020 (Pereira and Yañez-Pagans, 2021 citing the IMF, 2021). Based on data from the Innovation, Firm Performance and Gender survey (IFPG), nearly all businesses in the Caribbean were negatively affected by the pandemic, but small and women-led businesses were disproportionately affected (Pereira and Yañez-Pagans, 2021). Digital technologies and solutions were a lifeline for small firms around the world (OECD, 2020c), but firms surveyed in the Caribbean were confronted with obstacles to maintaining business (via digital channels), and cited access to digital payments as their second biggest obstacle in 2000, whereas in the survey preceding COVID-19 no firms selected access to digital payments as an obstacle to doing business (Pereira and Yañez-Pagans, 2021). The productivity benefits from digital technologies depend on complementary innovations and investments, for example, intangible capital and skills and organizational changes (Pisu et al., 2021).

The IFPG asked a random sample of formal firms operating in 13 Caribbean countries questions about the use of digital technologies, gender, management practices, innovation, and firm performance. The survey was conducted online from June to November 2020. Due to the timing of its implementation, the IFPG survey included questions about the initial (and expected) impact of COVID-19 on sales, innovation, and digitalization.

Digital technology use in the Caribbean firms appears to follow the familiar pattern observed in the broader LAC region, even though those observations were driven mostly by data from Latin American countries. Digital technology use is less frequent among small firms than large ones. Figure 2.18 shows that the vast majority of large firms use social media (73 percent) and have a website (69 percent). In the case of small firms, just over half (53 percent) use a website and 58 percent use social media. The IFPG survey asks firms about their innovation activities, and when firms answered that they had developed and/or introduced improvements in the sales and marketing of their goods and services in the three previous years (from 2017 to 2019), they were then asked if these improvements were related to the development of sales online. These responses therefore pertain to pre-pandemic circumstances. Differences between firms of different sizes were negligible and a smaller percentage of firms (roughly one in three) made progress in terms of the development of more sophisticated uses of digital technology, such as online sales. Although this does not necessarily account for firms that had already established online sales (with no need for improvement) prior to 2017.

FIGURE 2.18 USE OF DIGITAL TECHNOLOGIES IN CARIBBEAN FIRMS IN 2020, BY FIRM SIZE



Source: Authors' elaboration based on data from the IFPG survey, available at https://torre.nl/IFPGtest10/?section=Innovation.

Notes: Via the following link https://torre.nl/IFPGtest10/?section=Sales%2520and%2520Marketing, it is possible to explore the visualization of the data collected via the IFPG. Data about firms' awareness and expected impact of data and digital technologies for business intelligence are presented by country, with breakdowns by firm size, sector, and gender of the owner.

3 Cybersecurity

Cybersecurity is a complex issue of technology, professional know-how, and policy. This chapter covers cybersecurity from a few angles. It argues that cybersecurity is not only only a matter of the confidentiality of information, but also about the integrity and availability of data and systems. Businesses that fail to have secure systems in place may face debilitating consequences in terms of loss of reputation and/or clientele, as well as operational and financial costs. To this it must be added that as digital information is increasingly integrated into daily work, businesses have become far more vulnerable to cyberthreats, and attacks are becoming much more sophisticated (Gartner, 2022). That is, businesses are increasingly at risk of falling subject to the whims of hackers, which may, for example, seek ransom, publish sensitive information, or vandalize digital assets. Hacked businesses may subsequently result in costly lawsuits (see, for example, De Vynck, 2021).

FIGURE 3.1 STRUCTURE OF CHAPTER 3

Source: Authors' elaboration.

Note: For a better visualization of this interactive figure, please download the PDF

Increase awareness

As mentioned in the introduction of this chapter, businesses are increasingly falling prey to hackers. In particular, small businesses tend to underestimate their cyber risks. A survey of small businesses in the United States in 2017 found that while more than 75 percent of respondents thought that cyberattacks were unlikely to affect their businesses, more than 40 percent of small business owners were actually victims of cyberattacks, a good portion of whom did not even know it (Leadem, 2017). The same tendency was found in a study conducted in Colombia in 2017, where many public and private organizations that did not implement digital security measures (i.e., cybernetic risk assessment, vulnerability testing, maintenance of IT infrastructure, and/or identification of digital incidents) were found likely to be unaware that they were targets of cyberattacks (OAS, MINTIC, and IDB, 2017). The same study by the Organization of American States (OAS), the Ministry of Information and Telecomunication Technologies (MINTIC), and IDB (2017), found that the relative cost of digital incidents was higher for the smallest (micro) firms in Colombia, even though the absolute costs were higher for large Colombian firms. While cybersecurity is a growing issue for small firms, they typically have fewer resources to prepare themselves against such attacks and the economic consequences could be more devastating financially for smaller firms (OECD, 2021).[25] According to the OECD (2021), means of improving risk management include certification schemes, awareness campaigns, and legislation. Figure 3.2 delineates the most common types of cyberattacks.

25. The IDB has recently published a guide and a MOOC about cybersecurity for SMEs. The MOOC (in Spanish) is available at https://cursos.iadb.org/en/indes/microcurso-ciberseguridad-para-mipymes. The guide is available at https://publications.iadb.org/en/recommendations-information-security-and-reduction-cyberrisks-small-businesses-cybersecurity-best in English and at https://publications.iadb.org/es/recomendaciones-de-ciberseguridad-y-reduccion-de-riesgos-ciberneticos-para-pequenas-empresas in Spanish.

FIGURE 3.2 COMMON TYPES OF CYBERATTACKS

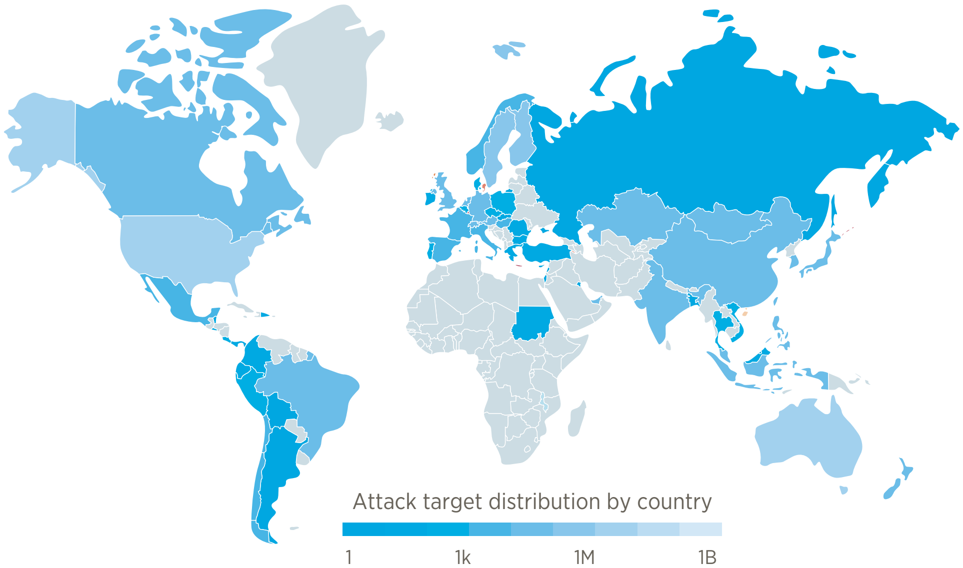
- **Phishing and social-engineering-based attacks** which trick employees into providing credentials and allowing data exfiltration where the attackers access and transfer data out of the enterprise.
- **Internet-facing service risks including cloud services** threats stem from inadequate security protection.
- **Password-related account compromises** this is where hackers identify common or reused passwords, and use them to access confidential data or systems.
- **Denial-of-service attacks (DoS)** occur when attackers overwhelm a company's systems and either slow the systems down or cause temporary shutdown.
- **Ransomware** is when attackers use malicious software to essentially take the enterprise's systems hostage, restricting the company's access to its own systems until ransom is paid and sometimes threaten to release data unless ransom is paid.

Source: Paraphrased from Gartner (2022).

The reality is that cyberattacks are now reported every day. For example, Figure 3.3 shows a map of the frequency of web application attacks in just one week. The OECD'S (2020a) roadmap toward a common framework for measuring the digital economy suggests that monitoring and measuring this indicator is important for policy makers to be aware, monitor, and manage increasing digital threats. Countries such as Argentina, Brazil, and Mexico appear to have more frequent web attacks than other countries in the LAC region. Some explanations behind their higher frequency could be that Akamai[26] is better able to collect data for those countries or perhaps it is because these are also typically the countries in the region with more advanced ICT sectors, as we will see in the next section.

26. Akamai is a company founded by faculty members at Massachusetts Institute for Technology (MIT) who developed a platform that offers a variety of technology solutions. The Akamai platform leverages data collected by its platform in the process of delivering over 2 trillion internet interactions, protecting and mitigating distributed denial of service (DDoS) attacks. While Akamai has a global presence, their clientele may be concentrated in advanced economies.

FIGURE 3.3 WEB APPLICATION ATTACKS OBSERVED OVER ONE WEEK IN APRIL 2022 FOR ALL INDUSTRIES[27]



Source: Excerpted from Akamai's Web Attack Visualization, available at https://www.akamai.com/visualizations/state-of-the-internet-report/web-attack-visualization.

Considering the increase in cyberattacks and the rise in digital activity during the pandemic, the IDB and the OAS decided to re-implement an assessment about the maturity of LAC countries in cybersecurity capacity along several dimensions in 2020 (IDB and OAS, 2020). The two organizations previously conducted a study in 2016 using a Cybersecurity Capacity Maturity Model for Nations (CMM), developed by the University of Oxford. The data are comparable between the two editions. The CMM assesses maturity from Level 1 "Startup"—which is the most basic level and implies that no cybersecurity maturity exists or that it is very embryonic—to Level 5 "Dynamic"—which is the most advanced level and implies that there are clear mechanisms in place, rapid detection and decision making, and constant monitoring. Extracting selected factors that are part of overall dimensions assessed by the CMM, Table 3.1 presents a tally of the number of countries in the region (out of 32 member countries of the OAS) according to the level of maturity they achieved in these indicators.

27. Based on the data from Akamai's Web Attack Visualization, which is the source used by the OECD in the 2020 roadmap publication, web application attacks can degrade web performance. Web application firewall and DDoS protection solution can protect against these types of cyberattacks. Data is available at https://www.akamai.com/visualizations/state-of-the-internet-report/web-attack-visualization.

TABLE 3.1 NUMBER OF LAC COUNTRIES IN EACH LEVEL OF CYBERSECURITY MATURITY (SELECTED FACTORS)

	2016					2020				
	1	2	3	4	5	1	2	3	4	5
	Startup	Formative	Established	Strategic	Dynamic	Startup	Formative	Established	Strategic	Dynamic
Private sector cybersecurity mindset	2	24	6	0	0	1	21	10	0	0
Users cybersecurity mindset	25	5	2	0	0	14	14	4	0	0
User trust and confidence on the internet	12	16	3	1	0	8	18	5	1	0

Source: Authors' elaboration based on IDB and OAS (2020).
Notes: The five overarching dimensions of the CMM are "(i) Cybersecurity Policy and Strategy; (ii) Cyberculture and Society; (iii) Education, Training, and Skills; (iv) Legal and Regulatory Frameworks; and (v) Standards, Organizations, and Technologies" (IDB and OAS, 2020: 41). The factors of private sector and users cybersecurity mindset as well as user trust and confidence on the internet fall under the culture and society dimension. The OAS includes six countries in the Caribbean that are not IDB members. The OAS LAC region also includes: Antigua and Barbuda, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines.

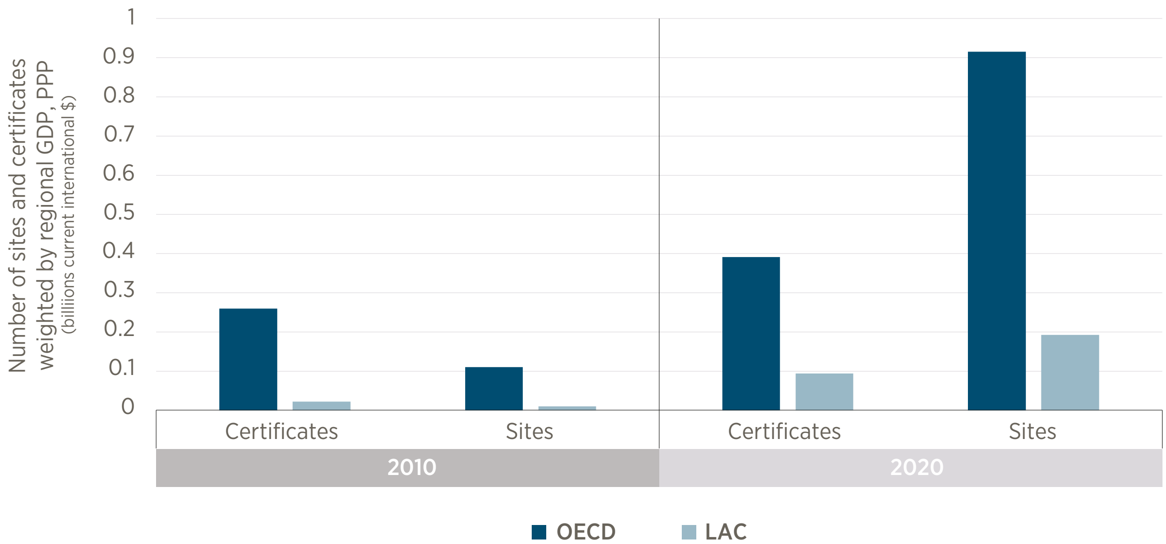
According to the CMM, in both 2016 and 2020 users in the majority of LAC countries were in the startup or formative level of cybersecurity maturity. By 2020, it seems that the private sector mindset about cybersecurity maturity had reached an established level in 10 LAC countries. Yet, the private sector mindset in 21 countries was still in the formative level of maturity.

Increase quality and standards

Firms face several challenges to maintain digital security that range from consistently implementing procedures to having personnel specifically responsible for the task of cybersecurity, and putting in place mechanisms to detect external intrusions. Small businesses often have limited capacity to maintain up-to-date security management practices, and the ones that do tend to be less comprehensive and not as sophisticated as those in large firms (OECD, 2021). As a proxy to the adoption of good cybersecurity practices in the region, we have used the International Organization for Standardization (ISO)'s certification for information technology on security techniques and information management systems ISO/IEC 27001.[28] Using these standards helps organizations manage the security of important information like financial assets and employee details.

Certification is voluntary, but organizations that choose to implement international standards can benefit from international best practices and provide assurance to their clients that they are on top of information security. The LAC region has far fewer sites and fewer certificates than the OECD. When weighted by GDP, to normalize the indicator, the relative difference in the number of sites is greater than certificates (see Figure 3.4). Fewer sites may contribute to less awareness and, as the importance of information/data security is increasingly recognized, in the medium run, it may lead to fewer organizations undertaking the certification process. Table 3.2 shows the count of the number of certificates and sites for different countries in the LAC region in 2010 and 2020.

FIGURE 3.4 REGIONAL DIFFERENCES IN ISO INFORMATION SECURITY MANAGEMENT SYSTEMS CERTIFICATES AND SITES, 2010 AND 2020



Source: Authors' elaboration based on the ISO survey results, available at https://www.iso.org/the-iso-survey.html. Data for GDP in current international PPP dollars are from the World Bank's World Development Indicators database, available at https://data.worldbank.org/indicator/NY.GDP.MKTP.PP.CD.
Note: "A certificate is the document issued by a certification body once the client has demonstrated conformity to the standard and a "site" is a permanent location where an organization carries out work or provides a service." ISO, explanatory note and overview on the ISO Survey 2021, available at https://isotc.iso.org/livelink/livelink/fetch/-8853493/8853511/8853520/18808772/0.Explanatory_note_and_overview_on_ISO_Survey_2021_results.pdf?nodeid=22272345&vernum=-2.

28. Information is available at https://www.iso.org/isoiec-27001-information-security.html.

TABLE 3.2 NUMBER OF ISO INFORMATION SECURITY CERTIFICATES AND SITES IN LAC BY COUNTRY, 2010 AND 2020

ISO/IEC 27001, 2010

Country	Certificates	Sites
Mexico	56	18
Brazil	41	22
Colombia	23	21
Chile	13	2
LAC avg.	10	8
Peru	9	12
Argentina	8	2
Costa Rica	6	
Uruguay	4	
Barbados	1	
Bolivia	1	2
Dominican Republic	1	2
Ecuador	1	1
El Salvador	1	1
Guatemala	1	
Guyana	1	
Jamaica	1	
Panama	1	

ISO/IEC 27001, 2020

Country	Certificates	Sites
Mexico	258	423
Colombia	238	413
Brazil	148	401
Chile	89	176
Peru	85	179
Argentina	57	117
LAC avg.	47	78
Ecuador	13	35
Guatemala	13	35
Uruguay	13	28
Dominican Republic	6	12
Honduras	6	10
Costa Rica	5	23
Bolivia	4	10
El Salvador	4	30
Panama	3	6
Paraguay	2	3
Suriname	2	7
Belize	1	1
Haiti	1	1
Jamaica	1	15
Bahamas		2
Barbados		3
Nicaragua		5
Trinidad and Tobago		1
Venezuela		6

Source: ISO survey results, available at https://www.iso.org/the-iso-survey.html.

4 From the Information and Communication Technologies Sector to the Digital Economy

The definition of the ICT sector and digital economy is evolving in tandem with technologies and digital transformations. As the digital landscape has proliferated, challenges to measuring the digital economy (or ICT sector) are widely acknowledged. Henry-Nickie, Frimpong, and Sun (2019), cite several experts[29] who have grappled with these challenges and who argue that they are due partly to digital activities being increasingly embedded in nearly every form of economic activity and also because digital products and services change rapidly.[30] Despite the challenges, finding ways to measure the digital economy and its growth is crucial as this is increasingly seen as a barometer for future economic growth and international competitiveness (Henry-Nickie, Frimpong, and Sun, 2019). Even before the pandemic, the global digital economy was estimated to have grown 2.5 times faster than global GDP and be worth US$11.5 trillion—which was roughly the equivalent of 15.5 percent of global GDP (Huawei & Oxford Economics 2017, as cited by Henry-Nickie, Frimpong, and Sun, 2019). This chapter documents remarkable progress and increased investment in companies in the digital economy in the LAC region in recent years. Yet LAC is not the only region seeing major growth opportunities in the digital landscape. Dominant global players make this a very competitive space. Even so, there is an opportunity for the LAC region to take advantage of its progress and carve a space for itself in the global digital economy.

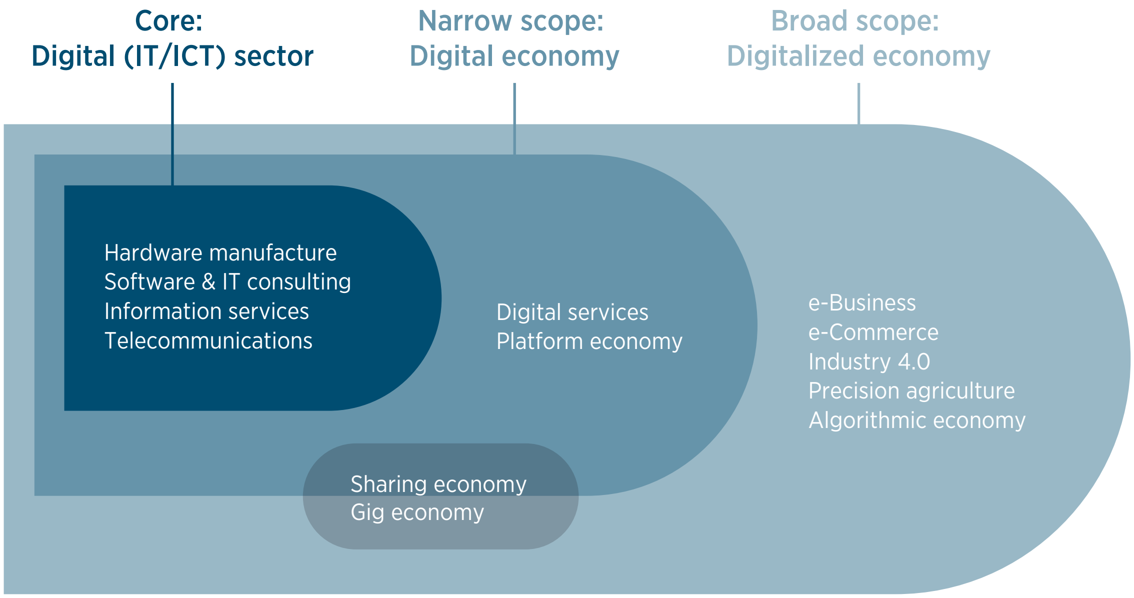
The push for digital transformation among firms across economic sectors in any country relies (at least partially) on a local supply of digital technology providers. This supply includes both incumbent firms and startups. A dynamic set of local technology companies engaged in experimentation, scale-up, scale-down, and exit facilitates digital technology creation and diffusion (OECD, 2020b). Early-stage venture capital (VC) investments (such as pre-seed and seed/angel funding) are crucial for helping new companies get off the ground. But venture money (i.e., series A, B, and C) also helps companies with strong business models stay financially afloat while they commercialize their ideas, scale their product/service, expand their market reach, and develop spin-off products (Zider, 1998; Reiff, Mansa, and Eichler, 2021).

29. Watanabe (2016), Brynjolfsson (2018), Nakamura (2018), Moulton (2018), as cited by Henry-Nickie, Frimpong, and Sun (2019).

30. The first time that the U.S. Bureau of Economic Analysis (BEA) estimated the digital economy within the national accounts framework was in 2018 (see Barefoot et al., 2018: 3).

To gauge the state of the digital technology providers in LAC, we first define the types of players we will include in the analysis. Figure 4.1 shows one way to parse out narrow versus broad definitions. According to UNCTAD (2019), the "core ICT sector" includes telecom networks and the internet, manufacturing of hardware (i.e., computers, telecommunications devices, semiconductors), and computer services (software, information services). Narrowly defined, but expanding beyond the core, the digital and IT (platforms, mobile apps, and payment services) are sectors that are dependent on the aforementioned core technologies, further characterized by high levels of innovation and growth in recent years. Broadly defined, digitalization—as it proliferates into other sectors (i.e., transportation, tourism, manufacturing, construction)—is sometimes harder to measure via the integration of digital technologies into production, value chains, service provision, or new business models (i.e., Industry 4.0, e-commerce).

FIGURE 4.1 REPRESENTATION OF THE DIGITAL ECONOMY



Source: UNCTAD (2019: 6).

The ICT sector feeds into the mushrooming of the digital economy in two main ways. First, it produces digital technologies, and second, via distribution of ICT enabled services, it permeates into other economic sectors (Henry-Nickie, Frimpong, and Sun, 2019). Drawing mainly upon data from CB Insights (2022), this chapter describes recent financing trends for LAC companies across the digital economy, capturing companies in core ICT and ICT-enabled industries. We take a peek at the LAC region's unicorns, fintech, and the most well-financed tech startups in the region. The investment trajectory in the ICT sector is truly impressive: in 2021, in the midst of the COVID-19 global pandemic, there was a dramatic uptick. Unicorns in the region more than doubled from 11 in November 2020 to 26 in February 2022, with three unicorns in AI. In early 2020, it was also reported that Latin America became fintech's hottest market (CB Insights, 2020). All this good news is tempered by the fact that almost all of the action is concentrated in a handful of countries in LAC. Furthermore, VC investment as a percentage of GDP in Latin America still only reaches 0.2 percent, which is less than other countries' VC investment as a percentage of GDP, as in the cases of China and Ireland (0.5 percent), the United States (1.8 percent), and Israel (3.6 percent). These calculations are based on Pitchbook Venture Capital Data and the World Bank's World Development Indicators GDP data (2021).

As part of this chapter, we also provide additional measures of the investments in the ICT sector. The roadmap toward a common framework for the digital economy (OECD, 2020a), for example, proposes measuring investment in ICT, trade in ICT goods and digitally deliverable services, value-added of information industries, and the contribution of ICT to productivity, as ways to approximate the contribution of the digital economy (or the ICT sector) to overall economic growth. Thus, this chapter of the report includes indicators about investment, the creation of content (mobile applications development), and trade. The indicators about investment in the companies span the whole digital economy portrayed above: from the broad scope to the core ICT sector, trade in digitally deliverable services, representing the narrowly defined digital economy, and ICT goods representing the core ICT sector. Figure 4.2 outlines the main points discussed in the current chapter.

FIGURE 4.2 STRUCTURE OF CHAPTER 4

Source: Authors' elaboration.

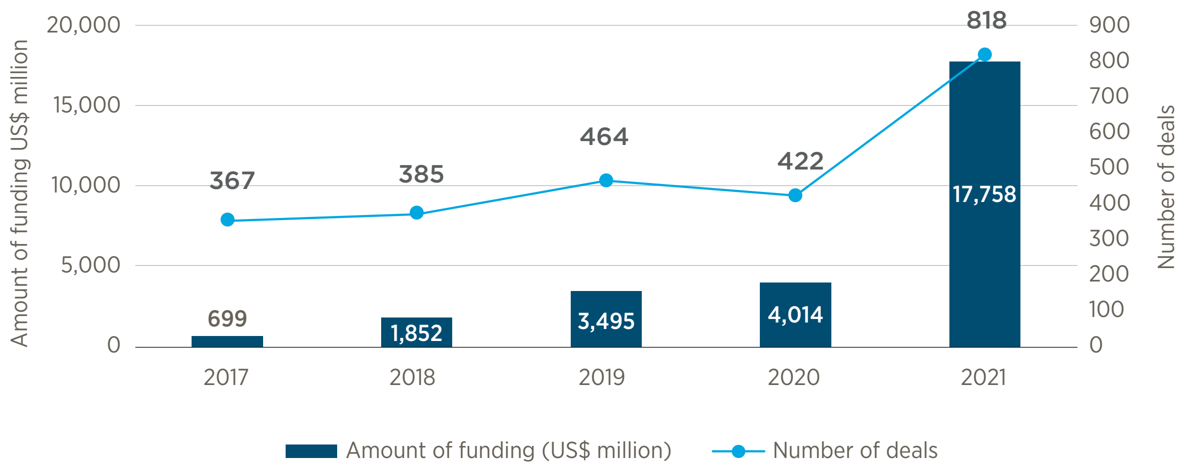
Note: For a better visualization of this interactive figure, please download the PDF

Investments in Digital Tech Startups

According to CB Insights[31] data, over the past five years financial deals and investments in digital technology companies in LAC increased, with a big growth spurt in 2021 (see Figure 4.3). While this is very encouraging news for the region, looking at the data in more detail shows there are still challenges. For one, the funding is concentrated in a few countries and merely on seed capital. The geographical distribution of deals in digital technology companies in LAC is highly concentrated in "the big five economies", namely Argentina, Brazil, Chile, Colombia, and Mexico. Investments are particularly concentrated: more than half (58 percent) of the deals in the region go to companies operating in digital economy in Brazil (Figure 4.3), and most of the financing is seed funding which indicates that investors and companies are still testing the waters.

31. CB Insights collects and continually updates company financing data based on machine learning software and algorithms to extract information from a wide array of unstructured and semi-structured publicly available data. They also get some private information directly from investors. For a full description of their methodology and more information about the sources they consult and the way in which their machine learning tools parse the data into relevant information, see: https://www.cbinsights.com/research/team-blog/private-company-financing-data-sources-cruncher/.

FIGURE 4.3 EVOLUTION OF EQUITY INVESTMENT[32] IN LAC COMPANIES OPERATING IN THE DIGITAL ECONOMY



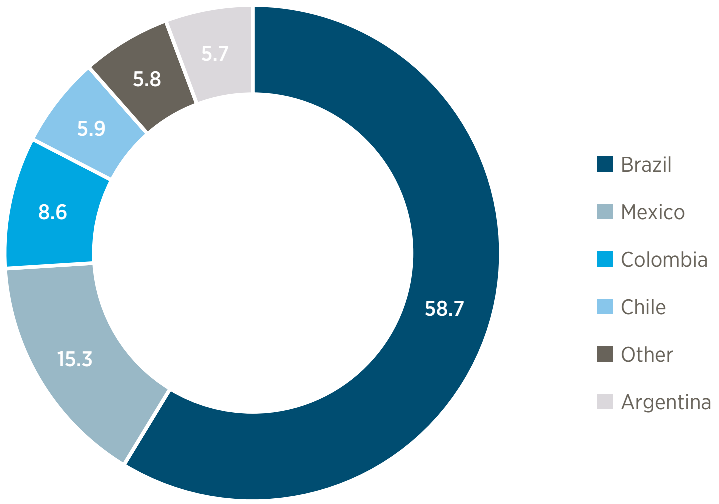
Source: CB Insights database, available at https://www.cbinsights.com/what-we-offer/technology-search-engine/. A subscription is needed to access the data.

Notes: Only active companies in the 26 IDB LAC countries were considered. The industries selected (defined by CB Insights) are the following: i) computer hardware and services (i.e., computer and technology leasing services; computer networking equipment; computer product distribution and support services; computer storage and peripherals; handheld computers and accessories; IT services; personal computers and notebooks; servers and mainframes; specialty computer hardware; supercomputers; workstations and thin clients; and gaming); ii) semiconductors (i.e., semiconductor equipment; analog chips; audio chips and boards; communications chips; components; design and packaging services; graphics, video chips and boards; memory, networking, and sensor chips; microprocessors; integrated circuits; and sensors); iii) internet (i.e., e-commerce; internet software and services); iv) mobile and telecommunications (i.e., fiber optics; mobile commerce; mobile software and services; radio frequency identification (RFID) systems; telecom devices and equipment; telecom services; towers and infrastructure; stealth mode); v) and software (non-internet/mobile) (i.e., accounting and finance software; application and data integration software; asset and financial management and trading software; billing, expense management, and procurement software; business intelligence, analytics and performance management software; collaboration and project management software; compliance; conferencing and communication software; content management software; customer relationship management software; data and document management software; database management software; education and training software; email; financial services software; gaming; government software; green/environmental software; healthcare software; human resources and workforce management software; legal software; manufacturing, warehousing, and industrial software; multimedia and graphics; networking and connectivity software; operating systems and utility software; retail and inventory software; sales and marketing software; scientific, engineering software; security software; storage and systems management software; supply chain and logistics software; testing; real estate; advertising, sales and marketing; stealth mode).

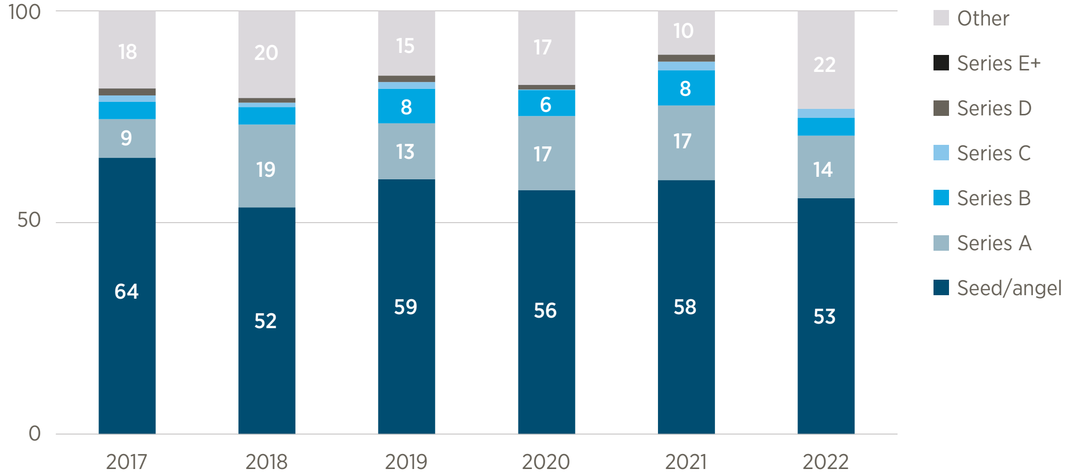
32. As a frame of reference, in the entire CB Insights database, in February 2022, there were 12,673 companies with US$85.14 billion in total funding in the LAC region. By comparison, OECD (excluding LAC) members had 473,508 companies with US$3.68 trillion in total funding. The funding represents financing that companies raised during the enterprise's initial phases of business, prior to going public. But the count of companies can include companies that have gone public. So, for example: Nubank, a technology-driven financial services startup founded in Brazil in 2014, appears as a company in CB Insights with its total funding amounting to US$2.574 billion, which is the amount of financing it raised before it went public. According to CB Insights, Nubank's current market capitalization is listed as US$46.50 billion (as of February, 2022), but this is not recorded in the total funding raised and so the funding does not factor into the region's total funding listed above. Yet, Nubank is counted as the number one out of 12,673 companies that raised funding in the region.

FIGURE 4.4 GEOGRAPHICAL DISTRIBUTION AND STAGE OF FINANCING OF INVESTMENT DEALS IN DIGITAL ECONOMY COMPANIES IN LAC, FROM JANUARY 01, 2017 TO APRIL 26, 2022 (IN PERCENTAGES)

Geographical distribution of investment deals in digital economy companies in LAC



Stage of financing investments in LAC digital economy companies

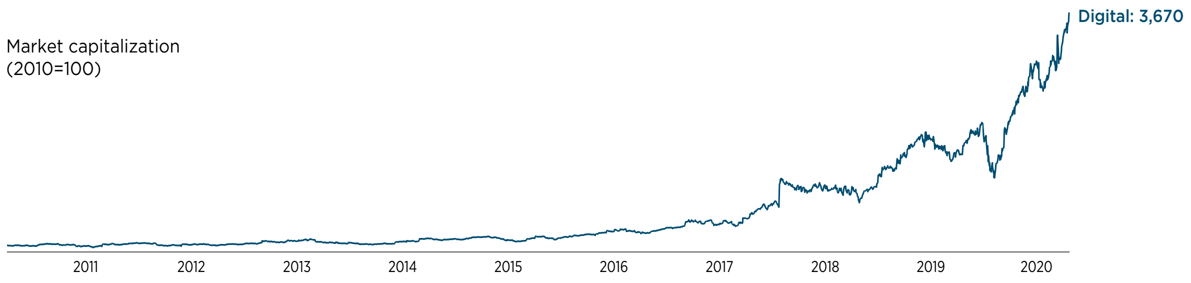


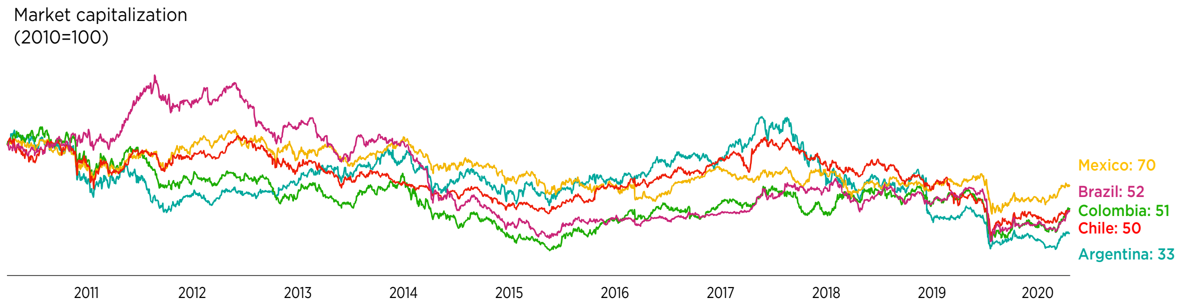
Source: CB Insights (2022). Updated April 2022.

A recent publication of the IDB LAB in collaboration with Surfing Tsunamis identified just over 1,000 technology companies dubbed Tecnolatinas (Peña, 2021). These are companies that were born in the LAC region and raised over US$1 million, and together employed 245,000 people. Figure 4.5 illustrates a rather stunning phenomenon: while the value of Tecnolatinas grew from US$7 billion to US$221 billion between 2010 and 2020, the market capitalization of top 40 publicly-listed traditional companies in LAC fell by US$489 billion over the same period (Peña, 2021). These numbers show two important points. First, that the upward trend was building well before the pandemic; and, second, that innovative technology companies are taking leadership positions in the LAC region. The relationship between the global tech giants, or "the Big Five", and investment in R&D is also increasing by leaps and bounds.[33] Staying abreast of investment trends in tech companies may provide an indication of growth areas for VC investment in startups in the LAC region, and can also be used as inputs to assess whether the disruptive digital technologies are likely to cut across industries, or to be industry-specific. There is still room for the to grow and shape our digital lives (Manjoo, 2022).

33. In 2021, the Big Five—that is, Alphabet (Google), Amazon, Apple, Facebook (now Meta), and Microsoft —invested US$149 billion in R&D, which represents a 34 percent increase over the amount invested in 2019 and roughly a quarter of the public and private R&D expenditure in the United States in 2020 (The Economist, 2022). While somewhat opaque, based on analysts observations and more than 16,000 publications by researchers at the Big Five, it is speculated that the big tech companies are busy investing in frontier technologies related to the metaverse, autonomous vehicles, health care, space, robotics, fintech, and crypto and quantum computing (The Economist, 2022). Acquisitions (also opaque) are also telling of the technological pursuits of the Big Five; while it appears to vary by company, more than a quarter of firms acquired by the Big Five from 2019 to 2021 were specialized in AI or big data (The Economist, 2022).

FIGURE 4.5 EVOLUTION OF MARKET CAPITALIZATION OF PUBLICLY-LISTED DIGITAL AND TRADITIONAL COMPANIES FROM LAC BETWEEN 2010 AND 2020

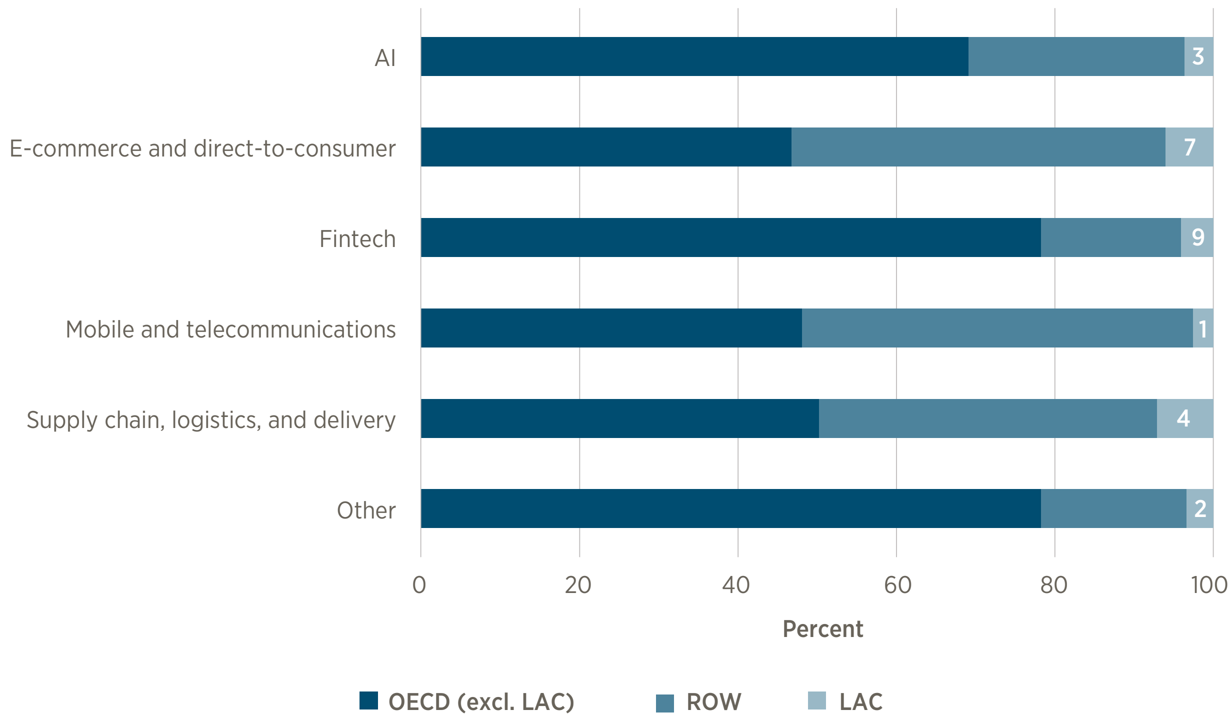




Source: Extracted from Peña (2021).
Notes: The trend line labeled 'Digital' includes data from: MercadoLibre, B2W, Despegar, Pagseguro and Globant. The trend line labeled 'Mexico' includes data from: Banorte, Santander Mexico, América Móvil, Walmart Mexico, FEMSA, CEMEX, Bimbo, Soriana and Alpek. The trend line labeled 'Chile' includes data from: Banco de Chile, Santander Chile, Banco de Crédito, Entel, Copec, Falabella, Enel, Cencosud, LatAm and Parque Arauco. The trend line labeled 'Brazil' includes data from: Banco Itau, Banco Bradesco, Petrobras, Telefónica Brazil, TIM, OI, Vale, Multiplan, Iguatemi and BRF. The trend line labeled 'Colombia' includes data from: Ecopetrol, Bancolombia, Aval, Davivienda, Cemento Argos, Nutresa and ISA. The trend line labeled 'Argentina' includes data from: Grupo Financiero Galicia, Banco Frances, Banco Macro, YPF, IRSA CP, Pampa Energía, Central Puerto, Loma Negra and Tenaris Source: Surfing Tsunamis, Bloomberg, Yahoo Finance.

As of March 2021, four of the 12 companies valued at more than US$1 million were unicorns (to be precise, they were valued at 1 billion). Moreover, as of February 2022, the number of unicorns operating in the region has grown to 26 and there are now three unicorns in AI. Figure 4.6 shows that even with the impressive growth of investments in tech companies in LAC, in a relative sense, the region has relatively few unicorn companies. There are 45 economies with at least one unicorn, and outside the OECD, Asia is the region with the most unicorns, with 167 in China. The largest number of unicorns in LAC fall within the fintech category.

FIGURE 4.6 UNICORNS IN LAC VERSUS THE OECD AND THE REST OF THE WORLD BY CATEGORY, 2022



Source: Calculations based on CB Insights (2022).
Notes: ROW stands for rest of the world. Other is a category provided by CBInsights. In addition, there are several other areas in which LAC does not yet have a unicorn.

BOX 4.1 FINTECH IN LATIN AMERICA

In 2021, there were reports that Latin America had become one of the fastest growing fintech hubs in the world, as fintech companies in the region raised record levels of investment and investors were paying attention (CB Insights, 2021a). Rapid expansion of fintech in Latin America found fertile ground in the region's SMEs, partly because fintech provided a viable alternative source of finance, but also since it is a much needed bridge between the unbanked and the financial system (Cantú and Ulloa, 2020). Even though investment in fintech in the region was already thriving, the pandemic thrust many consumers into paying for things digitally and online (e-commerce) for the first time. And while traditional banks remained the same, fintech began reinventing banking services and delivering much better customer service (Salas, 2022).

A forthcoming publication by the IDB and University of Cambridge based on a survey of 550 SMEs in the LAC region reports that nearly all (95 percent) of the surveyed companies indicated that fintechs offered them faster access to finance. Ninety percent also reported that their experience with fintech customer service was better than at a traditional financial institution.

By the close of the year 2021, fintech companies in Latin America raised US$9.4 billion across 188 deals (CB Insights database, available at https://www.cbinsights.com/what-we-offer/technology-search-engine/).[34] Figure 4.7 shows a non-exhaustive map of the more than 160 startups reshaping different aspects of the financial services industry in Latin America in November 2021.

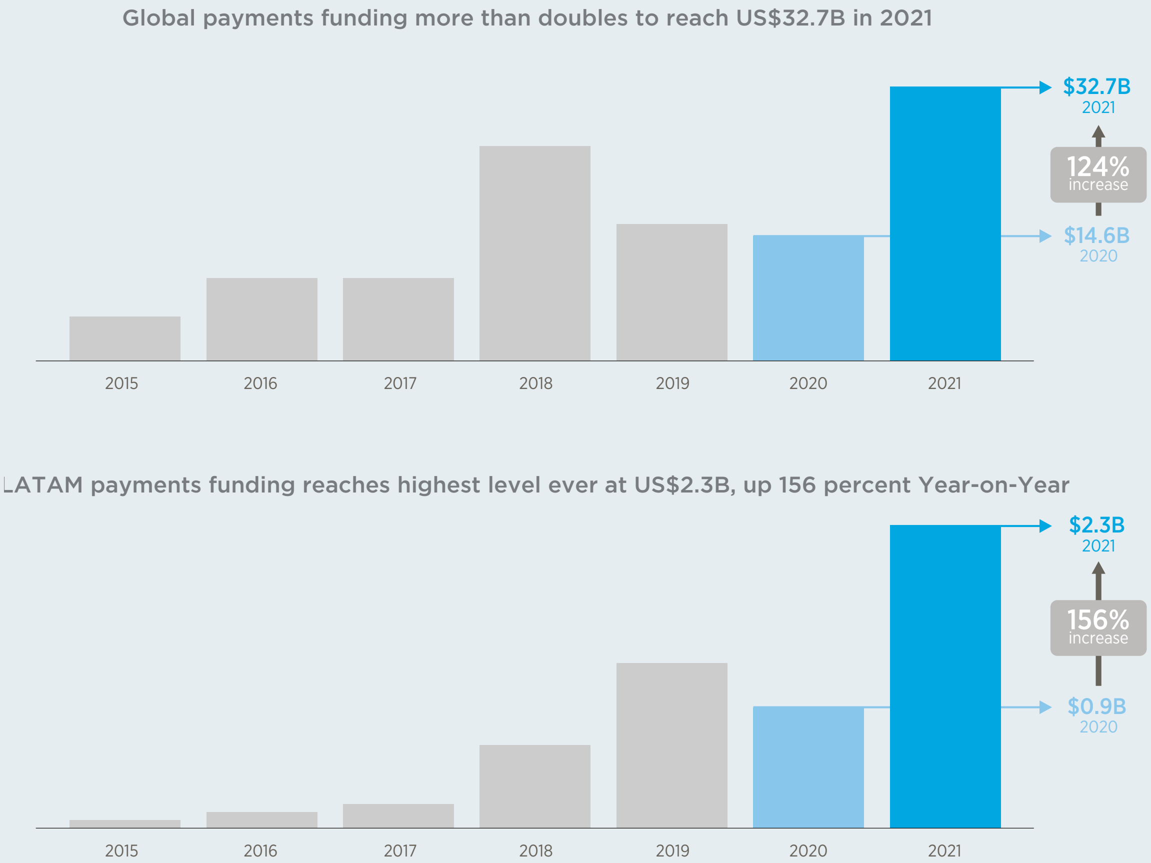
34. A subscription is needed to access the data.

FIGURE 4.7 COMPANIES CHANGING FINANCIAL SERVICES IN LATIN AMERICA

Source: CB Insights (2021a).
Note: The categories are not mutually exclusive. Companies are affiliated with the category identified as their primary area of activity.

Many countries in other regions with large swaths of the population unbanked, have found that undergoing a transition from cash to digital payments helps link the unbanked with the financial system; more than half of the fintech firms in Latin America offer payment services and alternative finance services (Cantú and Ulloa, 2020). Correspondingly, some of the most impressive growth has taken place regarding payments. In 2021, funding for firms in the payments space in Latin America reached its highest levels yet and increased faster than the rest of the world year-on-year, compared to 2020.

FIGURE 4.8 GROWTH IN FUNDING FOR PAYMENTS COMPANIES, IN THE WORLD AND IN LATIN AMERICA



Source: CB Insights (2021b)

While there is every reason to think that fintech will continue to grow in the region, there are some challenges that will not be easy to overcome. These challenges are very much aligned with the issues covered in this report and have been summarized by Cantú and Ulloa (2020) as follows: lack of digital identity and low financial inclusion, insufficient digital infrastructure to support rising digital payments and cross-border payments, and consumer data and privacy protection.

Source: Authors' elaboration based on CB Insights.

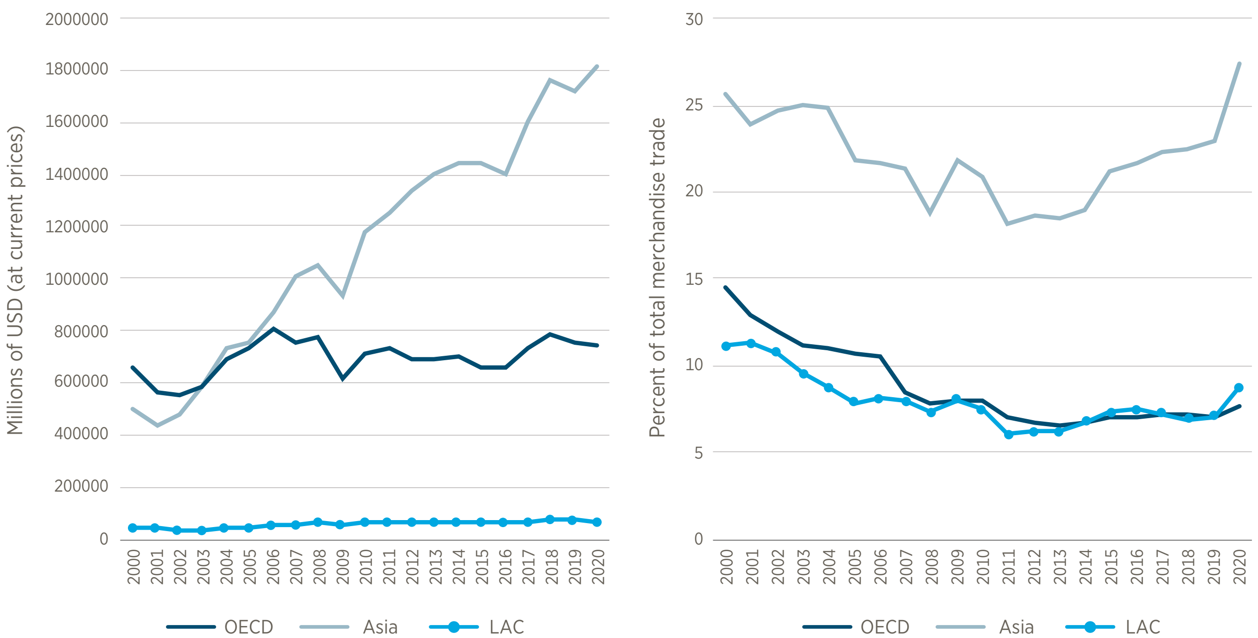
Trends in Digital Trade and Content Creation

Digital trade is a broader concept than trade in ICT goods and digitally deliverable services. Digitalization has increased speed, scale, and especially the scope of trade (López González and Ferencz, 2018). The very integration of digital technologies makes it challenging to statistically separate value-added statistics, such as those that are attributable to digitalization, versus the underlying product or service. Furthermore, operating within existing statistical frameworks for sectors, products and services, it is not yet clear when certain "traditional products" cross over into "digital products"[35] (UNCTAD, 2019). For the time being, for lack of a better way to measure the phenomenon, ICT goods and digitally deliverable services are the indicators being used internationally to shed light on the trade dimension of the digital economy (OECD, 2020a).

For the LAC region, trade in ICT goods (flows of exports), both in dollar value and as a percent of total merchandise trade, has remained fairly stagnant over the past decade. While trade in digitally deliverable services (flows of exports) as a percent of total trade in services was similarly stagnant from 2000 to 2019, there is a notable uptick in 2020. This uptick is also notable among regions and is clearly related to the onset of the global pandemic and the lockdown and social-distancing measures taken during this time, which broadly encouraged digital delivery of more services, apparently including trade services. It is interesting to note that while Asia clearly dominates trade in ICT goods (see Figure 4.9), it is the OECD that dominates in trade of digitally deliverable services (see Figure 4.10).

35. UNCTAD (2019: 49), citing the BEA, provides an example to illustrate classification challenges: should a smart refrigerator connected to the internet be classified as an ICT good (product) or as a refrigerator with digital aspects?

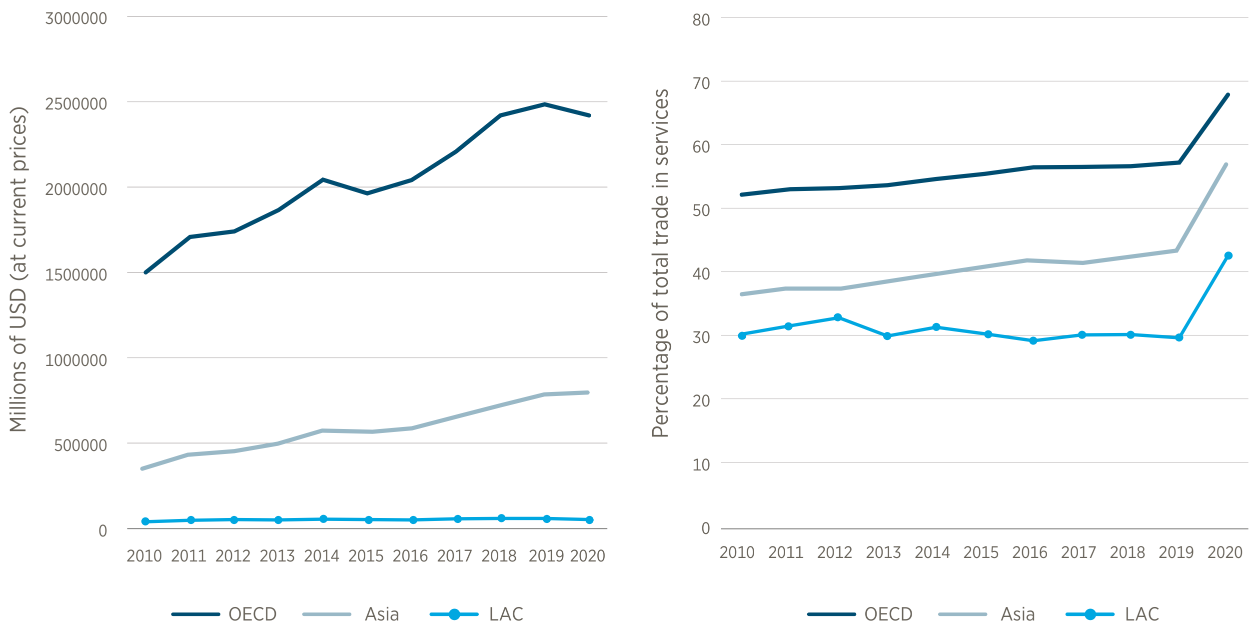
FIGURE 4.9 TRADE IN ICT GOODS, 2010 TO 2020



Source: UNCTADstat database, available at https://unctadstat.unctad.org/EN/.
Notes: Regional data are provided by UNCTADstat database on flows of exports. Definitions as described by UNCTAD are as follows: "For exports: ICT goods exports as percentage of the economy's total goods exports (ICT-4). The list of ICT goods is defined by the OECD, and was revised in 2010 and then adapted to HS12. This new list consists of 93 goods defined at the 6-digit level of the 2012 version of the Harmonized System."

During the pandemic, the uptick in the portion of digitally delivered services relative to all services did not translate to an uptick in the dollar value of digitally delivered services exported from LAC countries. There may be a few reasons for this. For instance, with services that were traditionally only delivered in person, online services may have acted as substitutes for in-person services and did not actually yield additional revenue. Initial pricing for substitute digital services may have also been set low to encourage participation. While they may have been crucial for firms to stay in business and for consumers stuck at home, financial gains (in dollars) may come later when firms are selling services digitally and in-person (see Box 4.2). For example, in the entertainment industry, prior to the pandemic, an online concert would have had limited appeal to concertgoers whose willingness to pay for tickets was presumably based on their concert-going experience.

FIGURE 4.10 TRADE IN DIGITALLY-DELIVERABLE SERVICES, 2010 TO 2020



Source: UNCTADstat database, available at https://unctadstat.unctad.org/EN/.
Notes: Regional data are provided by UNCTAD Stat database on flows of exports. Meta data on the indicator in the UNCTADstat database states that, "Digitally-deliverable services are an aggregation of insurance and pension services, financial services, charges for the use of intellectual property, telecommunications, computer and information services, other business services, and audiovisual and related services. The digitally-deliverable services series is based on the concept of potentially ICT-enabled services as developed by UNCTAD in a technical note in 2015 as well as in a report of the 47th United Nations Statistical Commission in 2016." Thus, the indicator might sometimes also go by "ICT-enabled services", described as tradeable services that are possible to deliver remotely.

BOX 4.2 THE JOINNUS EXAMPLE

Joinnus, a company "born digital" in Peru, was a successful startup platform selling tickets to live music (and other) events prior to the pandemic. Joinnus had to reinvent its business model when the firm saw its sales go to zero in the initial days of the lockdowns (see Suaznábar, Herrera, and Cathles, 2022 for a video describing the young company's experience). However, as with many aspects of digitalization propelled by the pandemic, the LAC region might have an opportunity to build on this uptick in the portion services that are digitally-deliverable. Joinnus, for example, has now expanded their market reach to more people outside Peru and has cultivated innovative ways of maintaining (and even increasing) audience engagement. While it took some time for the company to pivot and for consumers to adapt, there is a sense that Joinnus can now charge more for the digital experience, including via personalized add-ons. When the world reaches a post-pandemic state, Joinnus plans to become even more successful by optimizing omni-channel approaches (both digital and in-person). Digital channels are expected to maintain their popularity and utility in expanding market reach inside and outside the country's borders.

Source: Authors' elaboration.

Digital content/app development is an example of a digital service opportunity which the LAC region could work to develop further. One of the key variables related to digital content creation is mobile application (app) development. As with other digital tech companies, revenue in top app companies is sizable and growing, but app developers tend to be concentrated in large metropolitan cities (Szczepański, 2018). Direct app revenue received by major app stores is typically dwarfed by the app-related advertising revenue (Pon, 2016). So cities/countries with vibrant activity in app development may be simultaneously benefiting from another set of companies, which will in turn strengthen the digital technology ecosystem and attract more resources (often, including more skilled human capital). Addressing these issues in the LAC region is going to require coordinated policy efforts at national and international levels (OECD et al., 2020). Normalized values for LAC countries in mobile application development per person from the based on the NRI, show that there are two distinct groups: a few countries (i.e., Argentina, Brazil, Costa Rica, and Uruguay) are not far behind advanced OECD economies, while other countries in the region (Bolivia, Guatemala, Honduras, Jamaica, and Venezuela) are far behind regional front runners (see Figure 4.11).

FIGURE 4.11 MOBILE APPS DEVELOPMENT: NUMBER OF ACTIVE MOBILE APPLICATIONS DEVELOPED PER PERSON (NORMALIZED VALUE), 2018

Source: Dutta and Lanvin (2020).
Notes: The NRI normalized values for this indicator are based on data from the GSMA (2019).

5 Public Policy Recommendations for Digital Transformation

The digital transformation of LAC countries is an ongoing process that is not exempt of challenges. As we have seen throughout this monograph, gaps in terms of connectivity, data, or talent are hindering digital technology development and adoption in LAC. Furthermore, these gaps differ by country, region, and size of firms, thus requiring a wide range of differentiated policy interventions to foster technology adoption. Recent green shoots like the fast growth of VC flows to tech startups in LAC or the increased digital use brought by the COVID-19 pandemic are encouraging signs. Yet, further support is needed if we want the region to keep up with the digital revolution and reap all the potential benefits from it. In this concluding chapter, we suggest a few avenues that governments may take to implement a comprehensive set of digital promotion policies.[36]

Policies for Creating an Enabling Environment for Digital Technology Adoption

- **Connectivity, data, and regulation.** Public and private investments to ensure connectivity and access to quality high-speed internet as well as data storage need to be continued. In addition to this, the LAC region needs to increase the availability of data in a secure manner. Regulations on privacy, data ownership and data protection, as well as ensuring adequate cross-border data flows and cybersecurity are all aspects involved in promoting a secure data environment. Public and public-private initiatives related to open data and data sharing schemes (such as data trusts and data commons) could accelerate the availability of data. Other key regulatory updates include regulations of new technologies (such as AI ethic guidelines) as well as initiatives to accelerate the development, testing, and adoption of new digital solutions under technology testbeds or regulatory sandbox schemes. The latter allows to set temporary regulatory exemptions that can help innovators try out new products and services in regulated sectors such as finance, health, or energy.

- **Cybersecurity.** Policy recommendations to improve cybersecurity relate to both demand and supply. To stimulate demand for cybersecurity, policy makers need to implement awareness raising campaigns, promote self-assessment tools, and provide training on the basic steps to implement cybersecurity practices at the firm level. Regarding the supply, priority

36. Existing and forthcoming research by the IDB delve deeply on many of the policy topics listed in this section. These resources are listed for easy referral in Appendix 5.

should be given to the strengthening of assistance services (such as customer service centers), making knowledge resources available to practitioners, and training more qualified professionals. In addition to this, fostering the implementation of methodologies to protect the computer services and products supply chain and rolling out cybersecurity certification schemes will also contribute to ensuring a broader adoption.

- **Digital talent.** Having the necessary talent is the key to ensuring progress in both the development of digital solutions and their adoption and use. New technology developments are rendering some tasks and jobs performed by humans obsolete, while digital transformation in different sectors requires managers and workers to acquire a different set of new technical skills. Governments should consider implementing comprehensive policies to close the digital talent gap faced in the region. This implies developing a wide range of skills and profiles of specialists: data analysts who work on data management, data scientists who develop the algorithms, or data engineers and programmers. In addition to this, doctors and researchers are also needed working in research and technology centers, universities, and companies, pushing the frontier in the latest digital technology developments and, more importantly, quickly adapting new technologies developed in the world to the local reality. Moreover, capacities for technology absorption need to be strengthened at the firm level. Active policies for the generation of digital talent at the national level through scholarship programs, development of national postgraduate and engineering programs, among others, must be accompanied by interventions to attract and retain this generated talent.

In addition to this, there are new training formats that generate capabilities for some digital functions in the time span of a few months. Coding bootcamps, for example, are a very effective way to build coding skills for data analytics. These intensive, accelerated learning programs train students with a wide variety of academic backgrounds in programming languages and frameworks in just a few months, with good responsiveness from employers, who quickly hire them. As we saw on Chapter 1, LAC has seen an explosion in the growth of bootcamps from virtually none five years ago to several per country in actuality. The IDB is supporting the deployment of bootcamp-type programming courses in advanced digital skills in Costa Rica, Peru, and Uruguay through competitive funds that seek to attract international bootcamps to train advanced digital skills at the local level. The challenges going forward involve the scaling up of these interventions and implementing new schemes to facilitate student financing (such as income sharing agreements). Some countries combine these interventions with scholarship programs to foster certification in ICT related areas.

Finally, governments can take advantage of existing (or customized) online training courses that facilitate the acquisition of basic digital skills and technology change management skills for SME managers and entrepreneurs. This introductory training can be the gateway to the world of digitization for many companies and can implement cost-effective and massive interventions. Some issues that typically pop-up in these sorts of programs are related to ensuring firm participation and limiting attrition, the need to develop hands-on content useful for SMEs, as well as the potential to combine training with advisory services.

Policies to Support Digital Technology Adoption

Comprehensive policies to promote the massive adoption and use of digital technologies involve solving information asymmetries about digital technologies and capacities, providing technical assistance (through voucher and other grant schemes) and credit lines for the digital transformation of firms, and developing capacity building programs. These interventions should consider the different levels of digital maturity of firms as well as the sector-specific digital needs. Digital transformation goes beyond the acquisition of technology, as it requires a significant organizational change. In this sense, the interventions must be directed not only to the purchase of technology but also to foster business transformation strategies, updating internal processes, and supporting changes in business models to develop new products or services that take advantage of the new digital possibilities. In addition to this, grant schemes for innovation using digital technologies should be promoted.

From the supply side, it is key to foster the development of a range of digital support services for firms provided by local actors such as business development centers, technology and extension centers, incubators, accelerators, and other ecosystem agents. It is important to create a network of digital support services with public-private actors that allows for a support offer deployed throughout the entire territory, which allows redirecting the companies between the different nodes according to their requirements. Business development centers and technology centers play an essential role in the territory, taking advantage of their proximity to companies to provide close support. On the other hand, technology providers, e-commerce platforms, means of payment or telecommunications operators (even the financial sector in some cases such as in Singapore) become allies of the digital agenda and can contribute to accelerating the arrival of internet, digital services, and business support services.

Policies to Support the Development of Digital Technologies

A strong supply of ICT and digital services is a precondition for the digital transformation of the economy. Several aspects to promote the development of this sector include fostering access to credit for ICT and digital services firms which has typically been restricted because of the intangible nature of the assets of these companies (which impedes collateralizing these assets) and also due to the low capacity of financial intermediaries to adequately understand and evaluate technological projects. Some of the policy interventions include the rolling out of tax and fiscal benefits, subsidies for innovation projects, special agreements between financial intermediaries and ICT specialists to evaluate technological project proposals, among others. Likewise, it is key to bring the digital demand of companies closer to the supply of ICT solutions. This can be done through coordination of activities that mitigate information asymmetry between companies and solution providers, technical assistance, and training provision,[37] among other aspects.

As previously discussed in Chapter 4, the evolution of the ICT sector towards knowledge-based services has allowed the entry of new players, with a multitude of startups challenging the incumbent companies in the ICT and digital economy sector. These new players are key to increasing the sectors competitiveness. In addition, although the traditional R&D departments of large companies and universities still exist, there is a clear trend towards open innovation where large companies and public institutions leverage the agility and innovative power of startups. Despite the recent increase in VC flows to the region, we are still far from reaching the critical mass of developed countries, especially for later-stage financing, and we still have the pending challenge of moving from a concentration in B2C solutions, towards the development of more B2B solutions. The generation and expansion of these technological ventures depends on multiple factors, including the existence of a good scientific base, mature entrepreneurship and innovation ecosystems, a business-friendly environment, and a financial sector available to invest in medium-term high-risk projects. Regulatory aspects, already covered earlier in this chapter, will also be key to unlock the growth potential of this sector.

37. Policies for digital talent development have already been covered extensively earlier in this chapter.

Policies to Support the Collection of Comparable Data

Regional efforts to collect data on the enabling conditions and digital technology adoption among firms, will facilitate evidenced based policy making. LAC established a network for Science and Technology Indicators in 1994, called RICYT.[38] One opportunity could be to taking advantage of the fact that such a platform already exists along with the network and cooperation of national statistics institutes, universities, NGOs, and various other entities in 26 countries in the LAC region, plus Spain and Portugal, and seek to expand the indicators covered to include indicators specifically related to digital technologies. Alternatively, another similar network and platform could be established to house data on digital indicators from both national and international resources.

38. More information about the network can be found in their website via the following link http://www.ricyt.org/en/category/indicators/.

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Appendices

Appendix 1
UN Compilation of Data Protection and Privacy Legislation

COUNTRY	TYPE	TITLE OF LEGISLATION/DRAFT LEGISLATION
Argentina	Legislation	Ley 25.326 de Protección de los Datos Personales
Bahamas	Legislation	Data Protection (Privacy of Personal Information) Act, 2003
Barbados	Draft legislation	Bill - Data Protection passed in Senate and House of Assembly, 2019
Bolivia	Legislation	Ley general de Telecomunicaciones, Tecnologías de Información y Comunicación – Ley 167 from August 08, 2011
Brazil	Legislation	Protection of Personal Data Bill, 2011
Brazil	Legislation	Internet Act (Law Nº 12.965, April 23rd, 2014). Articles 7 and 8.
Brazil	Legislation	General Data Privacy Law
Chile	Legislation	Law 19.628 of 1999 sobre Protección de Datos de carácter personal
Colombia	Legislation	Ley 1581 de 2012 - Marco general de la protección de los datos personales en Colombia
Costa Rica	Legislation	Political Constitution of the Republic of Costa Rica, consolidated version to October 5, 2005
Costa Rica	Legislation	Constitución Política de la República de Costa Rica, versión refundida al 5 de octubre de 2005
Costa Rica	Legislation	Ley de protección de la persona frente al tratamiento de sus datos personales - Ley n.º 8968
Dominican Republic	Legislation	Ley No. 172-13, sobre Protección de Datos de Carácter Personal del 13 de diciembre de 2013
Ecuador	Legislation	Protection of Privacy and Personal Data Bill 2019
El Salvador	Draft legislation	Bill - Ley de Comercio Electronico y Comunicaciones
Honduras	Legislation	Ley de trasnparencia y accesso a la información pública DECRETO No. 170-2006
Jamaica	Legislation	The Constitution of Jamaica
Jamaica	Legislation	Electronic Transactions Act No 15, 2006
Mexico	Legislation	Ley General de Protección de Datos Personales en posesión de sujetos obligados
Mexico	Legislation	Ley Federal de Protección de Datos Personales en Posesión de los Particulares, 2010
Panama	Legislation	Ley 81, Protección de datos personales, 2019
Paraguay	Legislation	Ley 1682/2001 Reglamenta la nformación de carácter Privado
Paraguay	Legislation	Ley Nº 1969/2002 “Que modifica, amplía y deroga varios artículos de la Ley Nº 1682/2001”
Paraguay	Legislation	Ley Nº 5543/2015 “Que modifica parcialmente la Ley Nº 1969/2002”
Paraguay	Legislation	Ley Nº 5830/2017 “Que prohíbe la publicidad no autorizada por los usuarios titulares de telefonía móvil”
Paraguay	Legislation	Decreto Nº 8000/2017 “Por el cual se reglamenta la Ley 5830/2017 Que prohíbe la publicidad no autorizada por los usuarios titulares de telefonía móvil”
Paraguay	Legislation	Resolución Nº 80/2018 “Por la cual se aprueba la normativa reglamentaria de la Ley Nº 5830 Que prohíbe Que prohíbe la publicidad no autorizada por los usuarios titulares de telefonía móvil”
Peru	Legislation	Ley N– 29733 - Ley de Protección de Datos Personales
Trinidad and Tobago	Legislation	Data Protection Act, 2011
Trinidad and Tobago	Legislation	The Constitution of the Republic of Trinidad and Tobago
Uruguay	Legislation	La Ley 18.331 Protección de Datos Personales y Acción de Habeas Data del 11 agosto del año 2008 y el Decreto reglamentario 414/2009

Source: UNCTAD's data protection and privacy legislation worldwide, available at https://unctad.org/page/data-protection-and-privacy-legislation-worldwide.

Appendix 2
LinkedIn Disruptive Tech Skills Groups and Corresponding Definitions

SKILLS GROUP	DEFINITION
Aerospace Engineering	CATIA, ANSYS, Commercial Aviation, Aeronautics, Avionics, Airworthiness, Aerospace Engineering, Helicopters, Computer-Aided Engineering (CAE), Aerodynamics
Artificial Intelligence (AI)	Machine Learning, Artificial Intelligence (AI), Data Structures, Deep Learning, Image Processing, Computer Vision, Natural Language Processing (NLP), TensorFlow, Pandas (Software), OpenCV
Data Science	Data Analysis, SQL, Analytics, Statistics, R, IBM SPSS, PL/SQL, Tableau, Statistical Data Analysis, Big Data
Development Tools,	Java, Python (Programming Language), C++, Linux, C (Programming Language), C#, Git, Jira, Unix, .NET Framework
FinTech,	Blockchain, FinTech, Cryptocurrency, Bitcoin, Financial Technology, Ethereum, Solidity, Cryptocurrency Trading, Hyperledger, Bitcoin Mining
Genetic Engineering	Molecular Biology, Polymerase Chain Reaction (PCR), Genetics, Real-Time Polymerase Chain Reaction (qPCR), Molecular Cloning, Gel Electrophoresis, DNA Extraction, Genomics, Protein Expression, DNA
Human Computer Inter-action	Bootstrap, User Experience (UX), User Interface Design, User Experience Design (UED), TypeScript, Interaction Design, Wireframing, Usability Testing, User-centered Design, Sketch App
Materials Science	Materials, Materials Science, Characterization, Design of Experiments (DOE), Spectroscopy, Polymers, Metallurgy, Metrology, Scanning Electron Microscopy (SEM), Raw Materials
Nanotechnology	Nanotechnology, Molecular Modeling, Biosensors, Carbon Nanotubes, Interferometry, Nanomedicine, Nanostructures, Mechanical Properties, Nanoelectronics
Robotics	Automation, Robotics, Process Automation, Robotic Process Automation (RPA), Electrical Controls, Mechatronics, Electro-mechanical, Machine Design, Industrial Automation, UiPath

Source: Excerpted from World Bank Group-LinkedIn Digital Data for Development: Skill Group Definitions. Available at https://development-data-hub-s3-public.s3.amazonaws.com/ddhfiles/144635/skill-group-definitions.pdf

Appendix 3
LinkedIn Tech Skills Groups and Corresponding Definitions

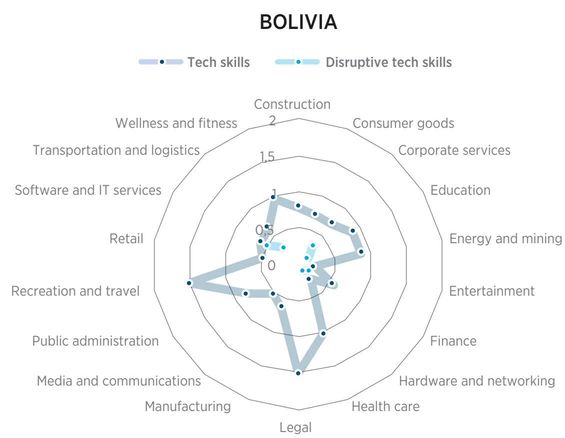
SKILLS GROUP	DEFINITION
Animation	After Effects, Autodesk 3ds Max, 3D Modeling, Animation, Maya, Motion Graphics, 3D, Rendering, V-Ray, Storyboarding
Computer Graphics	Computer Graphics, AutoCAD Mechanical, GIMP, Qt, Engineering Drawings, OpenGL, Digital Image Processing, Visualization, 2D graphics, Scalable Vector Graphics (SVG)
Computer Hardware	Computer Hardware, Ansible, Microcontrollers, PLC Programming, Printed Circuit Board (PCB) Design, VHDL, Verilog, Field-Programmable Gate Arrays (FPGA), Embedded C, Integrated Circuits (IC)
Computer Networking	Networking, Windows Server, Network Administration, Servers, Voice over IP (VoIP), Cisco Systems Products, Internet Protocol Suite (TCP/IP), Internet Protocol (IP), Virtual Private Network (VPN), Computer Networking
Data Storage Technologies	MySQL, Microsoft SQL Server, Databases, Cloud Computing, Oracle Database, Amazon Web Services (AWS), MongoDB, Data Center, Visio, PostgreSQL
Data-driven Decision Making	Business Decision Making, Decision Support, Ethical Decision Making, Data-driven Decision Making, Decision Analysis, Data Driven Testing, Decisiveness, Decision Modeling
Digital Literacy	Microsoft Office, Microsoft Excel, Microsoft Word, Microsoft PowerPoint, Microsoft Outlook, Microsoft Access, Computer Literacy, Office 365, Mac, Spreadsheets
Enterprise Software	SAP Products, SAP ERP, Software as a Service (SaaS), Enterprise Software, Microsoft Azure, Enterprise Architecture, SAP Implementation, Microsoft Dynamics CRM, Microsoft Dynamics NAV, Magento
Game Development	Unity, Video Games, Game Development, Game Design, Online Gaming, Gaming, Mobile Games, Unreal Engine 4, Gaming Industry, Perforce
Graphic Design	Adobe Photoshop, Adobe Illustrator, Graphic Design, Adobe InDesign, Adobe Creative Suite, Web Design, Art Direction, Logo Design, Illustration, Design
Information Management	SharePoint, Content Management, Content Management Systems (CMS), Document Management, Information Management, Knowledge Management, Records Management, Digitization, Laboratory Information Management System (LIMS), Archives
Mobile Application Development	Android Development, Android, Mobile Applications, Android Studio, Mobile Application Development, Android SDK, Firebase, Kotlin, iPhone, Mobile Device Management
Scientific Computing	MATLAB, SASS, Finite Element Analysis (FEA), Simulink, Bioinformatics, Abaqus, High Performance Computing (HPC), Scientific Computing, Creo, Hypermesh
Signal Processing	Signal Processing, Digital Signal Processing, Image Analysis, Encoding, Audio Processing, Signal Integrity, Video Processing, Kalman filtering, Image Segmentation, Acoustic Measurement

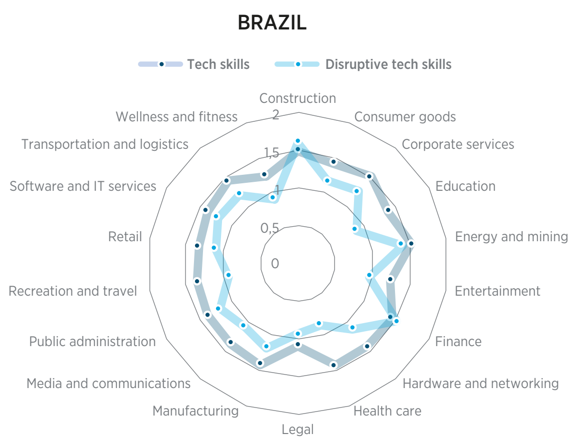
Social Media	Social Media, Facebook, Blogging, Instagram, Twitter, YouTube, Social Media Optimization (SMO), Social Media Advertising, Blogger, Social Media Blogging
Software Development Life Cycle (SDLC)	Agile Methodologies, Integration, Requirements Analysis, Scrum, Software Development Life Cycle SDLC, Solution Architecture, Requirements Gathering, Unified Modeling Language (UML), Systems Engineering, Software Design
Software Testing	Testing, Test Automation, Manual Testing, User Acceptance Testing, Test Planning, Regression Testing, Selenium, Software Testing, Test Cases, Functional Testing
System Administration	Windows, Operating Systems, Active Directory, System Administration, Virtualization, VMware, Disaster Recovery, Microsoft Exchange, Domain Name System (DNS), Powershell
Technical Support	Troubleshooting, Technical Support, ITIL, IT Service Management, IT Strategy, IT Management, Contact Centers, Windows 7, Software Installation, Service Delivery
Web Development	JavaScript, HTML, Cascading Style Sheets (CSS), Web Development, PHP, HTML5, WordPress, jQuery, XML, AngularJS
Web Hosting	Web Hosting, Internet Services, Postfix, Email Clients, Domain Management, Mail Server, Domain Registration, Managed Hosting, Hosted Services, Hosting Services

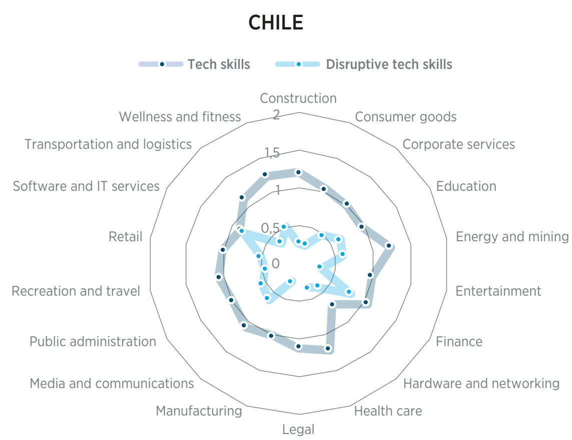
Source: Excerpted from World Bank Group-LinkedIn Digital Data for Development: Skill Group Definitions. Available at https://development-data-hub-s3-public.s3.amazonaws.com/ddhfiles/144635/skill-group-definitions.pdf.

Appendix 4
Digital Tech and Disruptive Digital Tech Skills in 18 LAC countries

This Appendix presents the relative skill penetration of tech and disruptive tech skills for all industries for each of the 18 countries provided in the dataset. In Bolivia, for example, there are more industries for which there are no data for disruptive tech skills. Whereas most tech skills appear to be below the global average (less than 1) for most of industries in Bolivia, some industries (specifically those related to legal and recreation as well as travel) appear to have a relatively high penetration of the group of skills called tech skills.







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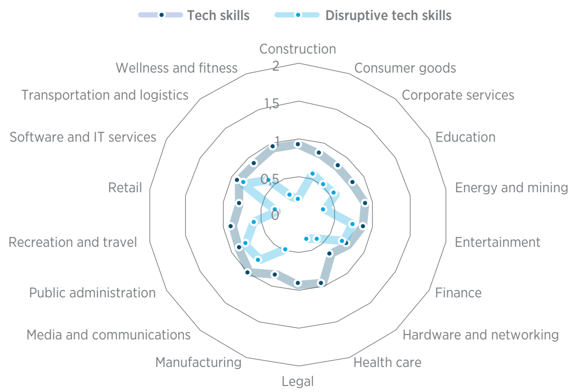

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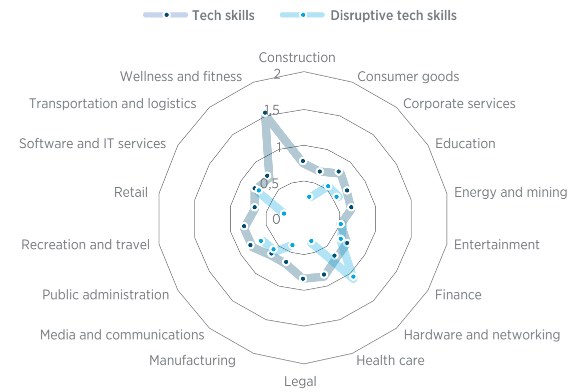
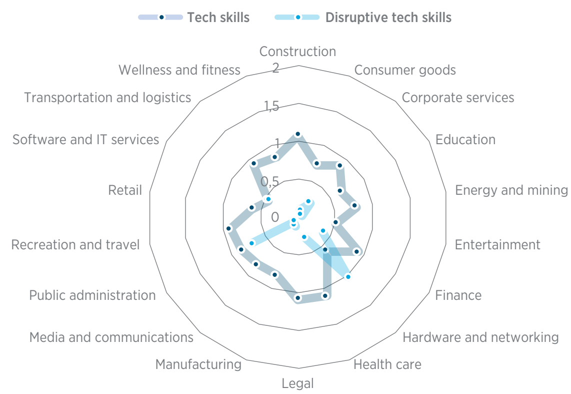
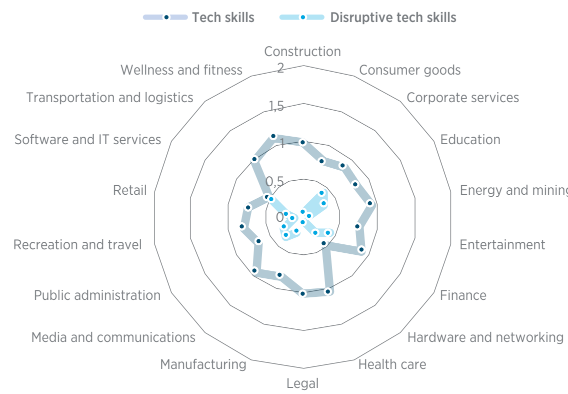


DOMINICAN REPUBLIC



ECUADOR



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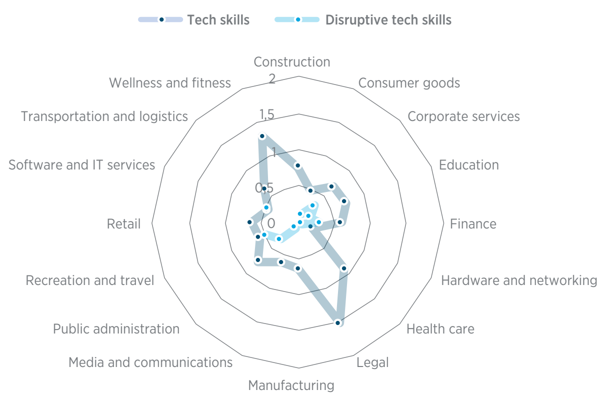
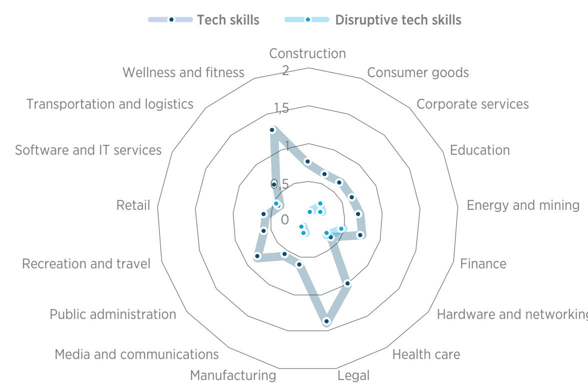


GUATEMALA



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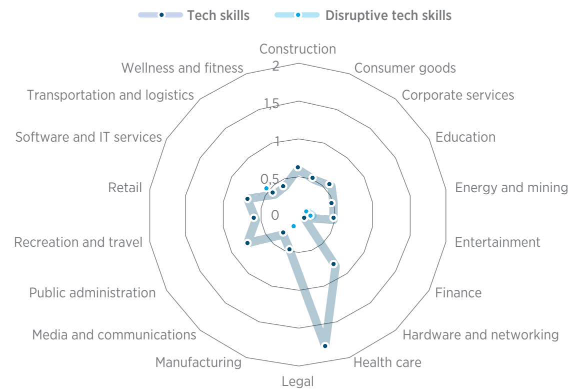

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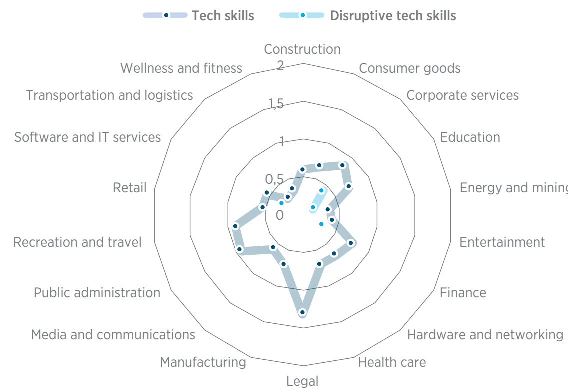

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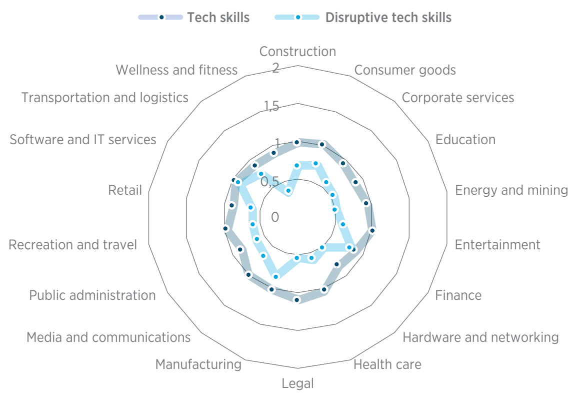

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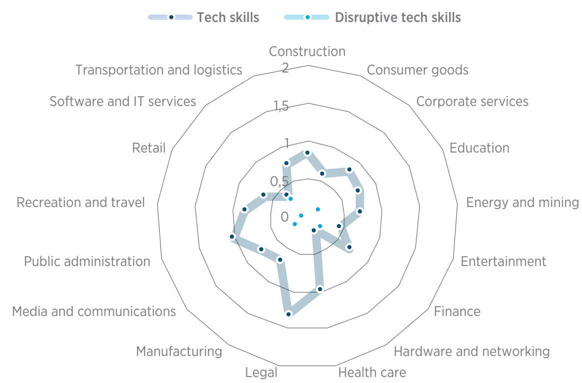

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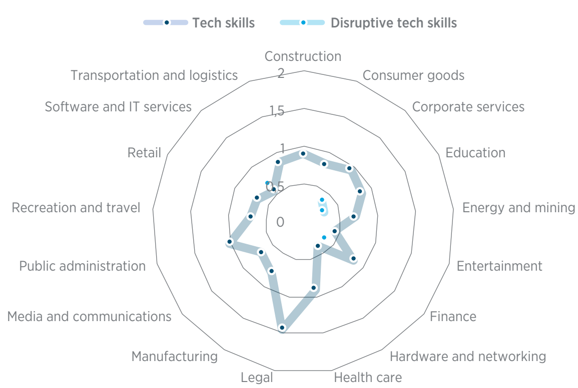
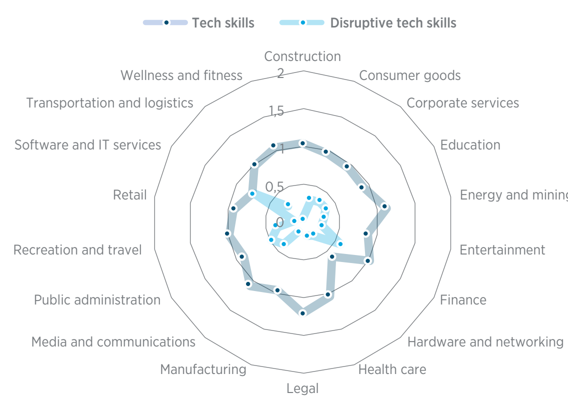
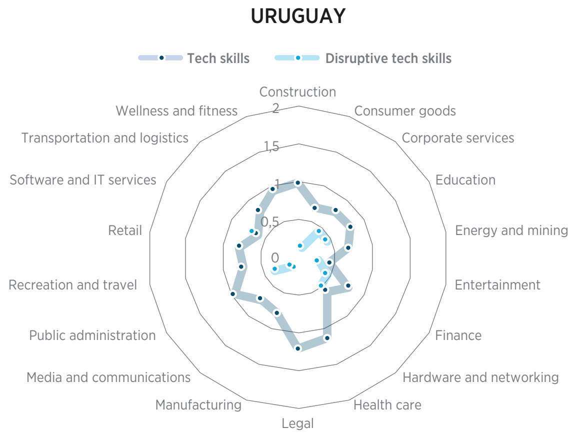
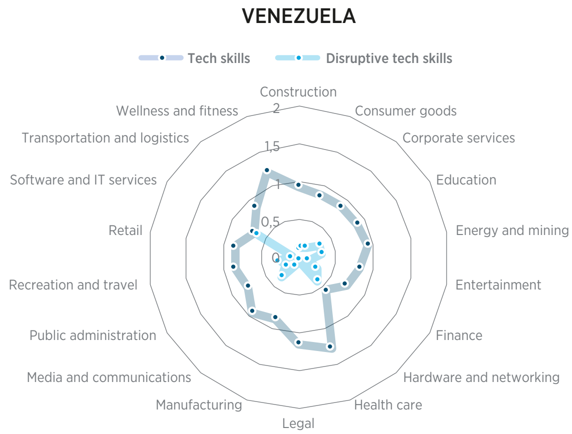


PERU







Source: LinkedIn skills penetration data obtained via the Development Data Partnership, available at https://datapartnership.org/. All data have been processed, analyzed, or graphed, so it does not share original data.

Appendix 5
Existing and Forthcoming Research by the IDB on Topics Related to Digital Transformation

Existing publications

Angelelli, P. et al. 2020. "Responding to COVID-19 with Science, Innovation and Productive Development." Washington, DC: Inter-American Development Bank. Available at https://publications.iadb.org/en/responding-to-covid-19-with-science-innovation-and-productive-development.

Cathles, A. 2020. "Sources of Data on Digital Talent in Latin American and the Caribbean." Washington, DC: Inter-American Development Bank. Available at https://publications.iadb.org/en/sources-of-data-on-digital-talent-in-latin-america-and-the-caribbean.

Cathles, A., and J. C. Navarro. 2019. "Disrupting Talent: The Emergence of Coding Bootcamps and the Future of Digital Skills." Washington, DC: Inter-American Development Bank. Available at https://publications.iadb.org/en/disrupting-talent-emergence-coding-bootcamps-and-future-digital-skills.

Navarro, J. C. 2018. "The Digital Transformation Imperative: An IDB Science and Business Innovation Agenda for the New Industrial Revolution." Washington, DC: Inter-American Development Bank. Available at https://publications.iadb.org/en/digital-transformation-imperative-idb-science-and-business-innovation-agenda-new-industrial.

Suaznábar, C., D. Herrera, and A. Cathles. 2022. "Convivir con el Coronavirus ¿Cómo aprovechar la inercia para digitalizar a las pymes de la región?" Washington, DC: Inter-American Development Bank. Available at https://publications.iadb.org/publications/spanish/document/Convivir-con-el-coronavirus-Como-aprovechar-la-inercia-para-digitalizar-a-las-pymes-de-la-region.pdf.

Suaznábar, C., and P. Henriquez. 2020. Transformación Digital Empresarial: ¿Cómo nivelar la cancha?. Washington, DC: Inter-American Development Bank. Available at https://publications.iadb.org/es/transformacion-digital-empresarial-como-nivelar-la-cancha.

Blog posts

Goellsch, M., A. Castillo Leska, and C. Suaznábar. 2021, July 27. Aprendiendo juntos para avanzar en la transformación digital de MIPYMEs: el caso de Uruguay. BID blog post. Available at https://blogs.iadb.org/innovacion/es/aprendiendo-juntos-transformacion-digital-de-micro-pequenas-y-medianas-empresas-y-la-propuesta-para-el-uruguay/.

Hernriquez, P. 2020, April 29. COVID-19: ¿Una oportunidad para la transformación digital de las pymes? BID blog post. Available at https://blogs.iadb.org/innovacion/es/covid-19-oportunidad-transformacion-digital-pymes/.

Navarro, J. C., and A. Cathles. 2019, July 8. Bootcamps de programación: ¿Cuáles son sus resultados y qué futuro tienen en la región? BID blog post. Available at https://blogs.iadb.org/innovacion/es/bootcamps-de-programacion-america-latina-y-el-caribe/.

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