Chapter 2

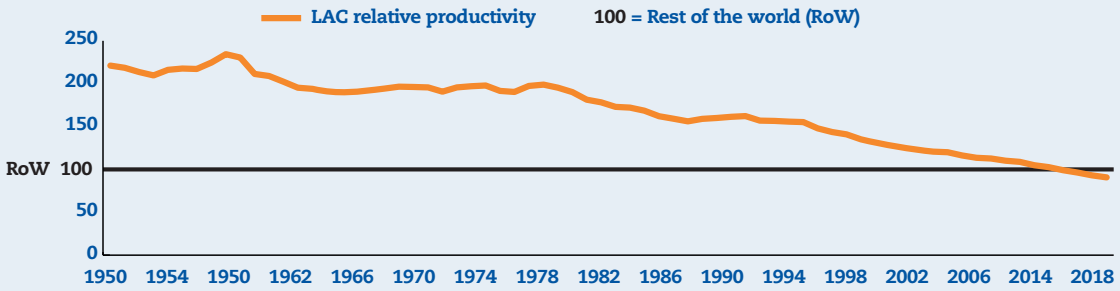
Fostering productivity and enhancing the digital transformation

Productivity in Latin America and the Caribbean relative to the Organisation for Economic Co-operation and Development (OECD) area has been falling since the 1950s. The growing gap reflects a production structure based on natural resources and abundance of low-skilled labour, which results in low value added. Large productivity gaps within sectors and firms reveal a heterogeneous productive structure. Structural difficulties could be amplified by the coronavirus (Covid-19) crisis. The digital transformation could help countries face the pandemic by improving productivity and efficiency and diversifying the productive matrix. However, its net impact will depend on policy choices and the development of indispensable and complementary factors, including communication infrastructure, transport connectivity as well as digital skills and capabilities.

The digital revolution can be a driving force of productivity growth

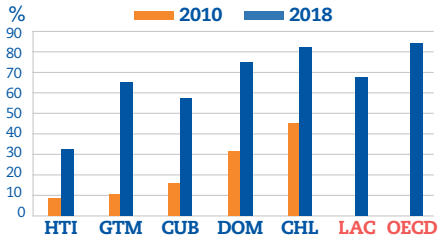
LAC countries' production structure and structural heterogeneity explain the growing productivity gap

LAC's labour productivity has decreased during the past decades, compared with the rest of the world



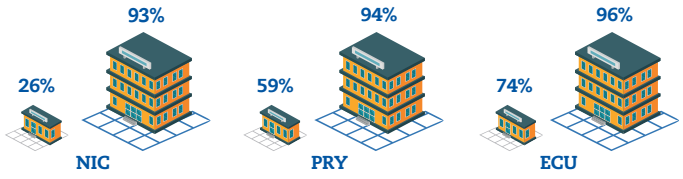
To take advantage of the digital revolution, indispensable elements, such as a holistic digital ecosystem and reliable infrastructure, are needed

The share of people in LAC using the Internet almost doubled since 2010



Low adoption of basic technologies, especially among small firms, remains an issue in some countries

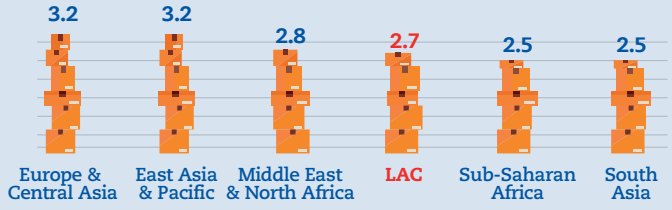
Share of small vs. large companies that own their own website, 2017



For LAC firms, a successful digital transformation depends on several complementary elements, including:

High transport costs hamper competitiveness, including the expansion of e-commerce

2018 World Bank Logistics Performance Index score



Digital skills are critical. LAC could further exploit the international market demand for IT services and programming

Introduction

Increasing productivity is one of the most relevant challenges for Latin America and the Caribbean (LAC) (OECD et al., 2019). The region's competitiveness is largely based on the advantages of natural resources and the abundance of low-skilled labour. This type of comparative advantage can provide periods of rapid growth in gross domestic product (GDP) (e.g. during the commodity boom) but not sustained productivity growth. The kind of competitiveness needed to achieve long-term productivity convergence with advanced countries relies on incorporating technology and diversifying the productive structure towards more dynamic sectors, both in technology and in terms of international demand (ECLAC, 2014).

Higher productivity gains go hand in hand with the accumulation of capabilities in advanced digital technological paths. As technological advances accelerate, there is less room for competition based on static comparative advantages, such as abundant natural resources and low-skilled labour. Economic development requires reallocating resources towards innovation and knowledge-intensive sectors, and diversifying towards sectors and activities with rapidly growing domestic and external demand.

The digital revolution involves large disruptions that could promote productive diversification and sustainable productivity growth in the region. Digital disruptions are triggering innovations in business models and production systems, reorganisation of economic sectors, new dynamics in the world of work, supply of smart goods and services, and new conditions of competitiveness. They involve various technologies, which have become increasingly numerous, cheap and powerful in recent years. Possibilities for progressive and inclusive structural change have increased in step but not uniformly across countries and sectors. Harnessing the digital revolution's opportunities increasingly depends on how economies, productive sectors, institutions and societies position themselves to absorb and adapt new technologies.

The digital transformation affects all sectors and adds value throughout production chains, but the magnitude of change depends on the state of indispensable and complementary factors. The digital transformation affects sectors with differing speeds and degrees (OECD, 2019a). Adoption of digital technologies by smaller companies in LAC shows potential, which is significant, considering the region's structural heterogeneity (ECLAC, 2013). Digital technologies also promote integration in productive chains by facilitating interaction in supply and distribution. Similarly, digital technologies can promote companies' commercial insertion by reducing information asymmetries, and transport costs. However, there is no direct relationship between the incorporation of information and communications technology (ICT) and increased productivity. The magnitude of the positive effect depends on indispensable and complementary factors, including proper access and diffusion of digital technologies, healthy business dynamism, small and medium-sized enterprise (SME) engagement in digital transformation, adequate transport connectivity and skills, and sufficient competition in the digital economy. Similarly, the specificities of the ecosystem in which the productive agents perform, characteristics of the technologies, features of the firms, and capacity to create efficient innovation systems also enable taking full advantage of the technologies (ECLAC, 2010; ECLAC, 2013).

Digital technologies and infrastructure have been more critical than ever during the coronavirus (Covid-19) crisis. Communication infrastructure and access to the Internet have been strategic in supporting economic and social life. For instance, in OECD economies some operators experienced as much as a 60% increase in Internet traffic compared to before the crisis (OECD, 2020a). The crisis will accelerate the ongoing structural changes of the past decade. Greater digitalisation will be a feature of the post-pandemic economy

(ECLAC, 2020a). As quarantines have increased virtualisation of economic and social relations, telework may prevail in more industries and regions, advancing digitisation even faster. The most technologically advanced companies, particularly selected micro, small and medium-sized enterprises (MSMEs) will increase their advantage. Long quarantines of workers encourage investment in automation and robotics and increased use of artificial intelligence (AI) tools (CAF et al., 2020).

This chapter begins by briefly analysing the coronavirus' (Covid-19) impact on the production structure. It then presents the causes of the persistent and growing productivity gap between LAC and OECD countries. It investigates how digital technologies could promote productivity growth, with an emphasis on the role of the digital ecosystem. The third section highlights the importance of communication infrastructure, transport connectivity, and digital skills and capabilities as indispensable and complementary elements to make the most of digital transformation. The fourth section explores the policies in the region to promote the digital transformation and increase productivity. The fifth section studies the role of the digital transformation in the region in the post-coronavirus context. Finally, the chapter concludes with policy recommendations.

Coronavirus (Covid-19) crisis: Impacts on an already challenged production and business structure

The coronavirus (Covid-19) pandemic has generated the greatest crisis of the last 100 years in LAC (see Chapter 1). It has exposed historical weaknesses in a production system characterised by a heterogeneous production structure between and within sectors and companies.

The economic crisis caused by the coronavirus' (Covid-19) affects supply and demand in the region. Concerning supply, sectoral impacts have been transversal but heterogeneous. Social restrictions have led to partial or total suspension of productive activities, mainly affecting sectors whose activity depends on physical proximity. Sectors defined as essential have had a moderate impact. The impact of the crisis is much greater for MSMEs, with serious job losses (ECLAC, 2020b). Owing to the interdependence of global value chains, interruption of certain productive activities has led to problems in supply of inputs, national and imported, creating difficulties for companies to continue operating.

Regarding demand, reduced consumer income and uncertainty about future scenarios have generated decline and change in consumption patterns. Most vulnerable groups have been affected by this crisis, in particular those informal workers hurt by a sudden income reduction. Decreased economic activity and other aspects of the international situation have reduced external demand. The decrease in commodity prices has affected in particular South American economies and some selected economies, including Mexico and Trinidad and Tobago (OECD, 2020b).

Companies have registered sharp decreases in income and experienced difficulties in the continuity of activities, which may significantly degrade the regional productive fabric. The lack of productivity and heterogeneity that characterises the productive structure has amplified the coronavirus' (Covid-19) impacts. The pandemic makes weaknesses more evident and exacerbates economic, social and environmental challenges. In the productive sphere, the situation intensifies the urgency of mitigating destruction of capacities, without forgetting the need to increase productivity sustainably, generate productive chains and promote innovation and digital transformation.

Economic reactivation must suppose important changes in firms and productive chain organisation. The pandemic has forced changes in companies' security conditions and relations among workers, suppliers and customers. Social distancing has accelerated

digital transformation and promoted processes that seek to increase productivity and efficiency. In an environment of rapid change and strong uncertainty, many companies have been forced to innovate, re-evaluate operations and change business models (ECLAC, 2020b).

Measures adopted by LAC countries to face the health emergency have led to firms' increased use of digital technologies[1] in their dealings with consumers, suppliers and employees, and in the organisation of internal management processes. Many changes will continue in the post-pandemic, particularly regarding consumer behaviour. Digital technologies will be key to new operating models in three respects. First, they will figure in promotion, sale and delivery of goods and services operations, and in supplier interactions. Second, companies will have to incorporate capabilities to acquire and process large amounts of information (Big Data) for decision processes (e.g. monitoring and adapting to changes in demand but also redefining supply chains). Third, in industry, it is reasonable to expect greater incorporation of connected devices in production processes and greater use of robotics to increase efficiency, especially given that health security may necessitate fewer workers in some stages of production.

The coronavirus (Covid-19) has exposed structural deficiencies in LAC's productive system. To face it, companies must seek greater efficiency and productivity, considering a series of key elements: how business models are rethought and value chains organised; orientation towards higher value-added products; change in energy consumption; greater interaction among firms (collective efficiency); and incorporation of new technologies and promotion of the digital transformation (ECLAC, 2020b).

Patterns of productivity and heterogeneity in Latin America and the Caribbean

Productivity dynamics are one of the most problematic aspects of LAC's economic performance (OECD et al., 2019; ECLAC, 2018a; ECLAC, 2014; ECLAC, 2010). LAC has a high and increasing productivity gap with developed economies. The lag of GDP per capita is mainly explained by low labour productivity. Increased labour productivity allows for more favourable insertion into the global economy while increasing disposable income, which promotes both internal and external demand.

The persistent productivity gap

LAC's aggregate labour productivity shows reduced and little persistent growth from 1950 onwards. LAC's productivity has decreased compared with the rest of the world since the 1960s (Figure 2.1).

GDP growth in LAC owes mainly to labour force expansion, with little contribution from productivity growth (Figure 2.2). There is, in this sense, growth by absorption of employment linked to increased aggregate demand, coupled with low or no technical progress and innovation. This contrasts with fast-growing emerging economies, such as the People's Republic of China (hereafter "China"), India or Korea, where productivity is an important driver of GDP growth.

The evolution of the region's employment structure largely explains the low productivity growth. The sectoral structure of employment in LAC from 1980 onwards shows three major changes: decreased share of agriculture, decreased share of manufacturing and increased participation of commerce (wholesale and retail trade). The combination resulted in rural-urban migration, which failed to produce productivity growth. The decline of labour in the agriculture sector prevented further deterioration of its productivity level. Nevertheless, the labour force arriving in cities failed to obtain

quality jobs owing to the simultaneous phenomenon of premature deindustrialisation since the 1980s. The commercial sector served as an avenue for emergency employment – largely informal and predominated by MSMEs (particularly microenterprises offering low-productivity jobs). This is reflected in the commercial sector's increased participation in total employment, from 14.3% in 1981 to 25.3% in 2018 (Table 2.1).

Figure 2.1. **Labour productivity of Latin American and Caribbean countries relative to the rest of the world, 1950-2019**

Note: Simple average of the 17 LAC countries covered by The Conference Board. Labour productivity is measured as the labour productivity per person employed in 2018 USD.

Source: Own calculations based on Conference Board (2020), *Total Economy Database* (database), www.conference-board.org/data/economydatabase.

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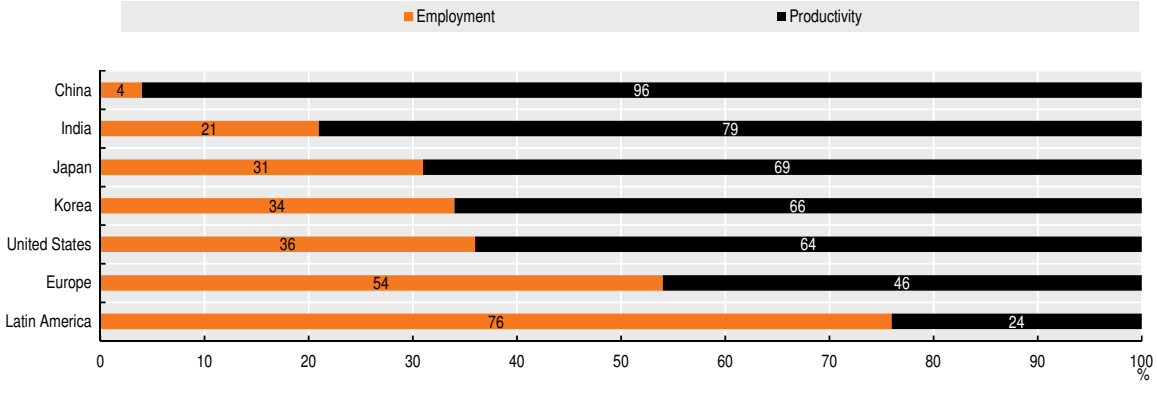
Figure 2.2. **Contribution of employment and productivity to GDP growth in selected countries and regions, 2000-19 (%)**



Note: Simple average of the 17 LAC countries covered by The Conference Board.

Source: Own calculations based on Conference Board (2020), *Total Economy Database* (database), www.conference-board.org/data/economydatabase.

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Table 2.1. **Participation in gross domestic product and employment by sector in selected Latin American and Caribbean countries, 1981, 2002 and 2018**

	Value added (%)			Employment (%)		
	1981	2002	2018	1981	2002	2018
Agriculture	5.2	5.6	5.5	23.3	20.2	14.6
Mining	6.9	8.0	5.2	1.0	0.5	0.6
Manufacturing	18.9	16.7	13.6	16.2	14.2	12.2
Electricity	1.6	2.6	2.5	0.9	0.5	0.5
Construction	10.2	6.6	7.1	7.1	6	7.7
Wholesale and retail trade	15.4	13.7	14.5	14.3	23.3	25.3
Transport and communications	4.3	6.7	9.6	4.7	5.1	6.4
Financial and business services	15.2	16	18.6	5.6	5.5	7.7
Community services	22.3	24.3	23.3	27	24.7	25
Total	100	100	100	100	100	100

Note: Selected LAC countries are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Uruguay and Venezuela.

Sources: ECLAC (2020c), *Databases and Statistical Publications* (database), https://estadisticas.cepal.org/cepalstat/WEB_CEPALSTAT/buscador.asp?idioma=i&string_busqueda=; ILO (2020), *Statistics and Databases* (database), www.ilo.org/global/statistics-and-databases/lang--en/index.htm.

The productive structure

LAC countries' productive structure and structural heterogeneity explain the growing productivity gap. Most countries in the region have developed productive activities that use low-skilled labour and operate with few connections with the rest of the economy. These activities do not create or benefit from technological spill-overs and local capacity building. Dynamic productive chains are isolated cases that do not affect the general economic landscape.

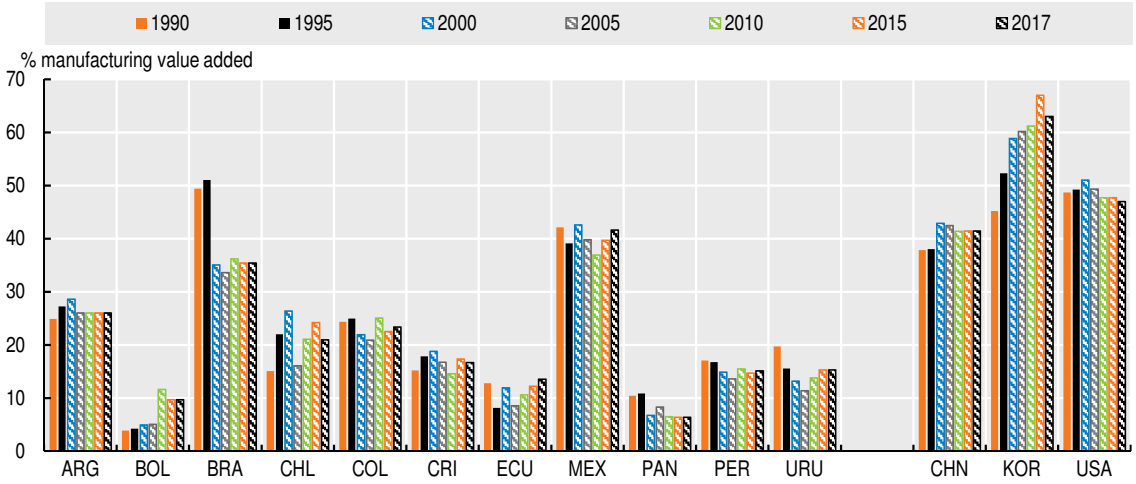
LAC has a poorly diversified productive structure, resulting in low value added. Countries' export specialisations are concentrated in goods with low technological content. This correlates with relatively lower value added generated by the manufacturing sector and, in particular, medium- and high-tech industries – an element especially relevant as technological progress is increasingly important (Figure 2.3). The region's poorly diversified productive structure and highly heterogeneous productivity across firms may make the digital transformation a greater source of polarisation, increasing productivity differentials within countries. Developing greater productive and technological chains requires policies that facilitate and promote the incorporation of technologies by firms in all sectors and independent of their size.

The productive structure's impacts on average labour productivity are rooted in structural heterogeneity (defined as wide variation in labour productivity among and within sectors). Variation in the region is marked enough to segment the productive system and the labour market. Technological and remuneration conditions are strongly asymmetric across segments (Cimoli and Porcile, 2013).

Two indicators highlight structural heterogeneity in productivity in LAC economies. The intersectoral indicator has shown high heterogeneity in recent years, compared with previous decades (Table 2.2): for instance, heterogeneity between mining and wholesale and retail trade increased between 1981 and 2018. Intrasectoral heterogeneity (units of production within a sector) is typically measured based on the coefficient of variation of the level of productivity of sectors. Using the standard deviation over the average of sectoral productivity, internal structural heterogeneity is estimated to have increased by almost 20% during the period: in particular, it increased by 50% between 1981 and 1998

owing to productivity movements in the mining and hydrocarbon sectors, then decreased by 35% by 2018 (Figure 2.4). Intersectoral and intrasectoral indicators are complementary, and both contribute to understanding the increased structural heterogeneity.

Figure 2.3. **Medium- and high-tech industry manufacturing value added in selected countries, 1990-2017**



Source: UNIDO (2019), *UNIDO Statistics* (database), www.unido.org/researchers/statistical-databases.
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Table 2.2. **Levels of relative productivity by sector in selected Latin American and Caribbean countries, 1981, 2002 and 2018**

	1981	2002	2018
Agriculture	20	25	34
Mining	606	1 322	846
Manufacturing	105	105	100
Electricity	165	448	409
Construction	131	99	84
Wholesale and retail trade	98	53	51
Transport and communications	84	119	135
Business services	247	259	218
Community services	75	89	84

Note: Selected LAC countries are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Panama, Paraguay, Peru, Uruguay and Venezuela. Base 100 = manufacturing sector in 2018.

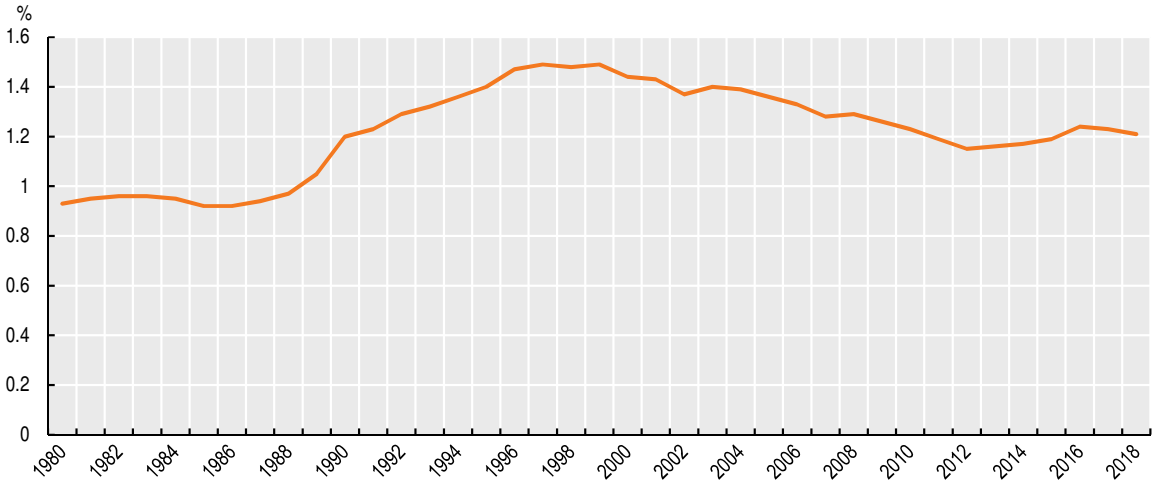
Sources: Own calculations based on official country data; ECLAC (2020c), *Databases and Statistical Publications* (database), https://estadisticas.cepal.org/cepalstat/WEB_CEPALSTAT/buscador.asp?idioma=i&string_busqueda; ILO (2020), *Statistics and Databases* (database), www.ilo.org/global/statistics-and-databases/lang--en/index.htm.

Structural heterogeneity is also observed in productivity by firm size. Productivity of micro, small and medium-sized enterprises in 2016 was 6%, 23% and 46% that of large companies in Latin America (LA), respectively – levels virtually unchanged since 2009 – vs. differentials observed in the European Union for micro (42%), small (58%) and medium-sized (76%) enterprises (Figure 2.5). The differentials are more pronounced when comparing firms' productivity in selected countries. Small enterprise productivity gaps are more than 18 times larger than those observed in European countries. For instance, in Brazil, microenterprise productivity represents 4% that of large companies, compared with 74% in France.

Productivity heterogeneity is important in identifying the potential impacts of the digital transformation. In a region where productivity disparities are apparent among

and within economic sectors and production segments, and where workers' productivity levels vary widely (associated with education levels), the digital transformation brings opportunity but also a risk of reinforcing disparities.

Figure 2.4. **Coefficient of variation of sectoral productivity in selected Latin American and Caribbean countries, 1980-2018**



Note: Simple average of the 18 LAC countries selected, depending on data availability.

Sources: Own calculations based on official country data; ECLAC (2020c), *Databases and Statistical Publications* (database), https://estadisticas.cepal.org/cepalstat/WEB_CEPALSTAT/buscador.asp?idioma=i&string_busqueda; ILO (2020), *Statistics and Databases* (database), www.ilo.org/global/statistics-and-databases/lang--en/index.htm.

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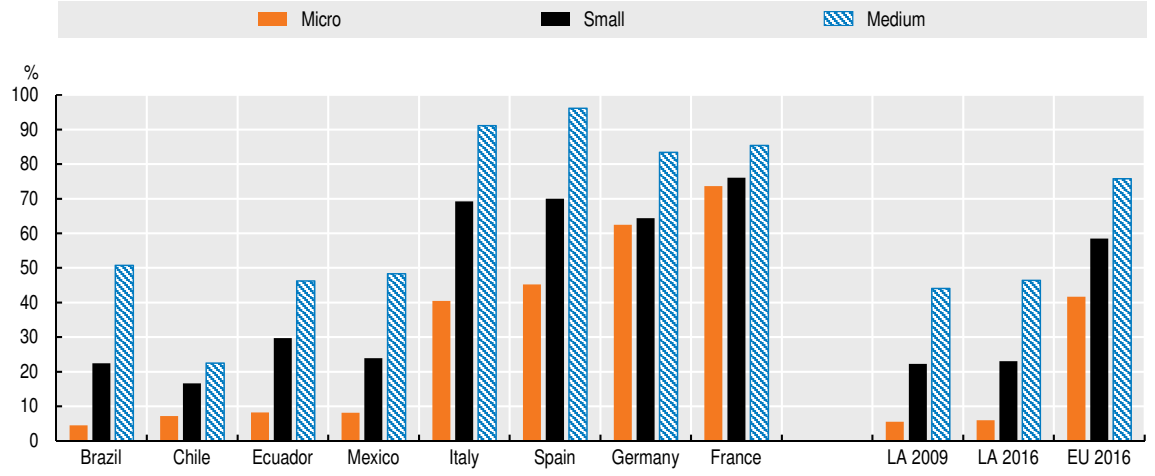
Figure 2.5. **Productivity gaps by firm size compared with large companies in selected countries and regions, 2016**



Source: ECLAC (2020b), "Sectors and businesses facing COVID-19: Emergency and reactivation", *Special report: Covid-19*, Economic Commission for Latin America and the Caribbean, Santiago, https://repositorio.cepal.org/bitstream/handle/11362/45736/5/S2000437_en.pdf.

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Structural heterogeneity is a key consideration in designing policies that balance economic growth with equality. Structural heterogeneity strongly influences the region's unequal income distribution. The low-productivity sector, which represents a large weight, mostly employs low-educated workers and offers almost no social security coverage (ECLAC, 2010; ECLAC, 2014; OECD et al., 2019).

Increased productivity with digital technologies

Digital technologies and productivity growth: A complex relationship

Productivity growth is the core engine of sustained economic growth (Solow, 1988).[2] Since the first industrial revolution, new technologies have improved productivity (Dosi, 1984) and can contribute to close the gap in Latin American and the Caribbean countries (ECLAC, 2016). On the cusp of the fourth industrial revolution, there is a growing debate on the potential of digital technologies to foster productivity in developed and transitioning countries. Traditional debate is polarised, with techno-optimists predicting a positive impact (Brynjolfsson, McAfee and Spence, 2014) and techno-pessimists questioning the incremental impact on productivity and growth (Gordon, 2012).

Innovation and technology dynamics are not independent of industrial structures, labour relations and income distribution (see Chapter 3 for the social effects of the digital transformation). Rather, they are embedded in complex political economies and thus highly context specific (see Box 2.1 for a specific case in the region). Ultimately, digital technologies' impact on productivity will result from proper access and diffusion of digital technologies, healthy business dynamism, SME engagement in digital transformation, adequate skills and sufficient competition in the digital economy (OECD, 2019a). These aspects have been discussed in the framework of the OECD Third LAC Regional Programme Ministerial Meeting on Productivity (Bogota-Colombia, October 2019). Finally, policies must tailor digital frameworks and include social and economic factors.

Data availability and theoretical and empirical assumptions make it difficult to disentangle the links between technology and productivity. The complexity may explain the mixed evidence (Box 2.2). Digital technologies are complementary to other factors: country, industry and firm structural characteristics. Cross-country studies suggest that firms' adoption of digital technologies varies widely among and within countries (Hagsten et al., 2012), depending on firms' capabilities and incentives (Andrews, Nicoletti and Timiliotis, 2018). Firm- and industry-level studies show that firms' capabilities and industry sophistication matter in accelerating the benefits of new technologies.

Box 2.1. **Digitalisation of production in Peru**

The United Nations (UN) Economic Commission for Latin America and the Caribbean, in co-ordination with the Development Bank of Latin America (CAF), is developing a pilot project focused on the digitalisation of production processes. It identified a production chain with significant impact on Peru's economy.

The Ica region is a key contributor to national GDP, and its exports represent 7.4% of the national total. The main agricultural exports are asparagus, avocado, hard yellow corn and tangerine. The project first evaluated the region's digital connectivity and the potential for digital solutions to key problems identified along value chains.

Results of agricultural export industry analyses led to the identification of potential technological solutions for various industries and value chains (Table 2.3). For the fishing value chain, they included radio-frequency identification-enabled catch sensor tracking systems, seabed and marine bank visualisations, geolocation systems for fleets, digitalisation of supplier-customer relationships and inventory management, and automation of product auctions. For the electric energy value chain, they included remote monitoring systems and atmospheric sensors, automatic management of energy reserves, predictive maintenance of assets, identification by leakage sensors in the distribution stage, and automatic monitoring of transport paths using drones.

Box 2.1. **Digitalisation of production in Peru** *(cont.)*

Table 2.3. **Potential technological solutions for various industries in Peru**

Technological solutions and production	Logistics and exports
Smart irrigation systems	Cold chain control
Field monitoring	Tracking and product traceability system
Smart collection tools	Efficient inventory management system
Geographic remote sensing	Logistics optimisation and management tools
Smart pest control	
Technological enablers include: IoT, Big Data, Cloud services, data analysis and drones.	

Note: IoT = Internet of things.
Source: Own elaboration based on official information.

The exercise showed that, to achieve a greater impact, policies related to the digitalisation of production must consider each sector's distinctive characteristics. Despite common enabling elements, such as infrastructure and digital skills, each sector requires tailor-made solutions.

Box 2.2. **Productivity measurement in the digital age**

Labour productivity is commonly measured as GDP per hour worked. Productivity growth usually measures the efficiency of productive processes in terms of input/output ratio: it rises when output increases more than input. Measuring productivity in the digital age, and thus productivity gains resulting from technology adoption, raises measurement issues.

1. Prices and quality may not be fully identified, implying mismeasurement of output growth in GDP. Price, volume and quality are fundamental to productivity measurement. Disentangling their relationship is particularly challenging in the digital age. In efficient markets, prices reflect some dimension of quality priced by consumers (Stiglitz, Sen and Fitoussi, 2009). The relationship between the quality and the price of digital products and services can be counterintuitive, e.g. digital product quality has increased but prices have fallen in the last decade. Some products, such as apps or digital services, are free to access and do not enter into GDP measures. Consumers nonetheless pay in personal data and exposure to advertisements. Owing to the complexity of disentangling price and quality effects, increasing digitalisation can increase mismeasurement of productivity.

2. Digital products have offsetting effects on multifactor productivity (MFP) measures. MFP measures the output produced by the combined effect of labour and capital. Digital products are both input and output and thus contribute to both sides of the MFP ratio, leading to an understatement of their contribution as input and resulting in the overstatement of the MFP measurement.

3. Globalisation and cross-border trade make input and output measurements more difficult. Aggregate-level production statistics can disguise measurement issues in output reporting. This could be the case in developed countries' offshore production, which is reported in the producing rather than in the owner country, negatively affecting the latter's productivity measurement. Cross-border trade might also affect capital measurement, especially in understating the contribution of knowledge assets, leading to MFP overestimations.

Productivity gains are strongly correlated with firms' performance and capabilities, and new technologies might widen productivity dispersion among and within countries. A new stream of research finds a positive link between sector-level diffusion of digital technologies and productivity growth (Table 2.4). Results are stronger for high-productivity firms. Firms closer to the frontier are more likely to adopt new technologies owing to the existence of important complementarities between new technologies and other investments that raise productivity. The efficient use of digital technologies is related to firms' capabilities, technological sophistication, managerial competences and workers' skills. High-productivity firms in technology-intensive sectors are also more likely to adopt new technologies and experience productivity gains (Berlingieri, Blanchenay and Criscuolo, 2017; Gal et al., 2019; Sorbe, 2019; OECD, 2019b).

Table 2.4. **Impact of digital technology complementarities on productivity gains: Evidence from the developed world**

Complementary variable	Focus of analysis	Results
Innovation and technological investment	OECD	**Investment in R&D and technology accelerates the benefits of digital technologies.** 1. Knowledge spill-overs at sectoral and country levels magnify the impact of ICT on productivity (Corrado, Haskel and Jona-Lasinio, 2017). 2. Innovation and R&D activities can contribute to productivity gains at the aggregate level and, if combined with digital technologies, can increase within-firm benefits (Bartelsman, Leeuwen and Polder, 2016). 3. ICT investment is an important channel to boost productivity gains (Cette, Lopez and Mairesse, 2017). 4. R&D, ICT and organisation capabilities are complementary, and joint investment increases productivity gains (Mohnen, Polder and van Leeuwen, 2018).
Skills and human capital	European Union	**Widening digital-related skills could strengthen the link between digital technology adoption and productivity.** 1. Shortage in technical skills at the industry level reduces the link between technology adoption and productivity performance (Gal et al., 2019). 2. Investment in skills upgrading is key to facilitating efficient technology adoption. Skills shortage is a main factor in lack of productivity gains in laggard firms (Andrews, Nicoletti and Timiliotis, 2018).
Sectoral sophistication	OECD	**Productivity gains vary across sectors, with stronger benefits for manufacturing.** 1. Technology adoption varies across sectors and sector-level structural characteristics, such as technological sophistication and human capital (Andrews, Nicoletti and Timiliotis, 2018). 2. Productivity gains are higher for sectors with standardised and routine-intensive activities (Chevalier and Luciani, 2018). 3. Digitalisation generates higher productivity levels in manufacturing (Dhyne et al., 2018; Gal et al., 2019). 4. Proximity – within-sector or in global value chains – with other digitalised firms can generate positive spill-overs and increase technology adoption and productivity benefits (Andrews, Nicoletti and Timiliotis, 2018).
Organisation capabilities	United States manufacturing, OECD	**Organisation capabilities and managerial ability can magnify productivity gains.** 1. Technology adoption is associated with a larger productivity increase if it is systemic and associated with broader incentives but leads to little or no gain when adopted in isolation (Aral, Brunjolfsson and Wu, 2012). 2. Dispersion in IT investment per employee explains 8% of productivity dispersion; management quality explains up to 17% (Bloom, Sadun and Van Reenen, 2017). 3. Organisation capabilities are complementary to ICT and R&D investment (Mohnen, Polder and van Leeuwen, 2018).
Quality infrastructure	United Kingdom	**Quality infrastructure is key to guaranteeing efficient use of digital technologies but has no direct impact on productivity.** 1. Communication infrastructure is a determining factor for adoption and use of digital technologies. Access to quality broadband is linked to complementary investment in ICT. There is no clear link with firms' performance (De Stefano, 2018).

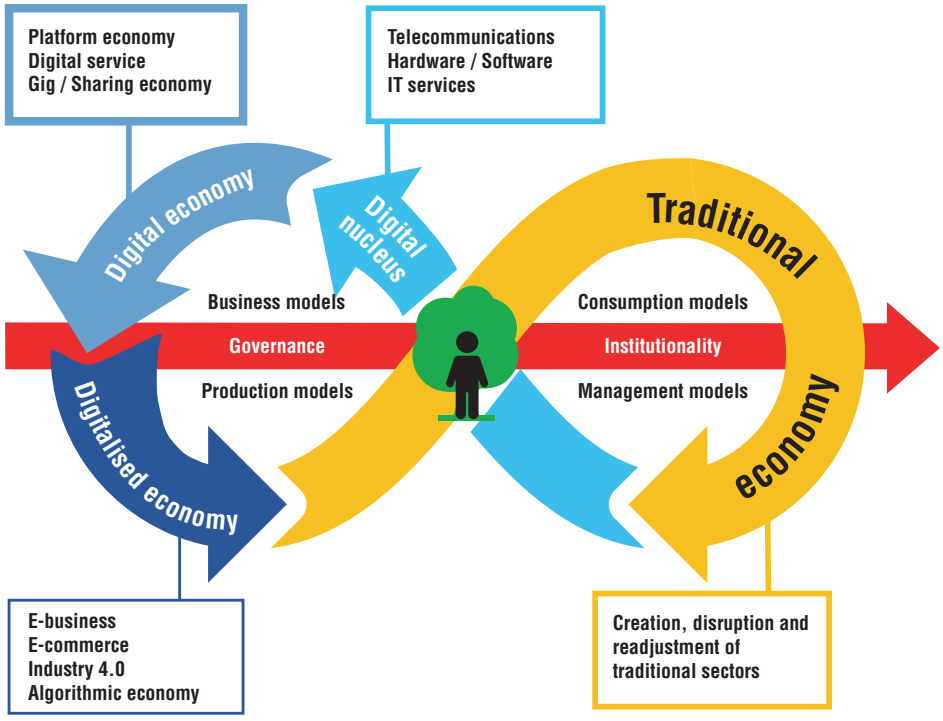
Notes: ICT = information and communications technology. IT = information technology. R&D = research and development.

The digitalised economy: Changing the production structure

The digital revolution is giving rise to a fourth industrial revolution, which is generating a digitalised economy. The current context is not simply a globalised world hyper-connected economically and socially; it is one in which the traditional economy's organisation, productive and governance schemes coexist and merge with the digital economy's innovations in business models, production, business organisation and governance (Figure 2.6). The coronavirus (Covid-19) pandemic has accelerated this phenomenon. Traditional and digital spheres are integrated and interact, leading to more complex ecosystems, which are undergoing rapid organisation, institution and regulatory transformation in keeping with the digital revolution (ECLAC, 2018b).

The first phase of the digital revolution led to the development of the digital economy: business models focused on the supply of digital goods and services (Bukht and Heeks, 2017). The value of goods and services changed radically. Digital cameras redefined photography, e-reading redefined print media, streaming redefined music, the sharing economy redefined transport and hotel industries, to name some of the first industries hit by the disruptive effects of the digital transformation.

Figure 2.6. **The digital transformation of the economy**



Source: Own elaboration.

Digital platforms make important contributions to the economy by creating new connections between supply and demand in various markets, reducing transaction costs and intermediation, generating efficiency gains in use of assets, and opening new markets and business opportunities, including for MSMEs to join global value chains (OECD, 2019c). New business models operate on digital platforms in multiple sectors in LAC. They facilitate commercial transactions (Amazon, Alibaba, Mercado Libre), financial services (Ant Financial, Avant, Mercado Pago, Nubank), social networks and over-the-top communication services (Facebook, Skype, WhatsApp), tourism and hosting

services (TakeOff, Booking, Airbnb), app development (Apple iOS, Google Android) and job matching (Laborum, LinkedIn, Workana, Freelancer). However, in part due to LAC's productive and social structure, the coronavirus (Covid-19) pandemic has demonstrated unequal adoption of these platforms across the population, which may accentuate digital exclusion by socio-economic status, age and location (see Chapter 3). These solutions require complementary factors, such as high connection speeds and digital skills. Lack of these factors compromises the use of more sophisticated digital platforms, as has been the case during the crisis.

Digital businesses have evolved to incorporate exploitation of data generated and exchanged on platforms. While offering services and digital goods with reduced intermediation and transaction costs, they have also expanded their business models. Data processed and analysed with intelligent tools allow for improved decision making and optimisation of the value proposition via greater agility in operations, market segmentation and customisation. This entails a need to regulate and consider the ethical issues of data collection and use. Protecting individuals from risk of data theft and misuse is another challenge (see Chapter 4).

Widespread adoption of digital technologies in all sectors made way for the second phase of the digital revolution: the digitalised economy. It is characterised by use of digitised information and knowledge as a production factor, productivity engine and optimisation tool for business models. Digitalisation goes beyond optimisation of production and management; performance is improved by reconfiguring products and services, business models and production based on the adoption of digital intelligence. This is driving the transformation of traditional industries, creating new ones: Autotech, Agritech and Fintech, to name a few (ECLAC, 2020d).

Algorithms revolutionised competition, presenting the possibility of collusion, cartels, segmentation, etc., and created government and private mechanisms capable of changing and regulating markets, for instance, through algorithmic fraud detection. However, given the large volume of data in LAC generated by the digital transformation and the value of those data to foreign companies, merger and acquisition strategies and the concentration of Big Tech markets may threaten the region's competitiveness. Furthermore, it is not clear which human decision-making will be supported by machines and the implications of the automation of decision-making processes for competition (OECD, 2017).

Creating a sustainable digital ecosystem depends on fair competition in markets. Sustainable digital transformation requires appropriate regulatory frameworks with solid institutions (e.g. guaranteeing competition, cybersecurity, privacy). The coronavirus (Covid-19) accelerated digital transformations, which in turn hastened the development of new legal and institutional frameworks.

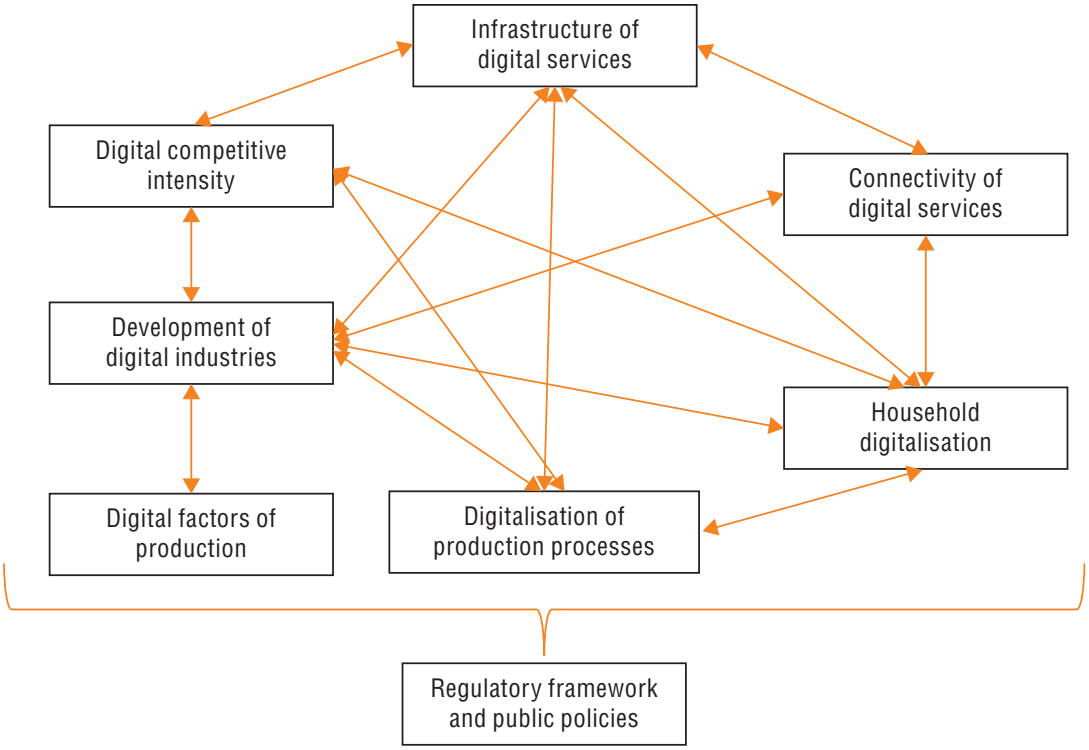
Digitalisation has the potential to increase productivity and achieve sustainable development, but its net impact will depend on policy choices and the digital ecosystem. Even in the most advanced OECD economies, the diffusion of digital technologies is far from complete.[3] Digitalisation changes consumption and production models, generating productivity and welfare gains among consumers that can be combined with environmental sustainability objectives to profit the whole society. However, development and adoption of digitalisation that is not guided by principles of inclusion and sustainability may reinforce social exclusion and discrimination, and unsustainable exploitation and production practices (ECLAC, 2020d). Digitalisation's net effect with respect to sustainable development will depend on the thorough assessment of the situation and policy action to route digitalisation adequately (see Chapter 4), and on the development of digital ecosystems that allow full realisation of the benefits of the transformation.

Digital ecosystem development in Latin America and the Caribbean

The digital ecosystem plays an important role in accelerating the benefits of digital technologies, with important implications for laggard firms, sectors and countries. It offers significant policy design opportunities, especially in LAC countries. Given the structure and technological sophistication of the region's productive sector, facilitating technology adoption is not enough. There is a need to develop all elements of the requisite digital ecosystem – infrastructure, human capacities and business environment – to promote investment, innovation and entrepreneurship.

The Digital Ecosystem Development Index[4] is based on eight multi-component pillars: infrastructure, connectivity, household digitalisation, digitalisation of production, competitive intensity, digital industries, factors of production, and regulatory frameworks (CAF, 2017; CAF et al., 2020). The ecosystem concept captures the pillars' systemic interrelation (Figure 2.7). For instance, communication infrastructure is essential for household access to and companies' use of digital content and services, and allows operators within the value chain (e.g. app and content providers) to connect and present a value proposition to the market (Katz, 2015).

Figure 2.7. **Structure of the digital ecosystem**



Source: CAF (2017), *Towards the digital transformation of Latin America and the Caribbean: The CAF Observatory of the Digital Ecosystem*, Development Bank of Latin America, Caracas, https://www.caf.com/app_tic/#es/home and https://scioteca.caf.com/bitstream/handle/123456789/1052/METODOLOGIA%20DE%20IDED.pdf?sequence=1&isAllowed=y; Katz and Callorda (2018), "Accelerating the development of Latin American digital ecosystem and implications for broadband policy", https://doi.org/10.1016/j.telpol.2017.11.002.

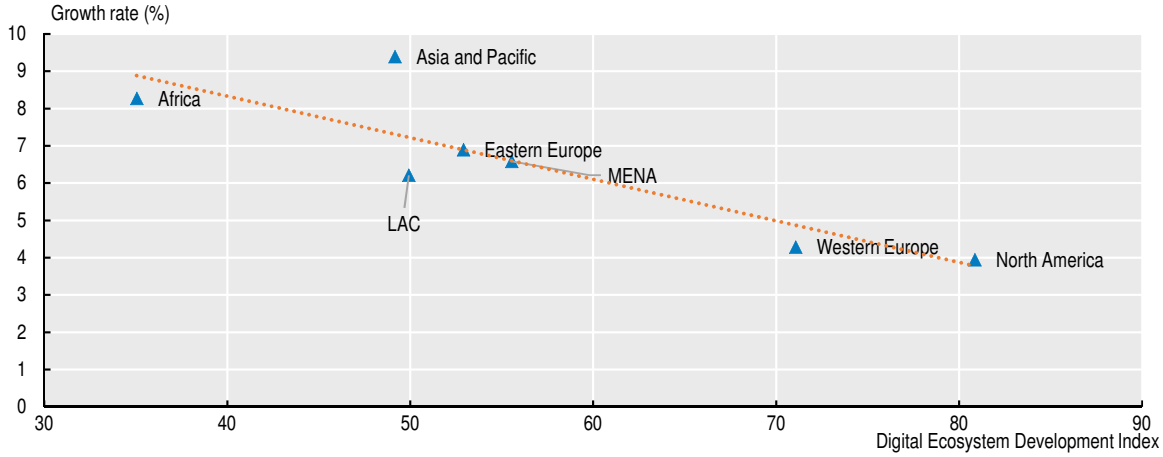
While the index shares indicators with the OECD Going Digital Toolkit, such as mobile and fixed broadband penetration, Internet users, UN E-Government Development Index and research and development (R&D) expenditure relative to GDP, the frameworks have different but complementary purposes (OECD, 2019d). The Going Digital Toolkit is structured along the seven policy dimensions of the Going Digital Integrated Policy

Framework, which cuts across policy areas to help ensure a whole-of-economy and whole-of-society approach to realising the promises of the digital transformation for all (OECD, 2019d). The Digital Ecosystem Development Index is based on an econometric model that measures digitalisation's economic development impact by assessing LAC's progress relative to OECD economies (CAF, 2017; CAF et al., 2020; Katz and Callorda, 2018). It includes conditions for the development of the ecosystem and related aspects, such as the degree of competitive intensity, regulatory frameworks (e.g. characteristics and attributions of the regulator) and the role of digitalisation in production processes (e.g. employees and access to the digital transformation).

Despite significant advances in the last 15 years, LAC's digital ecosystem is at an intermediate level of development (index value 48.7 on a scale of 0 to 100), compared with Africa (34.2), Asia-Pacific (42.1), the Middle East and North Africa (55.4), the OECD area (66.8), Western Europe (67.6) and North America (75.4) (Figure 2.8).

The annual growth rate of the index is lower in LAC than in other regions. Countries in the region belong to a group in the emerging world experiencing a moderate annual growth rate of digitalisation. LAC's index grew at a compound annual rate of 6.1% between 2004 and 2018, the third lowest among emerging regions after the Middle East and North Africa.

Figure 2.8. **Digital Ecosystem Development Index and its growth rate in selected regions**



Source: CAF et al. (2020), *Las oportunidades de la digitalización en América Latina frente al Covid-19*, CAF 2020, UN ECLAC 2020, https://repositorio.cepal.org/bitstream/handle/11362/45360/4/OportDigitalizaCovid-19_es.pdf.

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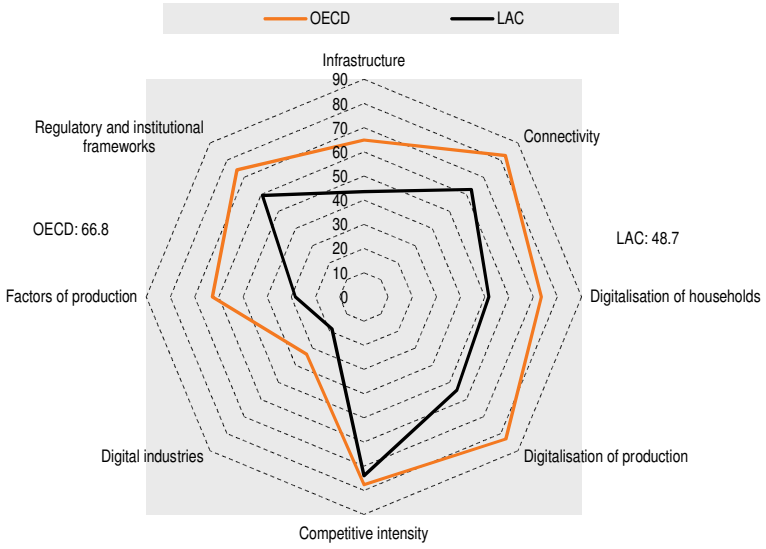
Gaps between LAC and OECD countries remain in the eight multi-component pillars of this index. LAC's least developed pillars are infrastructure, factors of production (human capital, R&D investment and innovative capacity) and limited development of digital industries (Figure 2.9).

Factors of production and digitalisation of households show significant gaps with OECD economies. Factors of production lag in all variables (Table 2.5). Differences in digitalisation of households variables are heterogeneous, but in all variables the region performs below OECD average (Table 2.6). Gaps between LAC and OECD member countries in the infrastructure and connectivity pillars are also noteworthy (Table 2.7).

Figure 2.9. **Digital Ecosystem Development Index in Latin America and the Caribbean and the OECD, 2018**



Sources: CAF (2017), *Towards the digital transformation of Latin America and the Caribbean: The CAF Observatory of the Digital Ecosystem*; ECLAC (2019a), *Regional Observatory on Planning for Development in Latin America and the Caribbean* (database), https://observatorioplanificacion.cepal.org/en/opengov.

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Table 2.5. **Digital Ecosystem Development Index, factors of production variables in the OECD and Latin America and the Caribbean, 2018**

Component	Variable	OECD	LAC
Human capital	Expectation of years of education (years)	16.4	14.4
	Tertiary education enrolment (gross %)	73.7	50.3
Education technology	Education establishments with Internet access (% of establishments)	81.7	55.9
	Student/computer ratio	6.8	41.9
Innovation	USPTO patents granted per 1 000 000 people	211.4	1.2
	Income from use of intellectual property (USD per capita PPP at current prices)	268.6	31.3
Investment in innovation	Public and private expenditure on R&D (% of GDP)	2.2	0.7

Notes: Values are population-weighted averages. GDP = gross domestic product. PPP = purchasing power parity. R&D = research and development. USPTO = United States Patent and Trademark Office.

Sources: World Bank (2020), *World Development Indicators*; USPTO (2020), United States Patent and Trademark Office; World Bank/UNESCO (2020), *Education Indicators* (database), https://data.worldbank.org/topic/education.

Table 2.6. **Digital Ecosystem Development Index, digitalisation of households variables in the OECD and Latin America and the Caribbean, 2018**

	OECD	LAC
Internet users (% of the population)	84.3	67.7
Social networks (% of the population)	61.5	59.0
Mobile data ARPU as a percentage of total ARPU	57.2	54.8
UN E-Government Development Index	0.82	0.65
Electronic commerce as a percentage of retail	9.6	4.8
VOD/OTT penetration (households)	40.8	4.9*

* Includes Argentina, Brazil, Chile, Colombia, Mexico and Venezuela.

Notes: Values are population-weighted averages. ARPU = average revenue per user. VOD/OTT = video on demand/over-the-top.

Sources: Euromonitor (2020), www.euromonitor.com/; GSMA Intelligence (2020), "Definitive Data and Analysis for the Mobile Industry" (webpage), www.gsmaintelligence.com/; ITU (2020), *World Telecommunication/ICT Indicators Database 2020*, www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx; United Nations (2019), *UN e-Government Knowledge Database* (database), https://publicadministration.un.org/egovkb; UNDP (2019), *Human Development Data (1990-2018)* (database), http://hdr.undp.org/en/data.

Table 2.7. **Digital Ecosystem Development Index, infrastructure variables in the OECD and Latin America and the Caribbean, 2018**

	OECD	LAC
Fibre optic connections as a percentage of total fixed broadband connections (FTTH)	20.8	7.4
International bandwidth per Internet user (bit/s)	121 389.1	55 819.4
Population coverage of 3G networks (% of the population)	98.8	94.6
Population coverage of 4G networks (% of the population)	96.4	86
IXPs per 1 000 000 people	0.21	0.12

Notes: Values by group of countries are population-weighted averages. IXP = Internet exchange point. PPP = purchasing power parity. Mbps = Megabytes per second. FTTH = Fiber to the home.

Sources: Own calculations based on GSMA Intelligence (2020), "Definitive Data and Analysis for the Mobile Industry" (webpage), www.gsmaintelligence.com/; Packet Clearing House (2020), *Packet Clearing House Data* (database), https://web.archive.org/web/20060413225415/www.pch.net/resources/data/; ITU (2020), *World Telecommunication/ICT Indicators Database 2020* (database), International Telecommunication Union, Geneva, https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx (accessed on 21 August 2020).

Communication infrastructure, transport connectivity and human capacity: Indispensable and complementary elements

The digital transformation affects all sectors and adds value throughout the production chain, but the magnitude of change will depend on indispensable and complementary factors. The digital transformation, as with other technological change, is not just about the diffusion of technology but also about the complementary investment firms need to make in skills, organisation changes, process innovation, new systems and new business models (Haskel and Westlake, 2017).

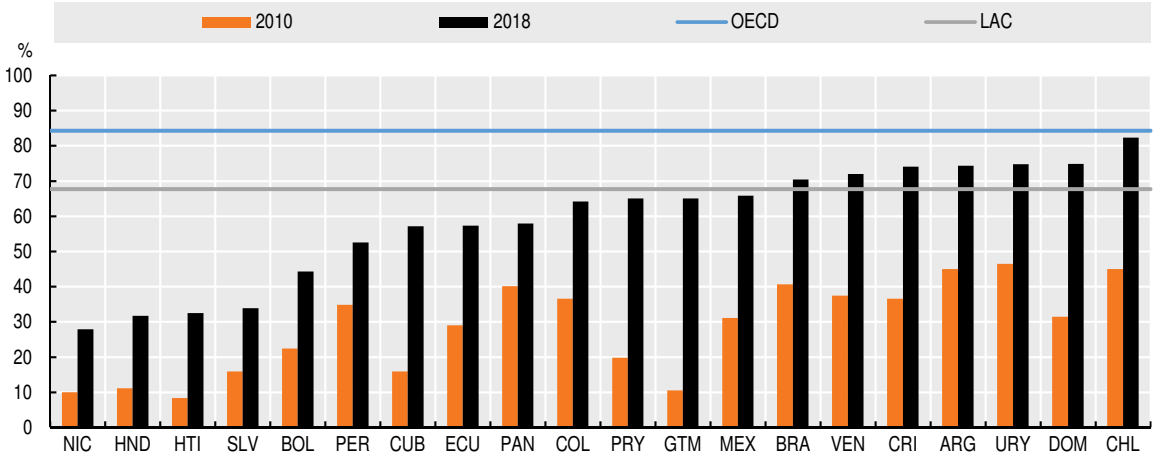
Connectivity and communication infrastructure deployment

Connectivity has evolved in recent years, particularly broadband, which was initially exclusively available through fixed networks but has now been complemented by a strong presence of mobile technology (OECD, 2019a). On average, the share of Internet users has improved in LAC countries and, despite a gap between the two regions, the digital divide with respect to the OECD area has been reduced. In particular, in 2018, 68% of the population used the Internet regularly – almost twice the share in 2010, although lagging behind the OECD average of 84% (Figure 2.10).

Active mobile broadband has evolved significantly in recent decades. In 2018, active mobile broadband subscriptions were more than five times higher than fixed broadband subscriptions (Figure 2.11), reaching, on average, almost 74% of the population.[5] The growth of active mobile broadband subscriptions is uneven across countries, exceeding 85% of the population in Brazil, Chile, Costa Rica and Uruguay in 2018 vs. close to 30% in Haiti and Honduras. Gaps between LAC and the OECD area have remained at around 30 percentage points, on average.

Despite improvements, connection speeds are below the world average, limiting types of services and apps available (Figure 2.12). Low connection speed prevents simultaneous apps, a critical issue during the coronavirus (Covid-19) pandemic: users in most LAC countries had to choose between telework, distance learning and entertainment.

Figure 2.10. **Internet users in selected Latin American and Caribbean countries, 2010 and 2018 (or latest available year)**



Notes: This indicator can include estimates and proportion of Internet users based on national household survey results. Figures reflect total population or individuals aged 5 or older. If neither were available (i.e. target population reflects a more limited age group), an estimation for the entire population was produced.

Source: Own calculations based on data from ITU (2020), *World Telecommunication/ICT Indicators Database 2020* (database), International Telecommunication Union, Geneva, https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx (accessed on 21 August 2020).

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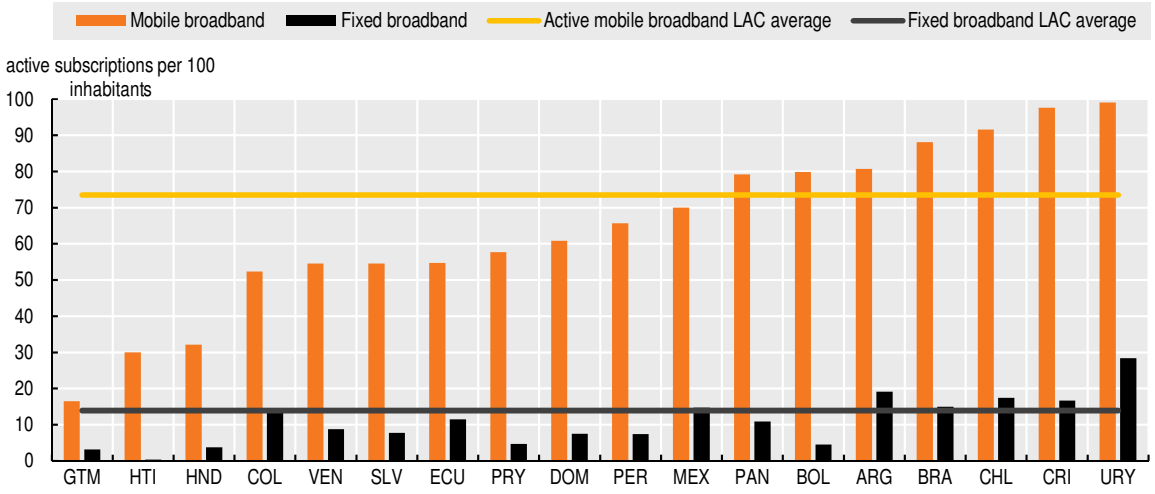
Figure 2.11. **Mobile and fixed broadband penetration in selected Latin American and Caribbean countries, 2018 (or latest available year), active subscriptions per 100 inhabitants**



Note: Active mobile broadband subscriptions refer to the sum of standard mobile broadband and dedicated mobile broadband subscriptions to public Internet. They cover actual not potential subscribers, even though the latter may have broadband-enabled handsets.

Source: Own calculations based on data from ITU (2020), *World Telecommunication/ICT Indicators Database 2020* (database), International Telecommunication Union, Geneva, https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx (accessed on 21 August 2020).

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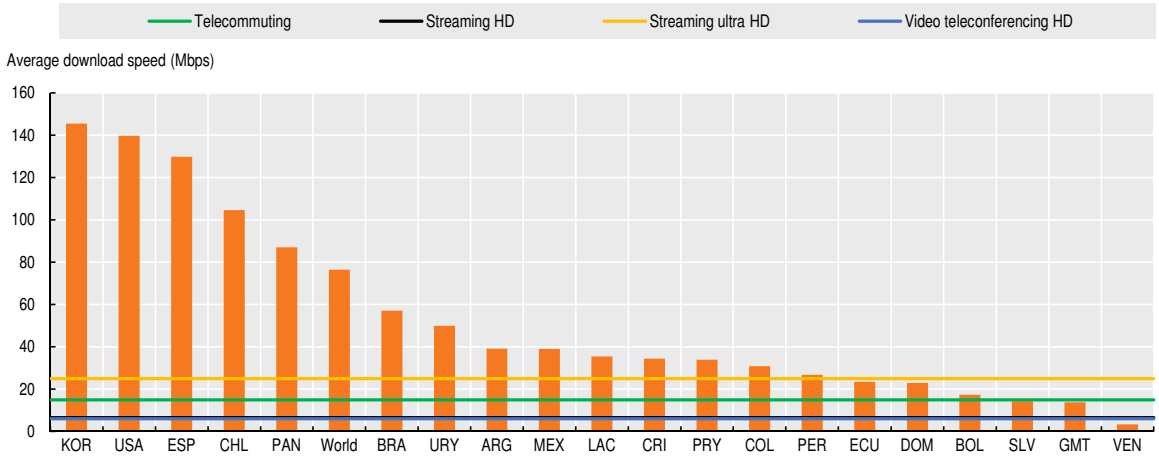
Figure 2.12. **Fixed broadband download speeds in selected countries compared to bandwidth requirements for Internet services, March-July 2020**



Note: HD = High definition. Mbps = Megabytes per second. The indicator reflects wired broadband speed achievable "onnet". It does not fully represent the overall Internet experience and it provides only a partial view on Internet speed. Nevertheless, it provides a useful partial indicator available for both OECD and non-OECD countries (OECD, 2019e). Fixed broadband download speed data are a monthly average from March to July 2020.

Source: ECLAC Regional Broadband Observatory (ORBA), based on data from the Federal Communications Commission and Ookla Global Speed Test Index.

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Because most content accessed in LAC is generated outside the region (particularly in the United States), international connectivity infrastructure is highly relevant. The development of content distribution networks (CDNs)[6] and Internet exchange points (IXPs) are key to improving network efficiency. IXPs allow Internet service providers (ISPs) to exchange traffic between their networks locally. Development of IXPs reduces both transmission costs, by not having to exchange traffic at distant points, and latency, an essential parameter in the quality of services that requires integrity in transmission. IXPs also play an important role in facilitating entry of Internet Service Providers (ISPs), which can achieve domestic interconnection with other ISPs.

IXPs also reduce dependence on upstream suppliers (i.e. suppliers of international connections), increase efficiency and provide alternative routes for traffic, ensuring the reliability and stability of network quality. They facilitate local or regional traffic and favour in-country hosting of content (for instance, through the installation of CDNs) and have a positive impact on the massification of Internet access by reducing costs, mainly when abundant local content emerges. Where there is no interconnection of large and small ISPs through IXPs that allow domestic access to locally developed content and apps in non-discriminatory conditions, it is reasonable to incentivise it, either by applying competition law or by mandating local Internet interconnection between all ISPs in the country through regulation, according to the most convenient modality.

Access to broadband and connection quality remain uneven among and within LAC countries. There are several initiatives to improve connectivity, primarily in broadband, along with specific initiatives to facilitate infrastructure deployment by easing the rights of way (Table 2.8).

Table 2.8. **Connectivity initiatives in selected Latin American countries**

	Connectivity objectives			Universal Service Fund (year)	National digital agenda	National broadband plan
	Speed	Coverage	Year			
Argentina	20 Mbps	2 million new connections	NA	Yes (2000)	Yes Digital Agenda 2030	Yes National Connectivity Plan
Brazil	No objective	2 471 cities	NA	Yes (2000)	Yes Strategy for Digital Transformation	Yes Internet for All
Chile	10 Mbps	90% of households (20% fibre)	2020	Yes (1994)	Yes Agenda Digital 2020	Yes Agenda Digital 2020
Colombia	25 Mbps 4 Mbps average for 2019	70% of households with Internet access 50% of households with broadband	2022	Yes (1976)	Yes National Development Plan 2018-22; 2030 Agenda	Yes Plan Nacional de Desarrollo 2018-22
Mexico	No objective	100% of population	2024	No	Yes National Development Plan 2024	Yes Internet for All

Source: ECLAC (2019b), "Observatorio Regional de Banda Ancha" (webpage), www.cepal.org/es/observatorio-regional-de-banda-ancha based on Cullen International (2019), "Cullen International" (webpage), www.cullen-international.com/.

5G-enabling communication infrastructure for digitalisation of production processes

Unlike previous generations, the fifth generation of wireless networks, 5G, is expected to transform technologies' role in society and firms radically. 5G is expected to enable a new era of the Internet of everything via massive connection, faster transmission speeds, lower latency and lower power. 5G represents the evolution of previous generations (2G, 3G and 4G). It aims to provide 20 Gbps download speed, 10 Gbps upload speed and 1 ms latency, i.e. 200 times faster download speed, 100 times faster upload speed and one-tenth the latency compared with current Long Term Evolution networks (4G) (OECD, 2019f). 5G is expected to lead to new use cases, such as smart cities and smart agriculture, more efficient logistics, transformed health and education services, and renewed security agencies. It is also expected to revolutionise the industrial sector and give rise to new business models through the integration of technologies such as AI, virtual and augmented reality.

One-third of possible use cases of 5G are projected to be in manufacturing, but it can foster growth in all sectors. With 3G and 4G, new business models, such as e-commerce, profoundly changed consumer industries, including retail and media (O'Halloran, 2019). The distinctive characteristics of 5G make it suitable for further innovating and revolutionising business and production processes across sectors. It can support the development and introduction of new apps, improve firm efficiency, enable Internet of things (IoT) services and promote new forms of competition (OECD, 2019f). The high-speed connectivity that the 5G enables can strengthen business-to-consumer and business-to-business services and make them more responsive to preferences. Its low latency allows for real-time remote control of machines at scale and across distances. Real-time remote control is also set to revolutionise the logistics industry with autonomous fleets and remote-control vehicles. High connection density allows connection of multiple devices without network congestion, enabling installation of sensors on factory machines and smart decision making based on real-time data from interconnected machines – the so-called industrial IoT (WEF, 2020).

Automation of some repetitive production processes would allow workers to focus on higher value-added activities, conditional on complementary training (see Human capacity development section and Chapter 3). Factories' enhanced operational effectiveness could generate economic benefits. 5G may also have environmental benefits by helping industries manage their carbon footprint with real-time data and smart grids (WEF, 2020).

In 2018, 4G became the most used mobile technology worldwide. With 3.4 billion connections (43% of the total),[7] 4G is expected to consolidate as the dominant mobile technology by 2025 (GSMA, 2019). 5G networks are becoming a commercial reality. Following the commercial launches of 5G networks in Korea and the United States on April 2019, other countries are expected to launch 5G in the coming years (OECD, 2019f).

5G technology will be operational in the medium and long term in LAC. The first phase of commercial 5G device availability was at the end of 2019, but most releases are expected to be launched by the end of 2020 or in 2021. Preparedness for 5G depends on multiple factors and varies, particularly because regional markets are at various stages of maturity.

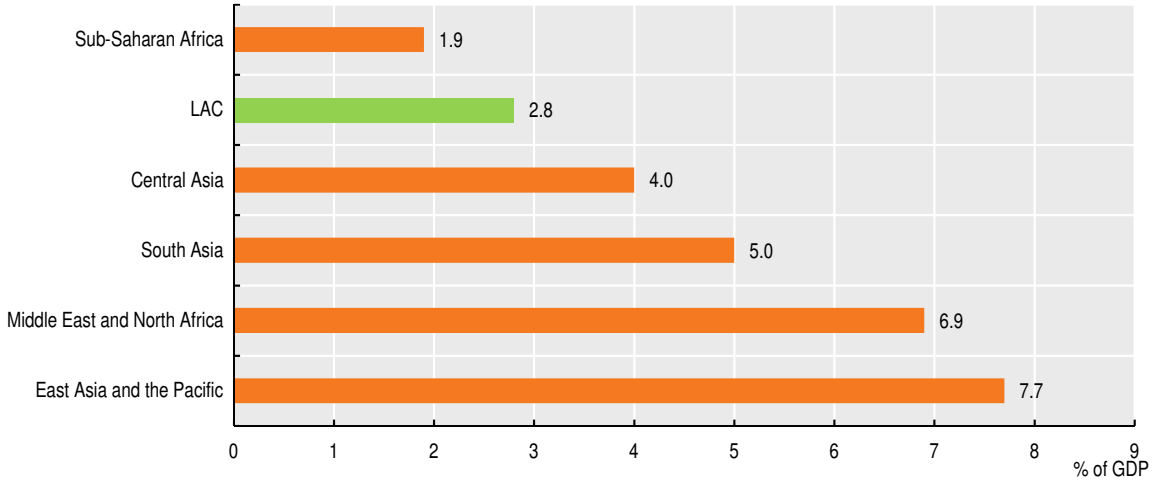
Transport connectivity: Transport infrastructure and logistics

When societies are well-connected, people experience greater overall productivity, access to jobs, basic education and health-care services, smooth social interactions, and empowerment through innovation and use of technology. New transport technologies have generally provided time savings, greater safety and lower environmental impact of mobility (ITF, 2019). Well-developed physical infrastructure reduces transaction costs, mitigates the obstacles of distance and time, facilitates the flow of goods, information and people, and helps markets integrate into global value chains. Inefficient and inadequate infrastructure hampers social integration and higher growth and prosperity.

Transport connectivity is fundamental to make the most of digital transformation. Thanks to digital platforms, e-commerce can expand markets and improve efficiency. Rapid growth in e-commerce could lead to increases in freight volumes of between 2% and 11%, depending on the transport mode (ITF, 2019). In that context, poor transport connectivity should be a barrier to the development of e-commerce for physical goods in most developing countries (Rodriguez, 2018). Well-functioning transport infrastructures, including roads, ports, airports, railways, as well as efficient logistics processes, such as postal delivery services and customs, help ensuring effective order fulfilment (Rodriguez, 2018). Conversely, inadequate transport infrastructure and logistics hamper firms to engage efficiently in e-commerce at local, regional and international levels. This is particularly evident for SMEs, which are for instance highly dependent on external logistics services.

Despite its income level, LAC does not have adequate infrastructures. More than 60% of the region's roads are unpaved, compared with 46% in emerging Asia and 17% in Europe. Two-thirds of sewage is untreated, and poor sanitation and lack of access to clean water result in a high mortality rate of children under age 5, according to the World Health Organization. Electricity disruptions and outages are among the highest in the world, affecting an adequate use of new technologies. Infrastructure spending against GDP is less than that of any other region except sub-Saharan Africa (Figure 2.13).

Figure 2.13. **Public and private infrastructure investment as a share of GDP in selected developing regions, latest available year**



Sources: ADB (2017), *ADB Annual Report 2017*, http://dx.doi.org/10.22617/FLS189307; International Bank for Reconstruction and Development/World Bank (2017), *Rethinking Infrastructure in Latin America and the Caribbean: Spending Better to Achieve More*, http://documents.worldbank.org/curated/en/676711491563967405/pdf/114110-REVISED-Rethinking-Infrastructure-Low-Res.pdf, based on Infralatam (2020), *Datos de Inversión en Infraestructura Económica* (database), http://infralatam.info; own estimates.

StatLink https://doi.org/10.1787/888934171799

Insufficient transport infrastructure in LAC

To make the most of digital transformation, it is essential to promote adequate transport connectivity. Transport infrastructure is a key ingredient to favour connectivity of people and merchandises. In Latin America, the total cost of transport, investment and maintenance for a road that is not maintained is three to seven times higher than the cost for one that is (OECD/CAF/UN ECLAC, 2018). Operational inefficiencies due to the poor condition of road and railway networks impede business development. Quality infrastructure is needed for sustainable and inclusive development (Box 2.3). Furthermore, adopting a multi-modal approach that shifts focus from roads (e.g. developing railways, ports and waterways) is central to promote adequate sustainable transport infrastructure.

Design flaws in concession contracts have caused excessive fiscal costs (OECD/CAF/UN ECLAC, 2018). Regulatory weakness and lack of institutional frameworks often result in significant delays with increased costs.

Affordable pricing for public transport is an important aspect of ensuring fair, inclusive public access and use. Regulatory frameworks ensuring affordability are required to promote equitable use of public transport. Innovative payment modalities accommodating particular income brackets, particularly those at the bottom of the distribution, should be considered. Regarding firms, transport costs-to-tariffs ratio in the region has been traditionally higher than in OECD countries (OECD, 2016).

Some countries in the region have improved regulatory and institutional frameworks for public-private partnerships. For instance, in the past five years, Colombia, Honduras and Peru have achieved more effective private participation in infrastructure through enhanced regulations (OECD/CAF/ECLAC, 2018).

However, most countries in the region have room to improve in several areas regarding road concessions. Exploiting the benefits of concessions requires stronger capacity for evaluating, tendering and managing contracts. In addition, better fiscal-accounting

procedures in the region could improve selection of contractors. This would prevent use of public-private partnerships solely to preserve fiscal space (OECD et al., 2019).

Box 2.3. **G20 Principles for Quality Infrastructure Investment**

In June 2019 in Japan, Group of 20 (G20) leaders endorsed the G20 Principles for Quality Infrastructure Investment (G20, 2019). The principles strive to maximise the spillover effects of infrastructure for sustainable and inclusive development by ensuring accessibility, affordability and inclusiveness, while also fostering gender equality, non-discrimination, human rights and labour standards, indigenous people's rights, climate action, job creation, poverty alleviation, mitigation of the effects of forced resettlement, transparent institutions and anti-corruption.

Principle 1: Maximising the positive impact of infrastructure to achieve sustainable growth and development
Principle 2: Raising economic efficiency in view of life-cycle cost
Principle 3: Integrating environmental considerations in infrastructure investments
Principle 4: Building resilience against natural disasters and other risks
Principle 5: Integrating social considerations in infrastructure investment
Principle 6: Strengthening infrastructure governance

The voluntary, non-binding principles can provide strategic direction for quality infrastructure investment in developing and emerging economies. To promote their implementation, the OECD Development Centre works with members and partner institutions to provide equal-footing policy forums that bring together developing and emerging economies and OECD countries to exchange experiences and lessons learned. Leveraging a unique membership of 30 non-OECD economies and 27 OECD countries, these policy dialogues can help identify concrete infrastructure development issues, cultivate a shared understanding of pressing needs and challenges, and promote better policy solutions through the exchange of knowledge and experience.

High logistics costs and the benefits of digitalisation

High logistics costs in LAC hamper competitiveness, including in the expansion of e-commerce. The region's 2018 World Bank Logistics Performance Index (LPI) score was 2.7: below Europe & Central Asia (3.2), East Asia & Pacific (3.2) and Middle East & North Africa (2.8) but above developing regions in sub-Saharan Africa (2.5) and South Asia (2.5) (Table 2.9). The region's main impediments are quality of infrastructure (see section above), efficiency of clearance processes, including customs, and cost and quality of logistics services.

Digital technologies can simplify administrative procedures and speed up cross-border shipments. Electronic single windows allow traders to submit import and export regulatory requirements electronically. Eliminating the need to send hard copies to various bodies enhances transparency, expedites clearance of international transactions and improves trade statistics. Countries including Argentina, Chile, Colombia, Costa Rica, Mexico and Peru have adopted the one-stop shops. Some countries have started interoperability efforts by sharing phytosanitary certificates (June 2016) and certificates of origin (end of 2017) (Opertti, 2019). This could create conditions for integrated one-stop border controls operating via cloud-based solutions, such as the IoT, which could make trade more seamless and reduce logistics costs (Martincus, 2016).

Table 2.9. **World Bank Logistics Performance Index (LPI) scores, by region, 2018**

Region	LPI score	Customs	Infrastructure	International shipments	Logistics competence	Tracking and tracing	Timeliness of shipments
Europe & Central Asia	3.2	3.0	3.1	3.1	3.2	3.3	3.7
East Asia & Pacific	3.2	3.0	3.0	3.0	3.1	3.2	3.5
Middle East & North Africa	2.8	2.5	2.7	2.7	2.7	2.8	3.2
Latin America & Caribbean	2.7	2.5	2.5	2.7	2.6	2.7	3.0
South Asia	2.5	2.3	2.3	2.5	2.5	2.6	2.9
Sub-Saharan Africa	2.5	2.3	2.2	2.5	2.4	2.5	2.8

Notes: LPI is the weighted average of scores on six dimensions: 1) efficiency of clearance processes by border control agencies, including customs (speed, simplicity and predictability of formalities); 2) quality of trade- and transport-related infrastructure (ports, railways, roads, information technology); 3) ease of arranging competitively priced shipments; 4) competence and quality of logistics services (transport operators, customs brokers); 5) ability to track and trace consignments; 6) timeliness of shipments in reaching destination within scheduled or expected delivery.
Source: World Bank (2018), *World Bank Global Logistic Performance Index 2018* (database), https://lpi.worldbank.org/international/scorecard/radar/254/C/DEU/2018/R/EAP/2018/R/ECA/2018/R/LAC/2018/R/MNA/2018/R/SAS/2018/R/SSA/2018?featured=17.

Digitalisation can make the logistics industry more resource efficient, agile and responsive to customer needs. New business models, including e-commerce, are contributing to the growing demand for logistics services. Industries with close links to logistics, such as retail, have undergone major transformations thanks to digital technologies. The logistics sector has been slower (Bauer, Dichter and Rothko, 2018; WEF, 2016), despite the benefits. Digital platforms not only help businesses connect with consumers but can better match shipment demand with logistics capabilities, e.g. through end-to-end online booking services. This could be particularly helpful for the internationalisation of SMEs, which often do not have the same experience as big firms in arranging international shipments. Moreover, the IoT, a network of smart devices, sensors and the cloud, coupled with advanced data analysis techniques, allows real-time analysis of supply chain data. Insights can be used to optimise decision making and rapidly detect and react to problems. Apart from reduced operating costs, improved data analytics brings environmental benefits. Network optimisation can reduce the number of trucks on the road, lowering emissions and waste. Digital platforms can support shared warehouse space and transport capabilities, increasing utilisation rates and reducing emissions (WEF, 2016).

Although the coronavirus (Covid-19) has accelerated the use of e-commerce platforms and encouraged companies to implement business models adjusted to decreased demand due to restrictions, barriers to e-commerce in the region should not be underestimated. Among them, high shipping costs, fear of misuse of confidential and sensitive information and low technological adoption by MSMEs require a systemic and policy approach, which will vary by country, in order to boost e-commerce.

Human capacity development for digitalisation in Latin America and the Caribbean

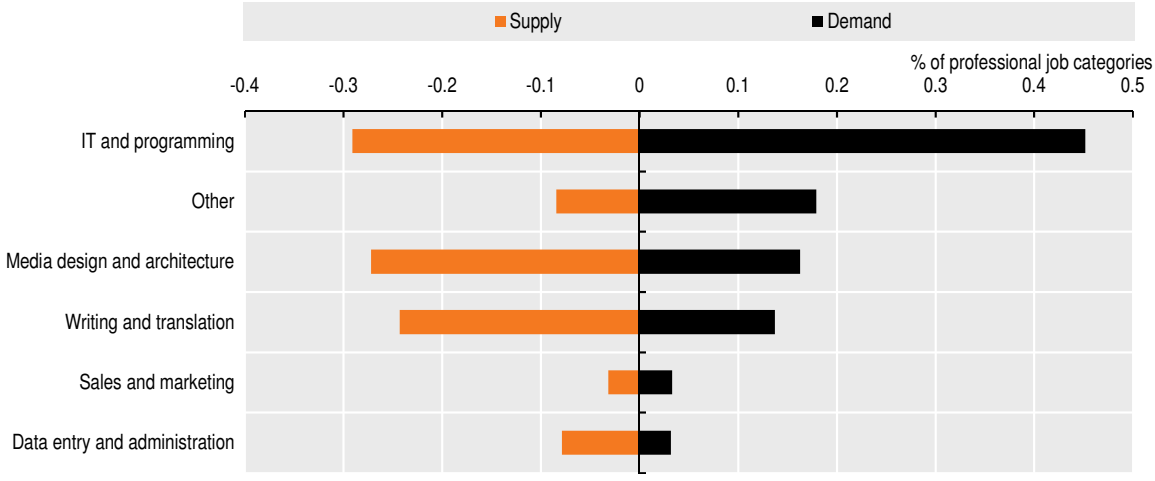
Benefitting from new technologies requires developing human capacities and adaptation to the new digital context. Evidence from the European Union suggests that productivity gains from digital adoption at the firm level tend to be weaker in the presence of skills shortages. Policies to support adoption should be complemented with the creation of conditions that enable laggard firms to catch up, e.g. via the promotion of better access to skills, notably ICT training for low-skilled workers (Gal et al., 2019; Andrews, Nicoletti and Timiliotis, 2018).

Factors of production represent the largest gap in digital ecosystem development between LAC and OECD countries. Formation of digital skills is a critical element.

Investing in appropriate skills and narrowing the region's gap relative to countries at the technological frontier will be essential for LAC to leverage digital technologies and avoid being left behind by the changes fundamentally altering the industrial landscape.

Gaps between skills supply and demand are large in LAC. In services related to IT and programming, global labour market demand significantly exceeds the supply of LAC professionals. The opposite is true for media design and architecture, and writing and translation services (Figure 2.14). The observed mismatch indicates a need to increase training in areas related to the digital economy to take advantage of the growing opportunities.

Figure 2.14. **Global labour market supply and demand of skills in Latin America and the Caribbean, 2019**



Notes: Other refers to: Local Jobs & Services, Freight Shipping & Transportation, Engineering & Manufacturing, and Business Accounting Human Resources & Legal. Based on Freelancer and Workana, two digital labour platforms. Freelancer has greater global reach; Workana focuses on Latin America. On these platforms, professionals offer specific skills, and clients seek assistance with specific projects. Both platforms offer professionals the opportunity to publish a profile and employers the opportunity to publish job opportunities.

Source: ECLAC (2020e), *Tracking the Digital Footprint in Latin America and the Caribbean*, https://repositorio.cepal.org/handle/11362/45484.

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To address human capacity gaps, it is important to consider both the demands of the productive structure and its expected or desired development trajectory. Limited training of researchers involved in creating new products and services affects the ability to develop new technologies and industries, while lack of human capacities for assimilating new technologies hinders adoption of potentially productivity-enhancing factors of production.

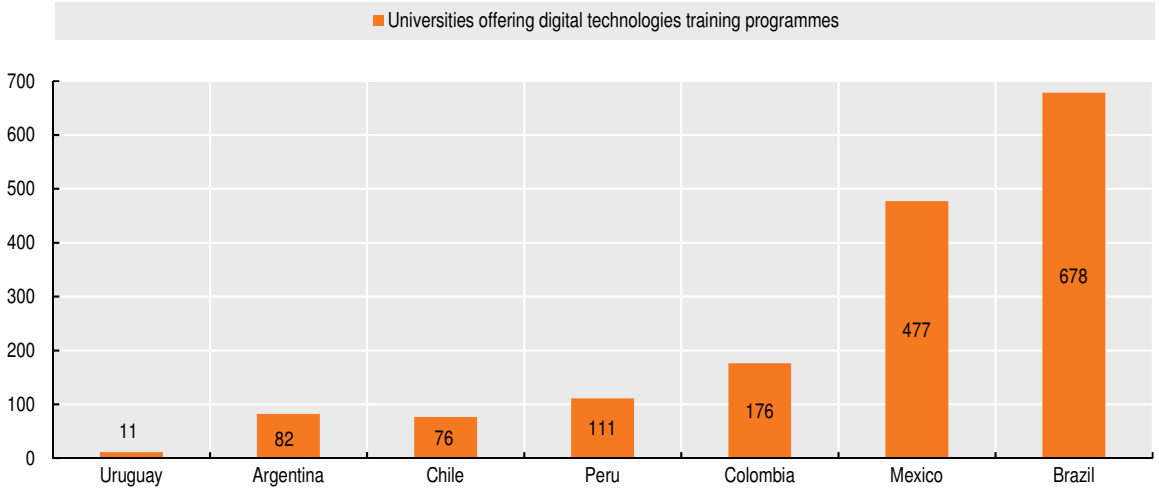
The skills and education requirements for each of these functions are distinct. Researchers involved in the development of digital technologies typically hold a master's degree and often a doctorate. Professionals incorporating digital technologies into production processes typically hold a certification of degree studies or master's, although they can also be qualified through a short career degree (e.g. vocational training or a certificate). Each profession entails very different skills. Those required for assimilating mature technologies include training in basic areas of management informatics; those required for incorporating advanced technologies into the production chain include training in areas such as AI and robotics.

ICT expands opportunities for continued education. Massive open online courses – free online courses open to anyone – and open education platforms offer affordable,

time-flexible training at all life stages and content adapted to personal or occupational needs. These technologies can boost productivity and help formal and informal workers with limited time or resources accumulate human capital and skills. Workers could benefit from alternatives to traditional education and training (OECD et al., 2019).

In the past two decades, LAC has developed a generous supply of digital technologies training programmes. More than 1 600 universities in Argentina, Brazil, Chile, Colombia, Mexico, Peru and Uruguay – 52% of total universities in the seven countries – offer more than 6 390 such graduate and postgraduate programmes (Katz and Callorda, 2018). Among the selected countries, Argentina has the most such universities (66%) (Figure 2.15).

Figure 2.15. **Number of universities offering digital technologies training programmes in selected Latin American countries, 2016**



Source: ECLAC (2018b), *Data, Algorithms and Policies: Redefining the Digital World*, https://repositorio.cepal.org/bitstream/handle/11362/43515/7/S1800052_en.pdf.

StatLink *https://doi.org/10.1787/888934171837*

Short-term course offerings are even more robust: more than 7 938 in the seven countries. Most include courses related to robotics and control, AI and machine learning, and Big Data and analytics (Table 2.10).

Table 2.10. **Number of short-term advanced digital technologies training courses by subject area in selected Latin American countries, 2016**

	Robotics and control	AI/machine learning	Big Data/analytics	Total
Argentina	196	216	201	613
Brazil	1 032	1 218	891	3 141
Chile	194	89	84	367
Colombia	441	208	178	827
Mexico	907	944	644	2 495
Peru	183	111	100	394
Uruguay	36	29	36	101
Total	2 989	2 815	2 134	7 938

Note: AI = artificial intelligence.

Source: ECLAC (2018b), *Data, Algorithms and Policies: Redefining the Digital World*, https://repositorio.cepal.org/bitstream/handle/11362/43515/7/S1800052_en.pdf.

Postgraduate offerings, especially doctorates, are limited. There are 294 doctoral programmes in digital technologies in the seven countries, with only 130 doctoral programmes offered by the top 20 top-performing universities (Table 2.11). This relative

shortage hinders development of specific digital skills and high-level basic and applied research, posing a major challenge for countries transitioning to knowledge-based economies that require citizens to innovate, adapt and leverage advanced human capital. The supply gap in high-level training programmes, mainly doctorates, affects the level and resources of R&D in the region.

Table 2.11. **Postgraduate digital technologies programmes in selected Latin American countries, 2016**

	Master's	PhD	Total
Argentina	37	35	72
Brazil	72	152	224
Chile	36	10	46
Colombia	68	13	81
Mexico	187	67	254
Peru	49	14	63
Uruguay	11	3	14
Total	460	294	753

Source: ECLAC (2018b), *Data, Algorithms and Policies: Redefining the Digital World*, https://repositorio.cepal.org/bitstream/handle/11362/43515/7/S1800052_en.pdf.

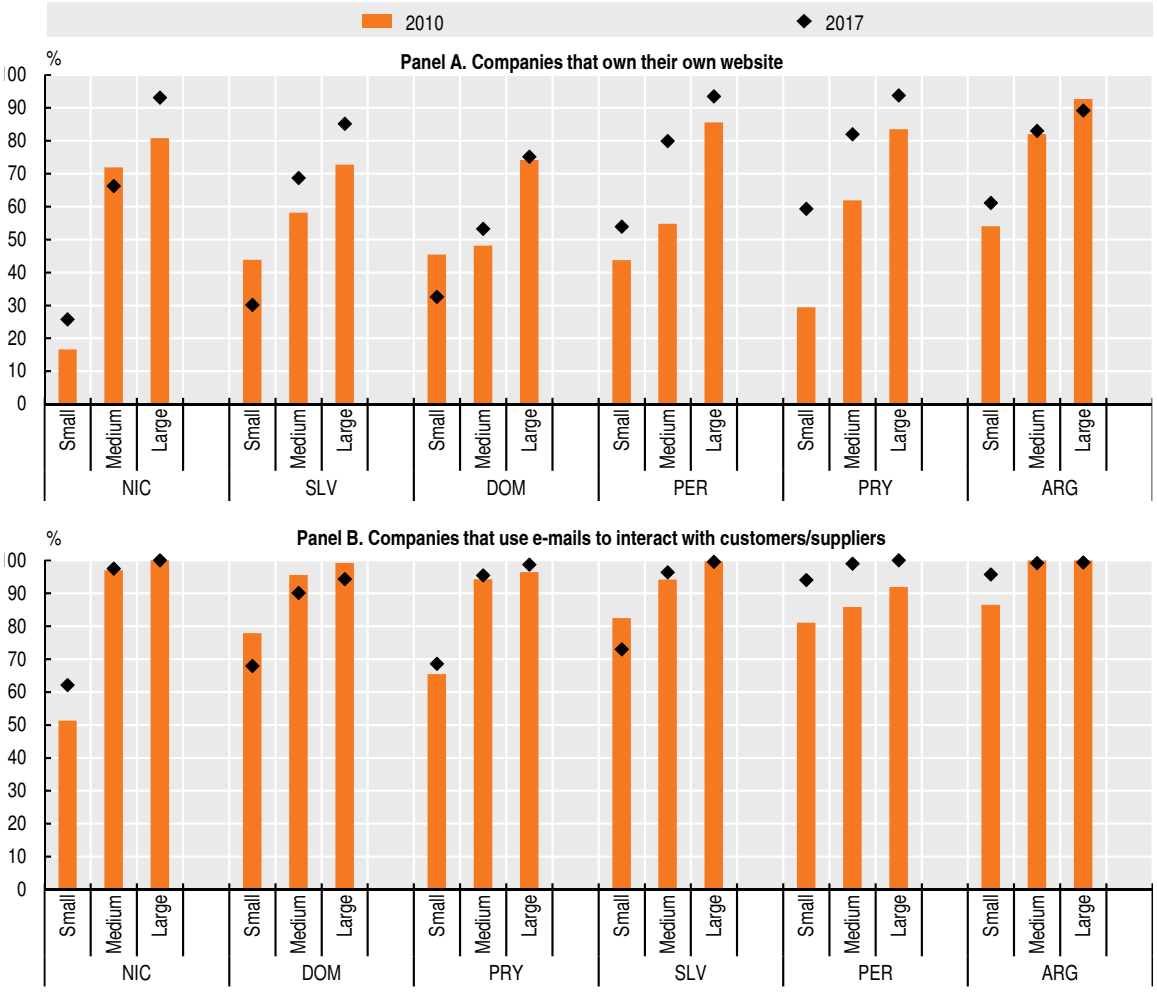
LAC policies to promote the digital transformation and increase productivity

LAC policies to promote the industrial sector's digital transformation and stimulate productivity show mixed results. Lack of strategic vision and stakeholder co-ordination often produce scattered initiatives. However, the potential of the digital revolution should not be underestimated, especially for MSMEs, given their important role in LAC's formal economy: MSMEs represent 99.5% of firms and 61.2% of employment but only 24.6% of production in the region (Correa, Leiva and Stumpo, 2018). With appropriate policies, digital technologies could help close the productivity gap with bigger firms. Despite advances in recent years, low adoption of even basic technologies, especially among small firms, shows that space remains for further policy intervention. For instance, in some countries of the region the gap between small and large companies that own their own website is higher than 30 percentage points (Figure 2.16).

LAC has yet to align public and private efforts to develop digital industries. Main reasons include limited understanding of the importance of the private sector, lack of co-ordination within public administration, lack of transparency and confidence in public-private relationships, and lack of co-ordination among stakeholders and in channelling private-sector efforts (see Chapter 4 for the role of national development plans and digital agendas [DAs] in the digital transformation) (Katz, 2015).

Some countries have recently begun to incorporate policies in their DAs to boost adoption and development of emerging technologies, including advanced robotics, sensors, AI, Blockchain and the IoT, to improve industry (see Chapter 4). Uruguay's DA created *Laboratorio de Fabricación Digital*, a digital manufacturing laboratory focused on priority industrial sectors. Similarly, the Cerro Industrial Technology Park laboratory facilitates training, invention and small-scale prototype production, and provides general access to tools for latest generation digital manufacturing. Brazil's E-Digital strategy objectives include implementation of the national IoT plan and testing platforms for the IoT in the value chains of four key sectors: health, agriculture, industry and smart cities. Colombia's ICT plan promotes projects oriented to the use of the IoT, AI and Blockchain in digital business transformation processes. The Centre for the Fourth Industrial Revolution Colombia, operated by the Ruta N Corporation in Medellín, was created to achieve this goal.

Figure 2.16. **Use of basic digital technologies by firm size in selected Latin American and Caribbean countries, 2010 and 2017**



Sources: Own calculations based on World Bank (2020b), *Enterprise Surveys* (database), www.enterprisesurveys.org/; Correa, Leiva and Stumpo (2018), "Avances y desafíos de las políticas de fomento a las mipymes", *Mipymes en América Latina: Un Frágil Desempeño y Nuevos Desafíos para las Políticas de Fomento*, https://repositorio.cepal.org/bitstream/handle/11362/44148/1/S1800707_es.pdf.

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In the last decade, the region has made advances in productivity policies for MSMEs. Many countries have adopted legal frameworks to support these firms; however, beyond historical institutions in Chile (SERCOTEC, INDAP, CORFO) and Brazil (SEBRAE), institutions to promote and assist MSMEs with operational and financial autonomy remain the exception. INNPULSA in Colombia and CONAMYPE in El Salvador have gained relevance in the last few years; the role of INADEM in Mexico still has room for improvement. Lack of common strategy among institutions, fragmentation of interventions and limited scope and budget remain the main limitations of LAC MSME productivity policies. Lack of systematic monitoring and evaluation of initiatives impedes learning from previous experiences (Correa, Leiva and Stumpo, 2018).

Many LAC countries have encouraged MSME adoption of digital technologies in the last decade, especially in order to stimulate entrepreneurship. Yet, there has not always been clear connection with national strategies for productive transformation. An analysis

of 11 categories of initiatives, on a scale of increasing complexity from creating an enabling ecosystem for the adoption of digital technologies to transforming technological and strategic capabilities of firms, shows that most initiatives are not yet implemented or still in the implementation phase (Figure 2.17). A vertical reading shows variation in the distribution of these programmes, with greater focus on enablers and policies to develop capabilities (upper part of the map) and less on more complex tools to change the productive structure (lower part).

Several countries have created dedicated online MSME platforms and portals. These include *Escritorio Empresa* in Chile, *Ventana Unica Pyme* in Costa Rica, *Portal Mi Empresa* in El Salvador and *Red de Apoyo al Emprendedor* in Mexico, which have physical offices, if needed. Awareness-raising and digital literacy initiatives are also common by way of awareness campaigns and technical assistance offered by dedicated bodies: *Centros de Transformación Digital Empresarial* in Colombia and the network of *Infocentros Comunitarios* in Ecuador, for instance, offer free digital skills training. Many countries have initiatives to facilitate access to and adoption of digital technologies. *Transformación Digital PyMEs* in Argentina, *Espacio Pyme* in Chile and *Kit Digital* in Peru provide digital training, technical assistance, software and apps to manage changes related to the digital transformation of firms. Financial assistance for adoption is offered through the innovation fund PROPYME in Costa Rica and the *Fondo Nacional Emprendedor* of INADEM in Mexico, among others. Brazil's SEBRAETEC is a SEBRAE programme offering assistance ranging from digital training to consulting for firms (Heredia, 2020).

There remain large opportunities to promote R&D, new business models and productive chain adjustments (Figure 2.17). Incentives for the ICT sector are sparse, although Argentina's Fiduciary Fund for the Promotion of the Software Industry and Mexico's Program for the Development of the Software Industry support SMEs in the ICT sector, among other activities. More needs to be done to support and promote research and innovation in industrial technology. Existing examples include Argentina's FONTAR, a fund for innovation in technology, and Brazil's EMBRAPII, an institution promoting R&D for industry, targeting risk sharing in the precompetitive phase of innovation (Heredia, 2020). The challenge for LAC is moving from policies that encourage adoption of digital technologies in the industrial sector to assistance for the complete transformation of production processes and the creation of new business models supported by new technologies (Heredia, 2020).

Industrial policies for the digital age are essential to encourage the economy to move towards higher value-added activities. The digital transformation of LAC's industrial sector is far from complete. Industrial policy for the digital economy must first strengthen the local IT industry. New technological sectors may contribute to technological development through the transfer and dissemination of technologies, generation of skilled human resources and export of services. Although countries, including Argentina, Brazil, Chile, Colombia, Mexico and Uruguay, have successfully promoted the IT industry, there are still deficiencies in diffusion of use of IT products and their appropriation for business activities, particularly among SMEs (ECLAC, 2018b).

Industrial policies must adopt a strategic vision and be part of both wider development plans and productive and technological sectoral plans. Collaboration between productive and research sectors (public research centres, universities, technological institutes) is fundamental for an institutional research structure closely linked to innovation and business development (Casalet, 2018). Creation of a virtuous digital ecosystem is essential for firms, governments and citizens to benefit from the digital transformation.

Figure 2.17. **Categories of promotion of digital technologies in micro, small and medium-sized enterprises in selected Latin American countries, circa 2019**

Category	ARG	BRA	CHI	COL	CRI	ECU	SLV	MEX	PER
Simplification of procedures (digital government)									
Awareness and digital literacy									
Facilitate access to digital technology									
Training									
Technical or financial assistance									
Development of new business opportunities									
Incentives for ICT sectors									
Support for the formation of digital companies									
Research and technological innovation									
Digital integration of production chains or suppliers									
Support for the development of new business models									

Notes: Colour intensity indicates the degree to which policy has been implemented; white indicates no implementation. ICT = information and communications technology.

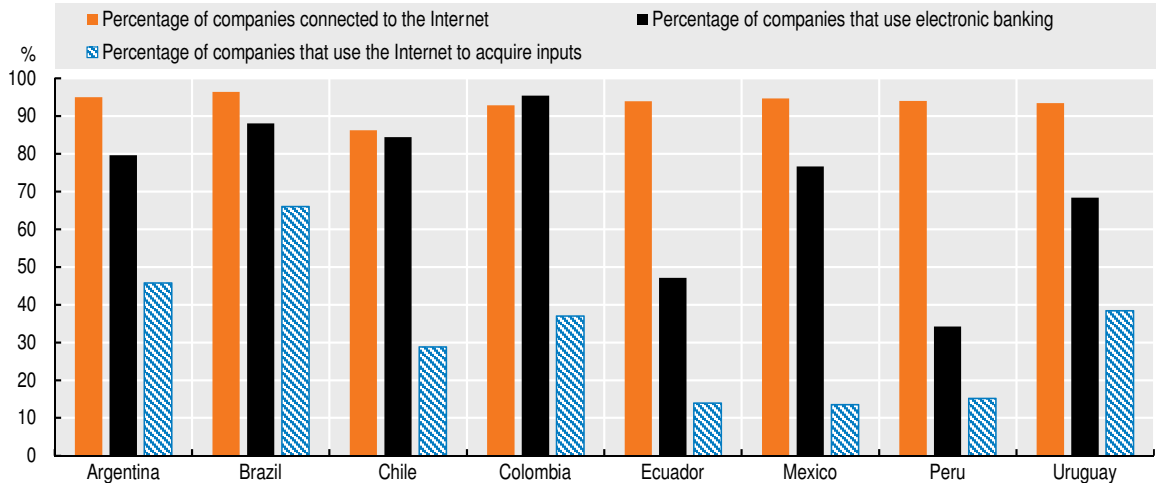
Source: Heredia (2020), *Políticas de Fomento para la Incorporación de las Tecnologías Digitales en las Micro, Pequeñas y Medianas Empresas de América Latina: Revisión de experiencias y oportunidades*, https://repositorio.cepal.org/bitstream/handle/11362/45096/1/S1900987_es.pdf.

Digital adoption will be facilitated by efficient resource allocation, since a firm's incentives to experiment with uncertain or risky digital technologies will be shaped by its perceived ability rapidly to scale up operations in the event of success and scale down and potentially exit the market at low cost in the event of failure (Andrews and Criscuolo, 2013). From this perspective, harnessing digital transformation for firms places an added premium on policies that foster business dynamism and efficient resource reallocation. This is a challenge in many countries, against the backdrop of declining business dynamism (Criscuolo, Menon and Gal, 2014) and rising resource misallocation (Adalet McGowan, Andrews and Mil, 2017); (Berlingieri, Blanchenay and Criscuolo, 2017) over the past decade.

The digital transformation post coronavirus (Covid-19)

For most LAC economies, recovery will be slower and more gradual than expected at the beginning of the pandemic. Despite government programmes, high loss of companies and jobs is expected. The greater the numbers, the greater the loss of accumulated capacities in firms, dispersion of knowledge and experiences and breakdown of relationships of trust among economic actors. Incentives other than those prevailing before the coronavirus (Covid-19) will be required for private companies, together with the state, to make necessary investments to diversify the economic structure, guarantee continuous and stable growth and avoid setbacks. Digital transformation will be central to firms' advancing towards greater efficiency and productivity, and there is room for improvement. For instance, the region entered into the Covid-19 crisis with low levels of companies using digitalisation in their every day operations (Figure 2.18). Digital technologies will be key to new operating models: companies will have to adopt technologies to process large amounts of information to improve decision processes, which may redefine business models. Industry should incorporate greater use of robotics to increase efficiency. Digital transformation may also affect business model operations through changes in the sale and delivery of goods and services or interactions with suppliers (ECLAC, 2020b).

Figure 2.18. **Latin America: Digitalisation of the supply chain, 2018**



Source: CAF (2020), *El estado de la digitalización de América Latina frente a la pandemia del COVID-19*, https://scioteca.caf.com/bitstream/handle/123456789/1540/El_estado_de_la_digitalizacion_de_America_Latina_frente_a_la_pandemia_del_COVID-19.pdf?sequence=1.

StatLink https://doi.org/10.1787/888934171875

The world should not be expected to return to pre-pandemic contexts. Although the crisis seems to highlight the fragility of multilateralism, globalisation will not be reversed: there will be demand for greater regional integration. The global economy could be regionalised around three poles: Europe, North America and East Asia. Given the structural challenges in LAC, this scenario would require progress towards greater productive, commercial and technological integration. The future of the region in the new economic geography entails regional value chains that make it less dependent on imported manufactures and enhance the productive structure towards more sophisticated goods. Industrial and technological policies must strengthen productive capacities and generation of new strategic sectors. This would provide greater resilience to regional production networks challenged by the diversification of suppliers (both in terms of countries and companies) that favours locations closer to final consumer markets (nearshoring) or relocation of strategic technological and production processes (reshoring).

The coronavirus (Covid-19) crisis has made it essential and more important than ever to reflect on the productive structure and regional integration mechanisms. Both must be part of the same strategy. There is an opportunity to recall the benefits of regional integration and resume actions towards inclusive and sustainable international governance based on the UN 2030 Agenda for Sustainable Development.

Conclusion

This chapter analysed the underlying causes of LAC's low productivity and evaluated the potential of digital technologies to augment productivity and facilitate the region's move towards a higher value-added productive structure with reduced structural heterogeneity.

Digital technologies are not independent from the sector, organisation structure and other context-specific aspects in which they operate. Digital technologies' impact is not deterministic and is dependent on multiple factors. Technological solutions and policies must be adapted to individual sectors and types of production units, including SMEs, to address the unique characteristics that influence their functionality. Despite the necessity

of context-specific interventions, common complementary investments are essential to reap the benefits of digital technologies' integration into productive processes.

Successful digital transformation strategies for industrial productivity rely on a broader range of interventions and sectors than ICT alone. Communication infrastructure, transport connectivity and skills are critical enabling elements in the digital era in which LAC lags behind the OECD area. Policy makers have numerous financing and business models for infrastructure investment. Appropriate mechanisms depend on the country and technological context. Policy makers must avoid the risk that adoption of digital technologies exacerbates inequalities. Expanding access to infrastructure and skills' development with targeted and context-specific policies is necessary to ensure that all individuals and firms benefit from new technologies and to avoid widening, with their distributional impacts, sectors' and firms' structural heterogeneity.

Notes

1. Digital technologies include smart phones, computing power, Internet of things, 5G networks, Cloud computing, artificial intelligence and blockchain.
2. In the economic debate started with Solow, productivity gains are considered measures of technological change, being the part of output unexplained by input adoption and therefore related to technological progress (Solow, 1957).
3. OECD research shows that there is potential to increase productivity in the digital age owing to supportive policy for firms (OECD, 2019g).
4. A composite index provides a useful general view of how countries are performing. Nevertheless, the use of aggregating multiple indicators into one composite is not without problem as good performance in one indicator can hide a bad performance in another indicator (OECD et al., 2019).
5. Proportions of Internet users are based on national household survey results for total population of individuals aged 5 or older. Active mobile-broadband subscriptions refer to the sum of standard mobile-broadband and dedicated mobile-broadband subscriptions to the public Internet.
6. Content delivery networks (CDNs) serve as aggregators of content, systems for the delivery of traffic directly to the terminating network, and providers of quality-enhancing inputs, such as caching of data close to the end user. CDNs are useful to providers of online services, such as the BBC, Google, Netflix and Hulu, which seek to improve their customers' experience. More direct delivery, fewer intermediate loops, and local caching reduce latency and improve the quality of service (OECD, 2013).
7. Not including IoT connections.

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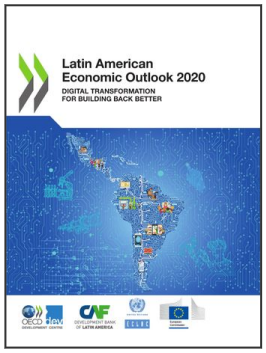

From:

Latin American Economic Outlook 2020

Digital Transformation for Building Back Better

Access the complete publication at:
https://doi.org/10.1787/e6e864fb-en

Please cite this chapter as:

OECD*, et al.* (2020), "Fostering productivity and enhancing the digital transformation", in *Latin American Economic Outlook 2020: Digital Transformation for Building Back Better*, OECD Publishing, Paris.

DOI: https://doi.org/10.1787/bbd35cb9-en