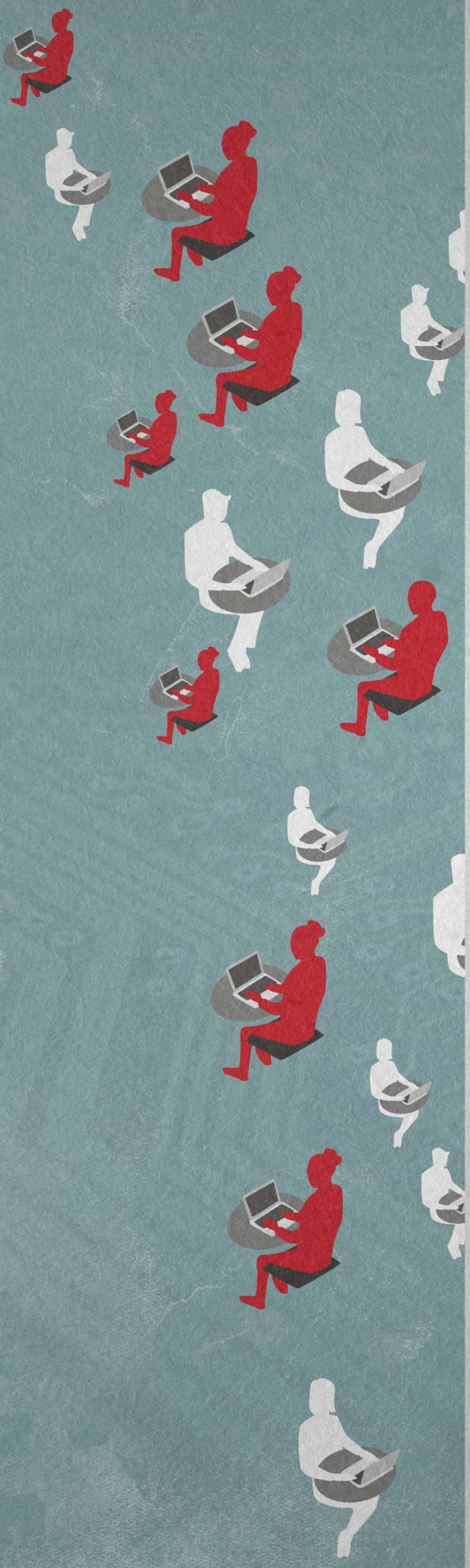

Sources of Data on Digital Talent in Latin America and the Caribbean

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Abstract*

This publication summarizes the main sources of data available for digital talent in Latin America and the Caribbean. It provides an inventory of resources including a general description of the source and a preliminary assessment along the following dimensions: country coverage, indicators by which advanced digital skills are measured, accessibility, and quality of the data. The paper contemplates broad categories of resources and, noting country differences, highlights gaps. To conclude, it proposes a set of strategies for filling gaps in information about digital skills.

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1. Introduction

The demand for advanced digital skills continues to grow. Industries such as auto manufacturing, healthcare, and financial services have all become digitalized. Existing roles require new digital skills, and entirely new positions are being created with job titles that previously did not exist (Citro, 2018). Firms and policymakers alike are worried about whether employees have the skills they need to work effectively with increasingly advanced digital technologies. While fears of job displacement abound, they are countered by the possibility of job creation or growth in demand for new roles as long as people have the right skills to get those jobs.

As always, the future of innovation will depend on the presence of a critical mass of skills and cutting-edge capabilities to facilitate a well-functioning innovation system. Today, the types of employees needed go well beyond the typical cadre of scientists and engineers. Many databases (i.e., UNESCO/UIS and RICYT) contain information about the formation and presence of scientists and engineers in Latin America and the Caribbean (LAC), but the sources of information for data regarding the presence of people with skills in advanced digital technologies are dispersed.

An integral part of formulating digital strategy is assessing the current supply of advanced digital skills. While data on digital skills across occupations in LAC are limited (OECD, 2016), a number of resources are emerging that track the status of digital skills from a variety of vantage points. Even if these initiatives do not always intentionally target the LAC region, many cover a handful of countries in the region. The LAC countries covered (as is the case for many other characteristics of the data), vary according to the source. Consequently, some countries in the region have much more information at their disposal than other countries.

Measuring the presence (or absence) of advanced digital skills is challenging, because the approaches to data collection must evolve alongside the latest developments in the technologies themselves, which are notorious for changing faster than their technological predecessors. Moreover, different sources of data have different methodological approaches. While each effort contributes, they each have limitations. The activation of advanced digital skills relies at least in part on solid information about the presence or absence of these skills. In this context, it is crucial to have a clear picture of emerging resources with information about advanced digital skills in LAC and to distil the utility of the available information.

This report constitutes a first approach to inventory existing resources and the main sources of data on digital skills in LAC. It includes a preliminary assessment of the resources along the following dimensions: the LAC countries covered, the type of data, the types of indicators by which advanced digital skills are measured, the accessibility of the data, and a brief discussion of the quality of the data. A summary draws initial conclusions about whether existing sources duplicate information and highlights gaps in information.

2. Focus on People's Advanced Digital Skills

One thing that complicates the review of sources of information about advanced digital skills is that there is no universal definition of digital skills (IEL, 2018; EU, 2016). Therefore, it is important to clarify the scope of the resources that were considered and included in the inventory.

The sources of data covered in the inventory focus on people's digital skills or talent. An important distinction must be drawn between resources that measure digital skills and those that measure important proxies, such as the capabilities of firms. There is a large and separate body of literature with sources of information about firm capabilities with respect to digital technologies or Industry 4.0 technologies. For example, a recent thorough study conducted in Brazil characterizes the capabilities of firms (1st through 4th generation) based on the types of technologies that firms are using (including many digital technologies) and links them to the industries' expectations up to 2027 (IEL, 2018). Based on a survey of 753 companies across different industries, the study convincingly documents the trajectory of various digital technologies, and a section of the report indicates the need for a skills revolution (IEL, 2018).

Evidently, the survey did not inquire about the skills of the people (employees) in the firms. Rather, the analysis focused on firms' uptake and use of particular technologies, which says nothing about whether people have the appropriate digital skills to work with these technologies or whether digital skills are absent or insufficient. The same is true of data that measure the extent of firms' engagement with digital platforms for business, such as e-commerce (i.e., UNCTAD). This information is useful from the standpoint of firm capabilities, which can include the skills of the workers but can also include other factors, such as updated equipment and infrastructure. These resources can indicate the extent to which firms are using the latest digital technologies, but they are distinct from, and fall outside the scope of, sources that explicitly measure people's digital skills.

A few indices, such as the ICT Development Index, the Global Talent Competitiveness Index (GTCI), and the Hayes Index, proport to have a sub-index related to digital skills. These were reviewed, but the proxies used for digital skills were determined to be too

broad to capture the presence of advanced digital skills. In the ICT Development Index, for example, the sub-index for skills is proxied by mean years of schooling, gross secondary school enrollment, and gross tertiary school enrollment. Such proxies may capture the presence of human capital in a country but are clearly too general to capture the presence of advanced digital skills. In the GTCI, two of the six pillars, or sub-indices, are related to skills, but they are also too broad to meaningfully measure digital skills.[1] The Hayes Index uses information on wages and job vacancies. While some of the skills presented in individual country profiles of the Hayes Index are digital, the index captures any skills that are in high demand. Thus, it may not be the best tool for identifying the presence of digital skills in particular.

Since digital technologies (and therefore the most relevant digital skills) change so quickly, the sources reviewed are limited to data collected within the past five years. Thus, for example, data collected by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatistica, or IBGE) project TIC-Empresa in 2010 in Brazil included some information on digital skills. This source is not included in the inventory of sources because the digital skill landscape has changed dramatically since 2010.

The focus of the inventory is on sources of data that document advanced digital skills in the LAC region. Some sources cover basic (or intermediate) digital skills, such as the use of the internet in the general population. These are also not included in the inventory. There are a number of initiatives outside the region that might have relevant information about digital skills (i.e., CEDEFOP, Eurostat, O*NET, European Digital Skills Survey), but they do not contain information about the presence of digital skills in LAC. Therefore, they are only referred to here as potential benchmarks for data collection.

A few entities are working hard to establish digital skills frameworks and continuously update them as digital technologies evolve. The European Commission developed the DigComp Framework[2] which is the ontology underlying Eurostat digital skills indicator (European Commission, 2016). The way in which the Eurostat indicator for digital skills maps onto the DigComp framework is presented in Appendix A, which highlights in yellow elements that overlap (almost exactly) with the International Telecommunication Union (ITU) digital skills indicator. The ITU digital skills indicator is based on nationally representative

[1] The VT Skills pillar is comprised of Mid-Level Skills, which is "based on GTCI scores for Workforce with secondary education; Population with secondary education; Technicians and associate professionals; and Labour productivity per employee," and Employability, which is "based on GTCI scores for Relevance of education system to the economy; Skills matching with secondary education; Skills matching with tertiary education." The GK Skills pillar is made up of High-Level Skills, which is "based on GTCI scores for Workforce with tertiary education; Population with tertiary education; Professionals; Researchers; Senior officials and managers; Availability of scientists and engineers," and Talent Impact, which is "based on GTCI scores for Innovation output; High-value exports; New product entrepreneurial activity; New business density; Scientific journal articles." Pillar contents are excerpted from: INSEAD, ADECCO, and TATA Communications (2019).

[2] Version 1.0, published in 2013, led to version 2.0, updated in 2016. The latest version, 2.1, is described by Carretero, Vuorikari, and Punie (2017).

household surveys. It is one of the core indicators identified by the Partnership on Measuring ICT for Development, a group of organizations that defined a set of 50 ICT indicators that meet international standards (ITU, n.d.). Table 2.1 displays the information collected from approximately 50 countries and the average percentage of the population with specific basic, standard, and advanced digital skills (as framed by the indicator).

Table 2.1. **ITU's Digital Skills Indicator and Distribution of Specific Digital Skills among Individuals**

Basic	
52%	Copying or moving a file or folder
52%	Sending emails with attached files (e.g. document, picture, video)
48%	Using copy and paste tools to duplicate or move information within a document
43%	Transferring files between a computer and other devices
Standard	
35%	Finding, downloading, installing and configuring software
33%	Connecting and installing new devices (e.g. a modem, camera, printer)
33%	Using basic arithmetic formulae in a spreadsheet
28%	Creating electronic presentations with presentation software (including text, images, sound, video or charts)
Advanced	
5%	Writing a computer program using a specialized programming language

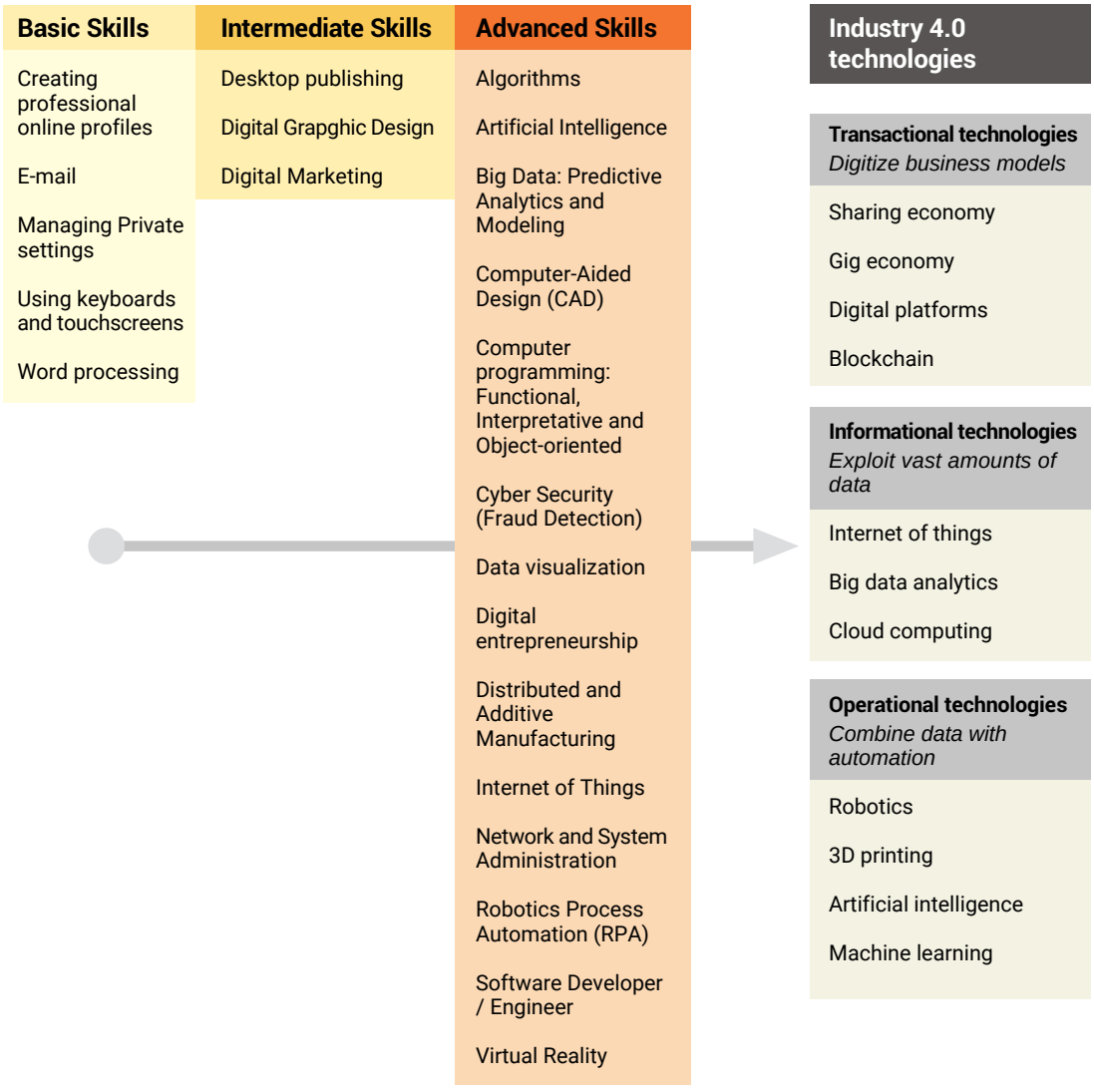
Source: ITU (2018a).
Notes: The ICT skills indicator is based on nationally representative household surveys conducted in 2017. For some countries, if 2017 data were missing data from previous years were used. Although 52 countries responded, some countries did not submit data for all skill types. For example, only 49 countries submitted data for the only advanced skill described as "writing a computer program."

The ITU's Measuring the Information Society Report (2018a) devotes an entire chapter to measuring digital skills around the world. The report emphasizes the lack of theoretical clarity regarding the definition and measurement of digital skills, which means that most indicators are limited (ITU, 2018a). Data being collected by Eurostat, the Organisation for Economic Co-operation and Development (OECD) (OECD, 2019), and the ITU make a distinction between basic and more advanced digital skills, but the amount of information collected at the advanced end of the digital skills spectrum is often quite restricted.[3] As confirmed by Table 2.1, the ITU digital skills indicator only collects information about one relatively generic advanced digital skill. In fact, a surprisingly small portion of the population (5 percent) indicated they possess this advanced digital skill.

[3] There is evidence that the DigComp Framework is evolving to introduce more proficiency levels and expand the examples of digital skills all along the spectrum (Carretero, Vuorikari, and Puni, 2017), but instruments and data collection have not adjusted in tandem.

Table 2.1 and Appendix A help distinguish between skills along the continuum of digital skills that can be considered basic, standard/intermediate, or advanced. Nevertheless, the lack of detail at the advanced end of the spectrum prompted further consultation with the ITU's digital skills toolkit (2018b) for a more detailed set of examples. This information was complemented with other resources to capture as many advanced digital skills as possible, considering the scope of Industry 4.0 technologies described by Fengler and Gill (2019). Figure 2.1 presents the guide used to identify and distinguish advanced digital skills from basic and intermediate digital skills in the review of potential sources of data on advanced digital skills.

Figure 2.1. **Guide to Identify and Distinguish Advanced Digital Skills in the Review of Potential Sources of Data**



Sources: The identification of the "Continuum of Digital Skills" is from ITU (2018b) and complemented with information from Citro (2018), Srai et al. (2016) and from a field visit to Ecole 42. The identification of "Industry 4.0 Technologies" is from a Brookings Institution and World Bank blog produced by the Europe 4.0 Team (Fengler and Gill, 2019).

Additionally, while nontechnical skills (i.e., adaptation, creativity, interpersonal, teamwork, perseverance, and problem solving)[4] are increasingly seen as highly relevant for working with digital and other advanced technologies (Deming, 2015), the main focus of this report is on technical digital skills. In some cases, when a source explicitly covers one or more of the nontechnical skills in conjunction with a technical skill (as is the case for the OECD's data on problem solving in a technology-rich environment), it is included in the review. A source that is exclusively focused on nontechnical skills, while potentially relevant for working with digital technologies, is not included here.

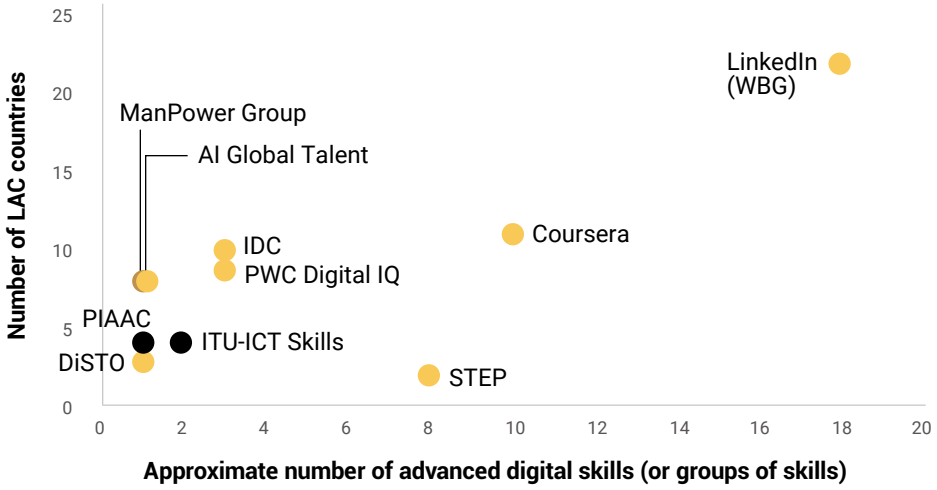
[4] In a field visit to Ecole 42, a coding school with the reputation for an innovate pedagogy, "adaptation and creativity" and "group and interpersonal" skills were highlighted as part of the skills portfolio for students to develop over the course of their training.

3. Preliminary Taxonomy of Data Sources

In line with the notion that there is no universally agreed up definition of digital skills, no two sources of data on digital skills (or talent) seem to use the same definition. Each source seems to create its own skills group to house related advanced digital skills in the way that facilitates its own analysis or reporting. The number of countries covered, the extent to which the sources specify advanced digital skills, and the number of skills covered also vary widely from source to source. Since the sources have different objectives, different potential audiences or users of their data, and different methodologies for data collection and analysis, a direct comparison of sources is often difficult.

Figure 3.1 plots two key dimensions of the available data: the number of LAC countries covered by the source (along the y axis), and the approximate number of advanced digital skills covered in the source (along the x axis). When the source strives for a sample representative of the population, the data point is represented as a black circle.

Figure 3.1. **Sources of Data: LAC Country Coverage and Approximate Number of Advanced Digital Skills Covered**



Source: Authors' elaboration based on the sources of data reviewed.
Notes: This figure does not include all sources of information in the inventory. For example, country specific studies and alternative sources are excluded to facilitate legibility. AI: artificial intelligence; DiSTO Project: "From Digital Skills to Tangible Outcomes: Improving Measures and Models of Engagement" (LSE, undated); ITU: International Telecommunication Union; ICT: information and communication technologies; PIAAC: Programme for the International Assessment of Adult Competencies; PwC: PricewaterhouseCoopers; STEP: Skills Towards Employability and Productivity (a World Bank initiative); WBG: World Bank Group.

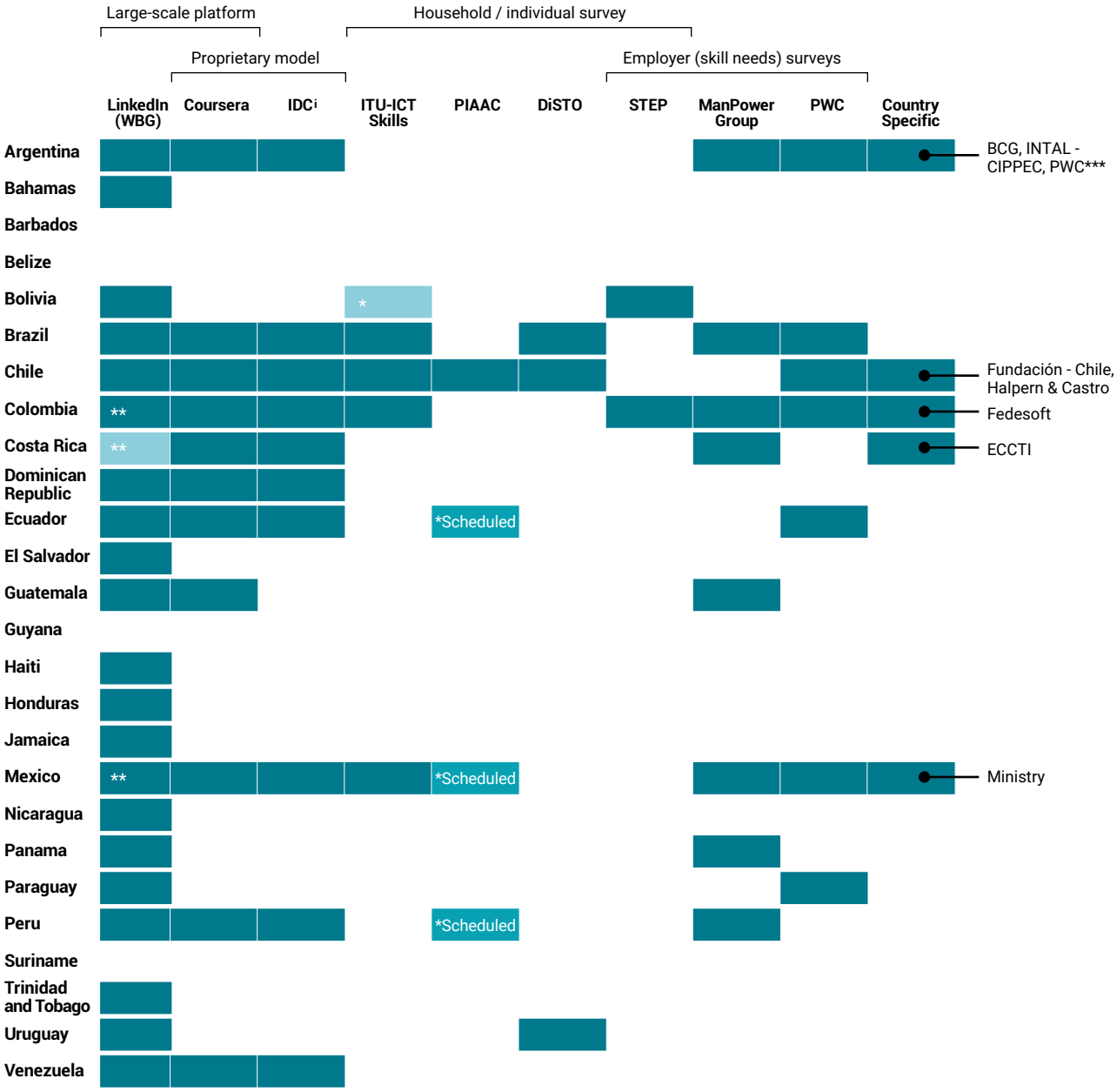
This is one way to quickly summarize two key points: (i) a handful of LAC countries have much more information available to them than others in the region about the presence of advanced digital skills in their economies, and (ii) most resources concentrate on a small number of advanced digital skills. In some cases, "skills groups" are counted as the "approximate number of advanced digital skills covered" because the source groups related skills in their analysis in such a way that it is not possible to extract unique information about each of the advanced digital skills that were grouped together.

The taxonomy presented in Figure 3.2 shows which LAC countries are covered by the data sources included in the inventory and indicates the type of data. For example, Figure 3.2 describes LinkedIn as "large-scale platform" data, and it describes Coursera as both "large-scale platform" and "proprietary model" data. Several sources are described as household/individual survey data and/or employer survey data.

As Figure 3.2 shows, some countries, none of the sources reviewed cover smaller countries (Barbados, Belize, Guyana and Suriname). Only LinkedIn data cover seven countries in the region (Bahamas, El Salvador, Haiti, Honduras, Jamaica, Nicaragua, and Trinidad and Tobago).

Caribbean and Central American countries tend not to be covered by sources that collect household survey data, nor are they typically covered by private initiatives which aim to identify skills shortages (e.g., ManpowerGroup or PwC). At least as far as was identified in this report, these smaller countries also tend to lack in-depth data from industry surveys (such as the one conducted by CIPPEC in Argentina or by Fedesoft in Colombia). By contrast, many of the sources reviewed for this report cover Argentina, Brazil, Chile, Colombia, Mexico, and Peru. This observation will be revisited in the recommendations section.

Figure 3.2. **Data Sources by Country and Type of Data**



Source: Authors' elaboration based on the sources of data reviewed.
Notes: [i] IDC proprietary model includes analysis of an employer-based survey. *Bolivia is mentioned in ITU (2018a) in the text so it seems the ITU has ICT skills data for Bolivia, but the country does not appear in chart 2.8 which shows the responses by country. **Costa Rica does not appear to be covered by the LinkedIn-WBG project, but at least 3 countries: Costa Rica, Colombia and Mexico) have economic graphs produced with LinkedIn data. There may be more LAC countries with LinkedIn Economic Graphs, but they have not been found in the search for sources conducted for this report. *Scheduled: Ecuador, Mexico and Peru are scheduled to participate PIAAC round 3. ***The preliminary PWC study specific to Argentina was reviewed and is included in the overall PWC section, not in the individual country / sector studies section. WBG: World Bank Group; IDC: International Data Corporation; ITU: International Telecommunication Union; ICT: information and communication technologies; PIAAC: Programme for the International Assessment of Adult Competencies (an OECD initiative); DiSTO Project: "From Digital Skills to Tangible Outcomes: Improving Measures and Models of Engagement" (LSE, undated); 'From digital skills to tangible outcomes - Improving measures and models of digital engagement' (DiSTO). STEP: Skills Towards Employability and Productivity (a World Bank initiative); PwC: PricewaterhouseCoopers; BCG: Boston Consulting Group; INTAL: Institute for the Integration of LAC; CIPPEC: Centro de Implementación de Políticas Públicas para la Equidad y el Crecimiento; Fedesoft: Colombian Federation of the Software Industry and Related Information Technologies; ECCTI: Estado de las capacidades en ciencia, tecnologia e innovacion.

4. Inventory

4.1. LinkedIn

LinkedIn data present an opportunity to identify advanced digital skills at a very granular level. Digital skills among platform users can be updated in real time, provided that platform users are vigilant about updating their skills. The search for sources of data on digital talent in LAC surfaced four initiatives using LinkedIn data:

1. The largest initiative (in terms of LAC country coverage) is a World Bank Group–LinkedIn partnership project, World Bank LinkedIn Digital Data for Development. Launched in 2017, the first data and resources were released on April 1, 2019.

2. A Microsoft/LinkedIn initiative, currently in progress and in the process of publication,[5] studies particular skills groups such as artificial intelligence (AI) in more detail at the country and sub-country level.

3. An Inter-American Development Bank (IDB) technical note published in August 2018: was the result of a collaboration between LinkedIn and the IDB to generate information for the 2018-2019 G20 meetings and discussion about the future of work (skills needs and employment) under the umbrella of new economic conditions in the digital economy.

4. Country-specific LinkedIn Economic Graphs featuring the top industries, big and growing employers, details about in-demand skills and jobs, and migration flows can be generated with data from LinkedIn. Economic graphs for Colombia, Costa Rica, and Mexico were identified either via public presentations or shared though collegial networks for this report. There may, however, be more economic graphs for other LAC countries, and it might be possible for LinkedIn to create economic graphs for other LAC countries.

Since the World Bank Group-LinkedIn Digital Data for Development partnership has the largest LAC country coverage, the inventory description of the source focuses mainly on that project. A brief description of the other three initiatives highlights potential for additional ways the data source can be used.

[5] An early version describing the methodology is available online (Roca, 2019).

The World Bank Group-LinkedIn Digital Data for Development partnership is designed to use a non-traditional private company dataset as a public good to help address policy questions. It can be particularly useful in gauging skills in the digital economy, an area where traditional government surveys cannot always keep pace with the information needed.

The project seeks to identify indicators of skill penetration to help answer questions such as, "Are particular skills (e.g., AI) being applied across industries? How is this changing over time?" and industry skills needs to answer questions such as, "For the industries I am interested in, what are the latest, most important skills?" (Zhu, Fritzler, and Orlowski, 2018: 11).

Type of data: Large-scale platform data

Country coverage: 140 countries

LAC country coverage: The project covers 22 countries in the LAC region. Twenty-one of the LAC countries covered are IDB members: Argentina, Bahamas, Bolivia, Brazil, Chile, Colombia, Dominican Republic, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela.

Which digital skills are covered?

There are many skill groups identified in the project's documentation, ranging from accounts payable to zoology. Clearly not all skills groups are advanced digital skills groups. Using the advanced skills in the continuum of digital skills (ITU, 2018b) as a guide. Table 4.1 excerpts the skills groups and the top 10 detailed skills in those skill groups that can be considered advanced digital skills groups. Some skills groups, such as computer hardware, digital literacy, signal processing, creativity skills, and problem solving, were considered but ultimately were not included in the table.

Table 4.1. **Advanced Digital Skill Coverage in LinkedIn**

Skills group	Detailed skill - Top 10 (by member count)
Artificial intelligence	Machine Learning, Data Structures, Artificial Intelligence, Computer Vision, Apache Spark, Deep Learning, Pattern Recognition, OpenCV, Artificial Neural Networks, Neural Networks
Cloud computing	Microsoft Azure
Computer graphics	Computer Graphics, AutoCAD Mechanical, OpenGL, Qt, GIMP, Digital Image Processing, Engineering Drawings, Adobe Freehand, 2D graphics, MEL
Computer networking	Networking, Windows Server, Active Directory, Software as a Service (SaaS), Network Administration, Voice over IP (VoIP), Cisco Systems Products, Internet Protocol Suite (TCP/IP), Network Design, Switches
Cybersecurity	Security, Network Security, Firewalls, Information Security, Computer Security, Information Assurance, Information Security Management, IT Audit, Security Audits, Vulnerability Assessment
Data science	Data Analysis, Forecasting, Statistics, Analytics, SPSS, R, Trend Analysis, Data Mining, SAS, Modeling
Data storage technologies	SQL, Microsoft SQL Server, MySQL, Databases, Cloud Computing, Oracle Database, Oracle HR, Data Center, Virtualization, PL/SQL
Data-driven decision making	Decision Support, Decision Analysis, Business Decision Making, Ethical Decision Making, Decisiveness, Data-driven Decision Making
Development tools	Java, C++, C, Linux, C#, Python, Unix, .NET Framework, ASP.NET, Git
Digital marketing	Digital Marketing, Online Marketing, E-commerce, Search Engine Optimization (SEO), Email Marketing, Digital Strategy, Direct Marketing, Google Analytics, Search Engine Marketing (SEM), Google Adwords
Enterprise software	SAP Products, Enterprise Software, SAP ERP, SAP Implementation, High Availability, SAP Netweaver, Microsoft Dynamics CRM, Cognos, Magento, Microsoft Dynamics NAV
Game development	Video Games, Game Development, Unity3D, Game Design, Online Gaming, Mobile Games, Gaming Industry, Gaming, Perforce, Unity
Robotics	Automation, Robotics, Control Theory, Process Automation, Machine Design, Electrical Controls, Mechatronics, Electro-mechanical, Motion Control, Machine Vision
Social media	Social Media, Social Media Marketing, Digital Media, Blogging, Facebook, Twitter, Social Marketing, YouTube, Instagram, Social Media Optimization (SMO)
Software development life cycle	Integration, Requirements Analysis, Agile Methodologies, Software Development Life Cycle (SDLC), Scrum, Solution Architecture, Requirements Gathering, Systems Engineering, Unified Modeling Language (UML), Software Design
Software testing	Test Automation, User Acceptance Testing, Manual Testing, Test Planning, HP Quality Center, Regression Testing, Debugging, System Testing, Software Quality Assurance, Test Cases
Technical support	Windows, Troubleshooting, ITIL, Technical Support, Operating Systems, System Administration, IT Service Management, IT Strategy, IT Management, Disaster Recovery
Web development	HTML, JavaScript, Cascading Style Sheets (CSS), PHP, Web Development, XML, jQuery, HTML5, WordPress, Web Services

Source: Excerpted from World Bank Group-LinkedIn Digital Data for Development: Skill Group Definitions. Available at: https://development-data-hub-s3-public.s3.amazonaws.com/ddhfiles/144635/skill-group-definitions.pdf
Notes: Detailed individual skills are extracted from LinkedIn members' profiles and grouped into more meaningful skills groups based on the likelihood of co-occurrence of skills in profiles (Zhu , Fritzler, and Orlowski, 2018).

Accessibility of the data: While the LinkedIn data are characterized as large-scale platform data, to be used as a measure of advanced digital skill penetration or industry skill needs the data must be extracted and cleaned for analysis. Phase 2 of the project pledges an automated data tool (see: https://linkedindata.worldbank.org/data), and phase 3 pledges to share the dataset and R codes that generate country results in 2020 (Zhu, Fritzler, and Orlowski, 2018). Currently, skills penetration and industry skills needs data are only publicly available at a global level. These are the aggregate of all the countries covered by the World Bank Group-LinkedIn Digital Data for Development project. Country-level results on the skills data are not yet publicly available. The project's website states that country-level pilot testing is being conducted to assess the potential risk of data misinterpretation and misuse of the skills data. One risk factor is that, when data are disaggregated to the country level, sometimes LinkedIn coverage of the workforce is insufficient. Access to the resources (dataset and R codes) seems to be conditional on the pilot testing concluding low risk for potential misinterpretation of the data.

Quality of the data/information: The major contributions of the LinkedIn data are (i) the very granular nature of the data on digital skills (no other source reviewed in this report can claim such detailed measurement of advanced digital skills) and (ii) the speed at which updates are available. There are, however, rather large caveats to bear in mind. The LinkedIn data cover only a very small slice of the overall workforce. As described in the project's documentation, in LAC countries (as well as in other regions in the world), LinkedIn's coverage of the workforce (as estimated by the International Labour Organisation, or ILO) is skewed toward younger age groups. In LAC, LinkedIn coverage of 25 to 34 year-olds is the greatest, but it is still just 10 percent of the ILO's estimated workforce. The calculation in Table 4.2 shows that LinkedIn data in the LAC region account for between 1 and 10 percent of ILO workforce estimates.

Table 4.2. **LinkedIn Coverage by Age Group, LAC Region**

Age group	Percent covered	LinkedIn (millions)	ILO workforce (millions)
15-24	**1**	1.28	92.81
25-34	**10**	12.97	129.69
35-44	**4**	5.18	116.73
45-54	**2**	1.73	96.67
55-64	**1**	0.63	53.86
65+	**1**	0.18	23.07

Source: Percentages calculated based on data in the other columns from Figure 3.3 in Zhu, Fritzler, and Orlowski (2018).

The project's documentation also admits a bias in industry distribution in different regions and countries. Globally, LinkedIn membership represents different fractions of the ILO's estimated workforce in the following six industries: "ICT23 (~48 percent); professional, scientific, and technical activities (~26 percent); mining and quarrying (~25 percent);[6] financial and insurance activities (~22 percent); arts, entertainment, and recreation (~14 percent); and finally, manufacturing (~3 percent)" and these are the industries with the greatest LinkedIn coverage (Zhu, Fritzler, and Orlowski, 2018: 32). While these percentages may appear small, absolute coverage must be considered. In absolute numbers, the LinkedIn data capture many people in the region who are in the prime working age. There are other sources[7] that suggest LinkedIn membership is greater than the eventual sample of LinkedIn members in the region used in the WBG project documentation. Furthermore, using household survey data, the ITU found that in around 50 countries only 5 percent of the population have advanced digital (computer programming) skills. So, even if the overall percentage of workers covered by LinkedIn may appear small, the absolute numbers are still relatively large and may disproportionately capture people who indeed have the advanced digital skills that are the focus of this report. From the point of view of transforming businesses, the trends that can be gleaned from analyzing advanced digital skills using these LinkedIn data can yield important insights.

Thus, while the LinkedIn data cover the advanced end of the digital skills spectrum and update in near real time, the extent to which they could be considered representative (especially in some industries in some countries) might be too low for them to be considered a reliable source of information. At this point, even if the dataset updates in near real time, the publicly available data and resources on the project's website will only be updated annually and the skills data are currently not available at the country level.

Furthermore, the LinkedIn data are self-reported and thus far[8] do not include a mechanism for assessing mastery of the skill. By nature of the platform, individuals using LinkedIn are promoting their professional skills to potential employers or networks of their professional contacts. Platform users might exaggerate their capabilities for the sake of seeming attractive to potential employers, and therefore self-reporting on LinkedIn may be even more prone to social desirability bias than other types of self-reported data. Social desirability bias in self-reported data may vary unequally across cultures in ways that are not correlated to digital skills (ITU, 2018a). Thus, an additional caveat (not emphasized by the project) is that the resulting identification of the presence of skills may not always be a useful tool for measuring skill proficiency in a particular domain.

[6] Some companies may have identified themselves as mining and quarrying companies on LinkedIn, though they might better be categorized as energy or utility companies.

[7] See, for example, Williams (n.d.).

[8] There are some potential mechanisms, such as endorsements of skills, which appear on individual profiles which, while not free from potential bias, are given by other LinkedIn members. The methodology does not indicate the use of this feature: "the individuals' company and industry of employment, location, work and education history, and self-reported skills extracted and aggregated for analysis" (Zhu, Fritzler, and Orlowski, 2018: 19).

The other three initiatives (Microsoft/LinkedIn, IDB technical note, and individual country economic graphs) illustrate potential additional uses of the LinkedIn data. The Microsoft/LinkedIn work demonstrates that it is possible to use machine learning techniques with the LinkedIn database to identify the largest possible sample of talent with a specific advanced digital skill (e.g., AI) for 5 LAC countries (Argentina, Brazil, Chile, Colombia, and Mexico). The machine learning estimates appear to be larger than estimates derived from searching the LinkedIn database with keywords. The IDB technical note (Amaral et al., 2018) shows how LinkedIn data can be used to investigate the transferability of workers' skills. The authors use a network analysis approach to ascertain the proximity of occupations based on skill similarity. For 10 countries, 4 of which are LAC countries (Argentina, Brazil, Chile, and Mexico), the authors assess the transferability of workers' skills and across declining and growing occupations within each country. Country-specific expected hiring gains, for example, from the declining occupation of information technology support specialist to the growing occupation of database developer in Argentina, can be calculated. While Costa Rica appears to be one of the few LAC countries not included in the World Bank Group-LinkedIn data project, it has a more detailed resource for skills in the country, also produced with LinkedIn data. The Costa Rica Economic Graph contains similar information about industry growth as the World Bank Group-LinkedIn data project, but also has information about the largest and growing employers in Costa Rica, the top in-demand jobs and skills in addition to country information about talent mobility (top countries people are moving to from Costa Rica). Public presentations indicate that Colombia and Mexico also have economic graphs produced with LinkedIn data. These are the three countries for which economic graphs were found as part of the search for data sources for this report. There may, however, be economic graphs for other LAC countries. The LinkedIn website expresses interest in partnering with interested governments to produce economic graphs for the country. The data are subject to the same limitations as the LinkedIn data described earlier, but a big advantage of the economic graph is that it contains country-specific data for skills.

4.2. Coursera

The Coursera Global Skills Index (2019) is a brand-new initiative, whose first edition was released in early 2019. The report provides a ranking of countries based on an index derived from large amounts of learner data. Coursera uses open-source data (Wikipedia) combined with crowdsourcing of educators and learners on their own platform and knowledge from industry experts to create a taxonomy that connects its three most popular domains with the most enrollments (Business, Technology, and Data Science)[9] to a range of competencies and skills.

Learners' countries are identified via the IP address used to access the Coursera website. Industries are identified based on the company where learners say they work. Grades on assessments for particular competencies were extracted from the Coursera platform, adjusted for the level of difficulty of the assessment, and then used to calculate individual skill proficiencies. To avoid undue influence of individual scores, weighted averages were then determined for each domain and competency within each entity (country or industry). To compare skill proficiency across countries, the weighted averages are converted into a percentile (zero to 100), which is then split into four even groups to form categories and the final ranking. Essentially, the countries with the students enrolled in Coursera courses whose grade distributions are the highest appear at the upper end of the percentile rankings. Likewise, countries with students enrolled in Coursera courses whose grade distributions[10] are the lowest appear at the lower end of the percentile rankings.

The 2019 report also provides measures for competency popularity and trending skills. Competency popularity is calculated by growth in Coursera platform enrollments from 2017 to 2018 in courses related to a particular competency. Trending skills are measured by the increase or decrease of an index of quarterly estimates of enrollments, Coursera and Google search trends, postings and salaries in the United States, and a broad measure of returns to skills based on the returns to numeracy scores in 22 countries (Hanushek et al., 2013).

Type of data: Relative ranking or trend: report format

Country coverage: 60 countries. They represent 97 percent of learners using the Coursera platform.

LAC country coverage: Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Mexico, Peru, and Venezuela

[9] Coursera (2019) reports that they have 38 million learners and at least 3,000 courses. The report states that 1,500 courses are in business, technology, and data science, but the report does not indicate exactly how many Coursera learners are in those three domains.

[10] Pulled from the Coursera assessments and adjusted by Coursera for the difficulty of the assessment (p. 47).

Which digital skills are covered?

Coursera identifies six competencies for each of domain. The report only provides a few sample skills per competency. Using the advanced skills in the continuum of digital skills (ITU, 2018 and Figure 2.1) as a guide, the following competencies and skills identified in their Technology and Data Science domains could be considered advanced digital competencies/skills.

Table 4.3. **Coursera's Advanced Digital Skills**

Technology (Coursera domain)
Computer Networking (Sample skills: blockchain, wireless networking)
Operating Systems (Sample skills: Android software development, iOS Software)
Human Computer Interaction (HCI) (Sample skills: user interface, machine translation)
Databases (Sample skills: relational database, key value database)
Security Engineering (Sample skills: cyberattacks, cryptography)
Software Engineering (Sample skills: software development, algorithms)
Data Science (Coursera domain)
Machine Learning (Sample skills: neural networks, natural language processing)
Data Management (Sample skills: SQL, Hadoop)
Statistical Programming (Sample skills: R, Python)
Data Visualization (Sample skills: line graph, bar chart)

Source: Excerpted from Coursera (2019).

Accessibility of the data: The data are available in report format. The country skills rankings are provided for each domain as well as the competency popularity and trending skills for each of the three domains (business, technology, and data science). The percentile score of each competency under each domain is presented by region for each country. Competency popularity and trending skills are presented for each of the 10 industries covered in the report (automotive, consulting, consumer goods, finance, healthcare, insurance, manufacturing, media, technology, and telecommunications). Industry rankings within the three domains are also presented in the report.

Quality of the data/information: The advantages of this data source are twofold. First, it provides a mechanism for capturing information on what people are willing to invest in learning.[11] Second, there is some assessment of the relative proficiency of skills, as long as Coursera can be trusted to have properly adjusted for differences in grading and assured equivalency of instruction across countries and industries.

[11] While it may be possible to audit some courses for free, the following site indicates that features such as graded assignments usually come at a cost ranging from US$39 to US$79 per month. See Bowden (2019) for more information.

Since the rankings and percentiles are in report format, the reader has limited information with which to judge the representativeness of the data. For example, for each domain, how many Coursera learners are from each country? What percentage of data science learners in Argentina are on the Coursera platform vis-à-vis the population of data science learners in the country? Without this kind of information available it is very difficult to judge whether the Coursera learner patterns properly identify the presence (or trends) of advanced digital skills in a given country. Only to the extent that the Coursera individuals' skills investment patterns are aligned with the demand for those skills does the source provide a true indication of industry positions or needs. For example, why would a truly proficient professional programmer need to enroll in a Coursera software engineering course?[12]

While Coursera has reasonable LAC country coverage (11 countries), those not covered in the report have virtually no learners on Coursera.[13] This suggests that Coursera coverage is far from complete and might vary substantially across different countries.

[12] Software engineering is one of the six competencies in the technology domain.

[13] Since 60 countries in their report represent 97 percent of enrollments, countries not in the report have virtually no presence on Coursera.

4.3. International Telecommunication Union: Information and Communication Technology Skills

The ITU collects data on telecommunications/information and communication technology (ICT) infrastructure, price, access, and use worldwide. To collect data about household access and use of ICTs, it reaches out to national statistical offices every September to collect information on 18 indicators that are on a core list of indicators agreed in partnership with a number of other institutions and last updated in 2016 (ITU, 2016).[14] Core ICT Indicator (HH15) refers to ICT skills. The questionnaire asks individuals about computer-related activities undertaken in the last three months. The ITU verifies, harmonizes, and sometimes collects missing data from official websites when countries do not respond to the questionnaire.

Type of data: Nationally representative household survey data

Country coverage: 49 to 52 countries

LAC country coverage: Brazil, Chile, Colombia, and Mexico

Which digital skills are covered?
A range of digital skills are covered (see Table 2.1), but only one advanced digital skill is covered by the indicator, defined as having undertaken the following computer-related activity in the last three months:

- Writing a computer program using a specialized programming language

Accessibility of the data: The ITU website says that the data from the 18 core indicators (the skills indicator is one) are published every December. While presumably these data are published in the World Telecommunication/ICT Indicators database, not everyone has access to it. For those without access, it would cost about 250 euro to purchase the June 2019 edition (ITU, 2019). The results are also available in report format in the Measuring the Information Society Report (ITU, 2018a). The exact percentages of the population with advanced digital skills, by country, can be estimated by examining Chart 2.3 on p. 34 where bar chart data are presented for countries that submitted data.[15] For this review, the ITU online help inquiry was contacted on May 21, 2019, to ask whether it was possible to have the data in excel format. As of September 2019, there has been no response.

[14] See the ITU website for more information:
https://www.itu.int/en/ITUD/Statistics/Pages/datacollection/default.aspx#questionnaires.

[15] Countries: Austria, Azerbaijan, Belgium, Bosnia and Herzegovina, Brazil, Bulgaria, Chile, Colombia, Co^te d'Ivoire, Croatia, Curac¸ao, Cyprus, Czech Republic, Denmark, Djibouti, Estonia, Finland, France, Georgia, Hungary, Indonesia, Ireland, Japan, Kazakhstan, Korea (Rep. of), Kuwait, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Montenegro, Netherlands, Niger, Norway, Poland, Portugal, Romania, Russian Federation, Saudi Arabia, Serbia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Togo, Tunisia, Turkey, and the United Arab Emirates.

Quality of the data/information: The ITU is a trusted resource collecting internationally comparable data on numerous ICT indicators. The advantage of data from this source is that they can be considered nationally representative and comparable across responding countries. These data will be updated yearly and, although not accessible to everyone in raw data format, they are fairly easily accessible. The major limitation is that there is only one broad measure at the advanced end of the digital skills spectrum (percent of the population having written a computer program within the past three months). More granular detail is needed at the advanced end of the digital skills spectrum. As the ITU itself acknowledges, these data are self-reported and subject to social desirability bias, which may not be correlated with digital skills and furthermore represents a limited benchmark focused on activities indicative of operational skills (i.e., button knowledge and programming) which do not capture management and critical skills needed for web 4.0 (ITU, 2018a). Many statistics offices collect information about access and simple use, but rarely delve into skills. When skills data are collected, they tend to be focused on activities, the skill-range is narrowly framed, and there is no process to verify proficiency via, for example, performance tests on a smaller scale (ITU, 2018a). Simply being capable of performing an activity does not indicate the skill with which a person executes the activity. The ITU is currently working on revising the methodology whereby data collection has been focusing on activities and shifting efforts toward a focus on skills (ITU, 2018a).

4.4. From Digital Skills to Tangible Outcomes

A study run by the London School of Economics and Political Science—"From Digital Skills to Tangible Outcomes: Improving Measures and Models of Digital Engagement (DiSTO)," (LSE, undated)—aims to address incompleteness and over-simplification in existing digital skills measures and develop new surveys to measure digital skills, digital engagement, and outcomes of internet use (Van Deursen Helsper, and Eynon, 2016). The project uses an elaborate methodology to test constructs within the survey instruments as they develop (i.e., cognitive interviews, followed by pilot testing), and then the project proceeds to draw a representative sample from within a particular target group. First conducted in the Netherlands and the United Kingdom, the project has expanded to include a few more countries, including some in the LAC region. The approach of the DiSTO project is distinct from other survey-based data sources reviewed, because the focus is on outcomes related to the use of digital skills. Thus, the survey questions are quite different, as are the resulting indicators.

Type of data: Survey (representative samples from particular target groups)

Country coverage: Six countries

LAC country coverage: Two or three LAC countries: Chile and Uruguay are participating in this study.[16] In Chile, a representative survey of 1,100 individuals in the metropolitan region is planned, and in Uruguay, a representative survey of 1,000 students in Montevideo's Secondary Public Schools system is planned. Brazil is also mentioned on the website, but Brazil does not have a project page.

Which digital skills are covered?
While the ITU highlights this project because it collects a full range of information (operational, information, social, and creative) and maps this to outcomes, there are certainly more detailed questions pertaining to what might fall into basic and intermediate or standard skills. There are still relatively few questions that cover advanced digital skills (using ITU 2018b and Figure 2.1 as a guide).[17]

The questions are divided into two categories to measure either achievement or satisfaction. The response scale is along a 5-point Likert scale with the option to select "not applicable" or "don't know." There are four sub-fields (economic, cultural, social, personal). Under the economic sub-field, the following outcomes questions could be related to a range of digital skills, including people with advanced digital skills:

[16] For Chile's project information see: http://www.lse.ac.uk/media-and-communications/research/research-projects/disto/disto-chile. For Uruguay's project information see: http://www.lse.ac.uk/media-and-communications/research/research-projects/disto/disto-uruguay

[17] The full questionnaire is available online: http://www.lse.ac.uk/media-and-communications/assets/documents/research/projects/disto/From-Digital-Skills-to-Tangible-Outcomes-Questionnaire.pdf

- The things I found online influenced how I do my job.
- Satisfaction with the way the internet has influenced the way I do my job.
- I found a job online that I could not have found offline.
- Satisfaction with a job found online.
- I got a certificate that I could not have gotten without the internet.
- Satisfaction with the quality of the course.
- I found educational material online that I could not have found.
- Satisfaction with the material.

In the full questionnaire, the only questions that potentially measure advanced digital skills are:

- I know how to design a website.
- I know which different types of licenses apply to online content.

Accessibility of the data: This study appears to be ongoing. There is a lot of information about the development of the survey instruments and the methodology used. On the individual project pages, it is possible to find information about the presumably planned activities in Chile and Uruguay. But what stage the projects are currently in is not clear, and there do not seem to be published results for either country at this juncture.

Quality of the data/information: This data source is distinct from the others because it is focused on the outcomes of the use of digital skills. The utility of this source of data at the advanced end of the digital skills spectrum is probably fairly limited, because there are not many questions that target the advanced end of the digital skills spectrum. It could be useful to know whether satisfaction with the quality of education and job-related information found online differs for those who have advanced digital skills (i.e., know how to design a website). There may be a way to ascertain whether the information available online is relatively more or less useful for people who are engaging in moderately advanced digital skill use.

4.5. Programme for the International Assessment of Adult Competencies

The Programme for the International Assessment of Adult Competencies (PIAAC) is an OECD initiative to capture the distribution of adult skills in literacy, numeracy, and problem solving in technology-rich environments (PSTRE). The 2019 Digital Skills Outlook released by the OECD in April 2019 relies almost exclusively on data from PIAAC to assess the skills needed for a digital society and implications for a digital world of work.

Type of data: Survey and assessment data are based on nationally representative samples of at least 5,000 adults (aged 16 to 65). Sampling strategies differ between countries, but sampling and weights can be applied to obtain internationally comparable estimates. Data are presented in the form of plausible values, which is the dominant methodology currently used by large-scale assessments and is meant to provide a distribution of skills subject to less noise when comparing groups or sub-groups. PIAAC assesses competencies using a 500-point scale, which is then grouped into levels. While 5 levels are used for literacy and numeracy, since there were only 14 tasks in the PSTRE part of the PIAAC assessment, only 3 levels are used for the PSTRE, which correspond to the following scores (Below Level 1: 0-240, Level 1: 241-290, Level 2: 291-340, and Level 3: 341-500). Data on scores and levels are publicly available.

Country coverage: Thirty-eight countries have participated in the PIAAC program or are scheduled to participate in the current round. There are three rounds in which data have been collected from different countries 23 countries in Round 1 (2008–2013), 9 countries in Round 2 (2012–2016), and 6 countries in Round 3 (2016–2019). Most countries have only participated in one round of data collection, only one county scheduled for Round 3 also participated in Round 1.[18]

LAC country coverage: Chile participated in Round 2, and Ecuador, Mexico, and Peru are scheduled to participate in Round 3 of data collection.

Which digital skills are covered?
PIAAC's PSTRE is defined as "using digital technology, communication tools and networks to acquire and evaluate information, communicate with others and perform practical tasks." The first wave of PIAAC focused on "the abilities to solve problems for personal, work and civic purposes by setting up appropriate goals and plans, and accessing and making use of information through computers and computer networks" (OECD, 2013: 8) The PSTRE assessment "included computer-based simulation tasks designed to measure the ability to analyze various requirements of a task, define goals and plans, and monitor progress until task purposes were achieved. The focus was not on computer skills per se,

[18] For more information, see http://www.oecd.org/skills/piaac/aboutpiaac.htm.

but rather on the cognitive skills required to access and make use of computer-based information to solve problems" (OECD, 2013: 44).

Table 4.4. **PIAAC's PSTRE Cognitive Dimensions**

Cognitive dimensions	Web environment	Spreadsheet environment	Email environment	Multiple environments
Goal setting and monitoring progress	2	1	1	1
Planning	2	2	2	4
Accessing and evaluating information	3	0	0	0
Selecting organizing and transforming information	2	1	3	1
Totals	**9**	**4**	**6**	**6**

Source: Excerpted from OECD (2013).

The background questionnaire asks respondents questions about activities and use of ICTs in the workplace and daily life, ranging from e-mailing to the use of word processing or spreadsheet software or a computer programming language (OECD, 2019).

Accessibility of the data: PIAAC data and public use files are freely available online.[19]

Quality of the data/information: The PIAAC data are useful for international comparisons and because they provide some assessment of digital skills. They are, however, similar to the data presently collected by the ITU because they are skewed toward the basic end of the digital skills spectrum. While people with advanced digital skills must perform exceptionally well on the PSTRE assessment, it might be difficult to determine their presence relative to people with solid standard or intermediate skills.

[19] For more information, see http://www.oecd.org/skills/piaac/data/

4.6. Skills Towards Employability and Productivity

The Skills Towards Employability and Productivity (STEP) program was designed by the World Bank. Like the PIAAC (developed by the OECD), it was designed to generate internationally comparable data on adult skills Household survey data are complemented with data from employer surveys that were conducted as part of the same project. Samples of registered firms are also surveyed to ask employers about the skills they are seeking and their hiring constraints.

Type of data: Household based survey of individuals and employer surveys

Country coverage: 13 countries

LAC country coverage: Bolivia and Colombia

Which digital skills are covered?
The STEP household survey asks respondents about the intensity and the complexity of ICT technologies used for everyday work activities. The survey also assesses cognitive skills, socio-emotional skills, and other job-related skills.

Table 4.5. **STEP's ICT / Digital Skills**

Skill	Question	Response scale to Measure Digital Skil
Requirement for work	Does your work require the use of the following … ?	Yes/no: e-mail, searching for information on the internet, data entry, word processing (such as Word), spreadsheets (such as Excel), databases (such as Access), presentation graphics software (such as PowerPoint), designing websites, or managing networks, advanced functions in spreadsheets such as macros and complex equations, accounting or financial software, CAD software, statistical analysis, Software programming, managing computer networks.

Source: Excerpted from the Questionnaire in documentation: https://microdata.worldbank.org/index.php/catalog/2012/related-materials.
Note: Advanced digital skills are highlighted in bold.

Accessibility of the data: Data by country are available with permission on the World Bank's website at: https://microdata.worldbank.org/index.php/catalog/step. There is also additional information about the geographic coverage within the country, sampling, response rates, weights, data collection, and processing.

Quality of the data/information: The information from this data source is potentially very useful, because it uniquely (compared to other sources) contains information from

individuals and employers. While the individuals are not necessarily the ones working at the firms surveyed, the source can shed light on both sides of the story (people's skills and employers' skill needs). The disadvantage is that there are a limited set of countries covered and the data collection process is lengthy and costly. It takes 28 months to gather the data and costs between US$470,000 and US$530,000 for collecting surveys from 3,500 randomly selected households, and US$111,000 to collect data from an average of 400 employers (Fernanda Prada and Rucci, 2016). A data collection process that takes more than two years is far too long to keep up with the pace at which digital technologies and the skills needed to work with them are evolving.

4.7. International Data Corporation

In 2016, the International Data Corporation (IDC) produced a paper that analyzed current and future trends of networking skills in information technology (IT). From February to May 2016 the IDC contacted around 5,615 IT managers. Potential respondents were selected because of their "responsibility for network infrastructure and management of professionals involved in network design, operation and maintenance, deployment, and support" (IDC, 2016: 2) in organizations with 100 employees or more and from a variety of sectors (i.e., government, healthcare, education, telecoms, financial services, manufacturing, retail and wholesale, media, broadcasting and publishing, travel, transport and distribution, resources and services (IDC, 2016).

The final number of complete interviews used in the analysis in the paper was 760. Information from the interviews was combined with a proprietary model developed by the IDC which includes information such as: gross domestic product (GDP), IT workforce estimates, population growth, and registered companies. The forecasts drew on a number of IDC's technology-specific tracker studies (IDC, 2016).

The paper presents estimates of the supply, demand, and gap of full-time equivalents (FTEs) with respect to groups of networking skills defined by the IDC and described below. The estimates cover 2015 and forecasting techniques are used to project annual trends into 2019.

Type of data: Employer interviews (760) and a proprietary model of analysis

Country coverage: 10 countries

LAC country coverage: All the countries in this study are in Latin America: Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Mexico, Peru, and Venezuela.

Which digital skills are covered?

The IDC paper classifies the IT skills they review into two groups: essential networking skills and emerging networking technology skills. The IDC refers to Total networking skills as the two groups together. The paper also describes some results based on their interviews with respect to nontechnical skills, including English proficiency, teamwork, creativity, and problem solving.

Table 4.6. **IDC's Digital Skills**

Essential networking skills	
Basic router and switch skills	
Network security	
Wireless networking	
VoIP and unified communications	
Emerging networking technology skills	
Video	**Total networking skills**
Cloud	
Mobility	
Datacenter and virtualization	
Big data	
Cybersecurity	
IoT	
Software development	

Source: IDC (2016).

Accessibility of the data: The paper is easily accessible online. The yearly estimates for total, essential, and emerging networking skills aggregated across the 10 countries are reported as FTE supply, demand, and the gap (between supply and demand). The paper also includes a unique analysis for each country covered in the paper. The soft skills are treated a bit differently; it indicates their relative importance from the standpoint of the companies interviewed for the paper. For some individual skills, such as cybersecurity skills, the paper briefly describes overall tendencies and companies' perceptions.

Quality of the data/information: The advantage of this data source is that it identifies precise estimates for the estimated shortfall of workers with advanced digital skills in IT for 10 LAC countries. Since the interviews span a wide variety of sectors, it could be considered an indication of the crosscutting advanced digital skill sets needed. The disadvantage is that the number of interviews conducted is limited, approximately 74 per country, assuming an even spread of interviews across countries. No interviews were conducted with organizations with fewer than 100 employees. While the inputs used in the model are described, the paper does not specify how the model works. This means that the reader has to trust the accuracy of the IDC analysis. Since the estimates for 2019, for example, were forecasts, they may or may not reflect actual influx or changes that were not captured by the modeling techniques.

4.8. Global AI Talent Report

The Global AI Talent report is produced by JF Gagne, the founder and CEO of Element AI, a Canadian company that helps traditional organizations transition into big tech. JF Gagne is also a member of the European Commission's high-level group of experts on AI. The 2019 report is the second year of publication for the AI Talent report. Experts in the field of AI are identified using three approaches: (i) Publications from 21 leading AI scientific conferences were reviewed and the profiles of participating authors were analyzed. (ii) LinkedIn was used to search for expert profiles using the following job titles: data scientist, research scientist, machine learning engineer, machine learning researcher, and data analyst. The search was limited to individuals with Ph.Ds. and only those who included "machine learning" in their profiles. (iii) To contextualize the information from conferences and LinkedIn, outside reports and other resources were used to calibrate the findings.

Type of data: Report format. The number of AI experts by country is reported in an interactive map. For a subset of countries, there is some additional analysis of gender composition and mobility of AI experts.

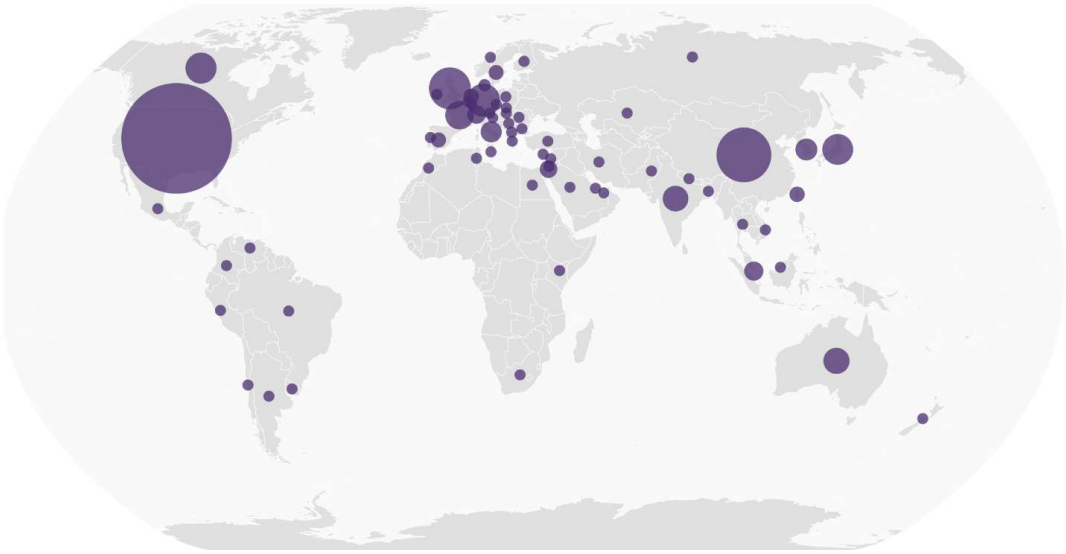
Country coverage: The report seeks to identify AI experts wherever they may be.

LAC country coverage: In Map 4.1, it is possible to see that experts have been identified in Argentina, Brazil, Chile, Colombia, Mexico, Peru, Uruguay, and Venezuela. The interactive map allows viewers to see the number of experts identified via conferences vis-à-vis LinkedIn searches. The data reported by gender and mobility of AI experts cover only a subset of countries that does not include any LAC countries.

Which digital skills are covered?
The report covers expert level AI skills. While the website acknowledges that AI talent is not limited to PhD or publishing researchers in the field of AI, the report is exclusively focused on Ph.Ds. in AI with machine learning skills.

Accessibility of the data: The results are freely available in the online report. For the number of experts in each country there is an interactive map. It is possible to click on the image below and see the results for other LAC countries (scroll to "where experts are working").

Map 4.1. **Global AI Report's Map of Experts in AI around the World**



Source: Excerpted from Gange, Kiser, and Mantha (2019).

Quality of the data/information: The advantage of the information from this source is that it identifies the top-tier talent in AI with machine learning skills. The main author of the report offers anecdotal evidence from his own company that these cutting-edge and highly specialized skills are hard to find and in the greatest demand in his company (Gange, Kiser, and Mantha, 2019).[20]

There are some potential sources of bias. For example, all conferences used to identify experts were held in English, and peer-reviewed publications submitted to academic conferences will reflect certain biases. Research published in peer-reviewed journals, private labs, and think tanks as well as by independent consultants were not considered. Only the publications of participants in 21 conferences were used in the 2019 report. The assumption of doctorate holders as a proxy for highly specialized skills could be questioned and may not sufficiently reflect industry expertise. AI engineers for product development, data experts, and business leaders who are cutting-edge and influential in the field may not appear in the data collected for the report. Nevertheless, it is useful for getting a preliminary sense of where expert talent in AI exists and where there is limited or no expertise.

[20] See the blogpost written by Gange, Kiser, and Mantha (2019).

4.9. ManpowerGroup 2018

ManpowerGroup is a widely cited source that has been conducting a survey of employers since 2006 to ask them, in generic terms, about the roles they have difficulty filling and the kinds of skills that are hardest to find. The most recent survey was conducted in 2018. While questions are not focused on advanced digital skills, some response categories touch upon skills that could fall at the advanced end of the digital skills spectrum. As noted by Fernanda Prada and Gucci (2016) in a comprehensive guide to workforce skills assessments, the ManpowerGroup survey is a not a direct measurement of skills or skill-related performance of their employees; rather, it measures some employers' perceptions of the absence (or short supply) of skills.

Type of data: Employer survey

Country coverage: 43 countries or territories

LAC country coverage: Argentina, Brazil, Colombia, Costa Rica, Guatemala, Mexico, Panama, and Peru

Which digital skills are covered?
While digital skills are not the focus of the survey, employers surveyed are asked which vacancies/roles are hardest to fill, and one of the response categories available is IT (further described as: cybersecurity experts, network, administrators, technical support). The report publishes aggregate global results, presumably aggregating all survey responses from the 43 countries. There is an interactive version of the report, from which it is possible to extract information by country, as seen in Table 4.7. Employers surveyed in the LAC region tend to indicate that IT roles are as difficult to fill as the employers from other countries, hovering around the survey's global average of the 6th hardest role to fill of the top 10.

Sources of Data on Digital Talent in Latin America and the Caribbean

Table 4.7. **ManpowerGroup's Digital Skills: Assessment of the Relative Importance of IT, by LAC Country**

	1	2	3	4	5	6	7	8	9	10
Argentina	Skilled Trades - electricians, welders, mechanics	Sales reps- B2B, B2C, contact center	Technicians- quality controllers, technical staff	Engineers- chemical, electrical, civil, mechanical	Accounting & Finance - certified accountants, auditors, financial analysts	**IT - cybersecurity experts, network, administrator, technical support**	Professionals - project managers, lawyers, researchers	Office support- administrative assistants, PAs, receptionists	Drivers - truck, deliver, construction, mass transit	Teachers
Brazil	Sales reps: B2B, B2C, contact center	Drivers: truck, deliver, construction, mass transit	Skilled Trades - electricians, welders, mechanics	Technicians- quality controllers, technical staff	Accounting & Finance - certified accountants, auditors, financial analysts	Healthcare professionals - Doctors, nurses, other non-nursing health professionals	**IT - cybersecurity experts, network, administrator, technical support**	Office support- administrative assistants, PAs, receptionists	Manufacturing - production and machine operators	Engineers- chemical, electrical, civil, mechanical
Colombia	Manufacturing - production and machine operators	Skilled Trades - electricians, welders, mechanics	Management Executive	Drivers: truck, deliver, construction, mass transit	Sales reps: B2B, B2C, contact center	Technicians- quality controllers, technical staff	Accounting & Finance - certified accountants, auditors, financial analysts	**IT - cybersecurity experts, network, administrator, technical support**	Office support- administrative assistants, PAs, receptionists	Customer support - call center operators, customer service reps
Costa Rica	Technicians- quality controllers, technical staff	Sales reps: B2B, B2C, contact center	Skilled Trades - electricians, welders, mechanics	Office support- administrative assistants, PAs, receptionists	Engineers- chemical, electrical, civil, mechanical	Management Executive	**IT - cybersecurity experts, network, administrator, technical support**	Drivers: truck, deliver, construction, mass transit	Accounting & Finance - certified accountants, auditors, financial analysts	Professionals - project managers, lawyers, researchers
Guatemala	Sales reps: B2B, B2C, contact center	Technicians- quality controllers, technical staff	Skilled Trades - electricians, welders, mechanics	Office support- administrative assistants, PAs, receptionists	**IT - cybersecurity experts, network, administrator, technical support**	Drivers: truck, deliver, construction, mass transit	Management Executive	Engineers- chemical, electrical, civil, mechanical	Accounting & Finance - certified accountants, auditors, financial analysts	Professionals - project managers, lawyers, researchers
Mexico	Manufacturing - production and machine operators	Sales reps: B2B, B2C, contact center	Office support- administrative assistants, PAs, receptionists	Skilled Trades - electricians, welders, mechanics	Drivers: truck, deliver, construction, mass transit	Technicians- quality controllers, technical staff	Engineers- chemical, electrical, civil, mechanical	Accounting & Finance - certified accountants, auditors, financial analysts	Professionals - project managers, lawyers, researchers	Management Executive
Panama	Technicians- quality controllers, technical staff	Sales reps: B2B, B2C, contact center	Office support- administrative assistants, PAs, receptionists	Accounting & Finance - certified accountants, auditors, financial analysts	Drivers: truck, deliver, construction, mass transit	**IT - cybersecurity experts, network, administrator, technical support**	Engineers- chemical, electrical, civil, mechanical	Customer support - call center operators, customer service reps	Professionals - project managers, lawyers, researchers	Skilled Trades - electricians, welders, mechanics
Peru	Office support- administrative assistants, PAs, receptionists	Sales reps: B2B, B2C, contact center	Skilled Trades - electricians, welders, mechanics	Technicians- quality controllers, technical staff	Management Executive	Manufacturing - production and machine operators	Engineers- chemical, electrical, civil, mechanical	Drivers: truck, deliver, construction, mass transit	Teachers	Accounting & Finance - certified accountants, auditors, financial analysts
"Global"	Skilled Trades - electricians, welders, mechanics	Sales reps: B2B, B2C, contact center	Engineers- chemical, electrical, civil, mechanical	Technicians- quality controllers, technical staff	Drivers: truck, deliver, construction, mass transit	**IT - cybersecurity experts, network, administrator, technical support**	Accounting & Finance - certified accountants, auditors, financial analysts	Professionals - project managers, lawyers, researchers	Office support- administrative assistants, PAs, receptionists	Manufacturing - production and machine operators

Source: ManpowerGroup (2018).

The interactive report also indicates the distribution of the reasons why it is hard for the company to fill roles (Table 4.8). It is not possible to have this information by role, for example, whether specifically for IT roles the biggest constraint is lack of hard skills or experience. The distribution is presented in aggregate format for all roles that the company finds difficult to fill.

Table 4.8. **ManpowerGroup: Reasons Why Roles Remain Unfilled (in percent)**

	Argentina	Brazil	Colombia	Costa Rica	Guatemala	Mexico	Panama	Peru	Global
Lack of applicants	17	8	21	20	9	18	16	14	**29**
Lack of experience	17	23	**34**	23	**39**	18	**27**	**28**	20
Applicants lack required hard skills	**27**	**33**	17	**30**	22	17	21	17	19
Applicants lack required soft skills	13	19	3	5	6	7	8	5	8
Applicants expect higher pay than offered	10	8	12	13	12	**21**	13	18	12
Applicants expecting better benefits than offered	8	4	2	1	4	7	7	7	2
An issue specific to my organization	2	1	3	4	1	4	1	1	4
Other / don't know	6	4	8	4	7	8	7	10	6

Source: ManpowerGroup (2018).

Accessibility of the data: The aggregate data are available in report format. Via the online interactive report, it is possible to get the breakdown of some of the responses by country.

Quality of the data/information: The information collected by Manpower group is frequently cited and is useful to get a sense of the skills that are difficult for employers to find and how this compares to previous years. The primary disadvantage is that the description of the methodology is very vague, making it difficult to evaluate which slice of firms are surveyed or responding. ManpowerGroup was contacted via online inquiry on May 20, 2019, to request more information about the survey methodology. As of September 2019, no response had been received (other than an automatic reply confirming receipt of the request).

4.10. PwC

PwC provides services to the majority of the world's fortune 500 companies and more than 100,000 entrepreneurial and private firms (pwc.com). A variety of reports produced by PwC touch upon the perceptions of firms with regard to their digital skills needs. These reports often contain some LAC country coverage. PwC has published Digital IQ research since 2007.[21] The 21st CEO survey focused on the talent challenge of rebalancing skills for the digital age. In 2018, PwC surveyed 1,189 CEOs in Asia-Pacific Economic Cooperation (APEC), and a small section of the report describes the sentiment in Chile for the need to upgrade digital skills (PwC Chile, 2019). In 2016, the PwC report of its Global Industry 4.0 survey, Building the Digital Enterprise, claims that the big challenge for the implementation of the newest technologies is the lack of digital culture and skills (PwC, 2016). PwC also conducts studies for individual countries. For example, in Argentina a PwC survey-based study is currently under way about digital talent and how the labor market is responding to the private sector demand.[22]

Type of data: The data are presented in report format based on survey research conducted by PwC or an entity hired by PwC.

Country coverage: Depends on the report.

LAC country coverage: LAC country coverage also depends on the report. Oxford Economics fielded the 2018 PwC Digital IQ research (PwC Digital IQ, 2018). The executive survey was conducted in the first quarter of 2018, with 2,280 respondents from over 60 countries. The following LAC countries and the percentage of respondents from each country participated: Argentina (1 percent), Brazil (2 percent), Chile (<1 percent), Colombia (1 percent), Ecuador (<1 percent), Mexico (2 percent), Paraguay (<1 percent), Peru (1 percent), and Uruguay (<1 percent).[23]

The PwC 21st CEO Survey (2018) on rebalancing skills for the digital age was based on 1,293 interviews with CEOs in 85 countries. One figure in the report presents information about LAC, but details about which countries and how many CEOs are from the LAC region are not included. An e-mail was sent on June 9, 2019, to the PwC contact information listed in the report to request more information. As of September 2019, there had been no response. In the PwC APEC surveys (2018) there were 50 CEO respondents from Chile, 80 from Mexico, and 37 from Peru. The PwC Global Industry 4.0 survey covered 2,000 participants from 9 major industrial sectors and 26 countries, and the report shows that the only LAC countries represented were Brazil and Mexico (PwC, 2016). Clearly, the survey on digital talent and the response of the labor market in Argentina only surveys firms in Argentina.

[21] See https://www.pwc.com/gx/en/ceo-survey/2018/deep-dives/pwc-ceo-survey-talent.pdf for more information.
[22] Translated from: "Talento Digital: ¿Cómo responde la oferta laboral a la demanda empresarial?" PwC, unpublished.
[23] See https://www.pwc.com/m1/en/publications/global-digital-iq-survey-regional-focus-middle-east-africa-2018.html for more information.

Which digital skills are covered?
This depends on the report. In the Digital IQ research, the following skills are covered:

Table 4.9. **PWC's Digital Skills**

Foundational Skills:
Mobile / cloud
Emerging Tech Skills:
IoT, robotics, virtual reality, augmented reality, block chain, RPA (robotic processed automation), drones, AI)
Digital Skills:
Digital strategy and planning, User experience and human-centered, cybersecurity and privacy, creative strategy and design, technology architecture and design, prototyping, evaluating emerging technology, data analytics

Source: https://digital.pwc.com/DIQ2018.

Responses tallied according to a company classification assigned by PwC appear to address the following additional issues:

- Obstacles to upskilling with response options, including lack of time, lack of structure for delivering training, lack of strategic focus on training, lack of institutional knowledge
- Whether the respondent thinks the workforce is digitally savvy
- Whether the respondent thinks the company's digital strategy is integrated with corporate strategy
- Whether the respondent thinks the CEO is a champion for digital

Accessibility of the data: Report format. The survey data collected are analyzed and presented in tables and figures that typically aggregate all the responses. Sometimes grouping companies into four categories (assigned by PwC) and/or showing responses by company characteristics. Reports are accessible online, with the exception of the preliminary results from the Digital Talent survey in Argentina.

Quality of the data/information: Similar to the ManpowerGroup survey, this information might be useful to get a sense of general trends. The surveys focus on the perceptions of big companies and the skills they need, are having trouble finding, or predict will be useful for them in the future. The questions are not asked in a way that provides an assessment of the presence of digital skills in the companies or the country; rather, they are designed

to identify the absence of digital skills and their relative importance. Such information might help policymakers understand (for a particular slice of firms) which digital skills are in short supply. A general critique of this source is that the information is based on limited responses and even fewer responses from companies in the LAC region. In the Digital IQ survey, 61 percent of the respondents are from very large and wealthy organizations with revenues of US$1 billion or greater. According to the Forbes top 2,000 companies in 2019, there are 51 publicly listed companies[24] in LAC with sales of US$1 billion or more. Moreover, the PwC reports do not explain the survey methodology. The number of companies contacted and the response rates are not described. Nor do they provide company profiles (size or industry) by country. A distribution of company size and industry is often presented with the information already aggregated across all survey responses. Individual reports for a particular country, like the one for Argentina, would appear to be much more useful as explicit information about digital skills needed by firms in the region. The preliminary report circulating for Argentina, however, does not include information about the number of firms or the profiles of the companies that responded (size and industry).

[24] The breakdown by country is as follows: 20 in Brazil, 13 in Mexico, 8 in Chile, 6 in Colombia, 2 in Argentina, and 2 in Peru.

4.11. Country -and Industry- specific Entities

Fedesoft (Colombia Software and IT sector)

The Colombian Federation of the Software Industry and Related Information Technologies (Fedesoft) is a trade association of the Colombian national software industry. It has about 535 affiliated companies, which represent nearly 50 percent of the country's total software industry.[25] A recently released study conducted by Fedesoft in 2019 presents results from a survey of companies in the Colombian software industry that was conducted in 2018. Companies responded to very specific questions about the educational qualifications or certifications needed for particular positions and the level of difficulty in finding/selecting people for various positions.

Type of data: Report based on a survey of firms in Colombia's software industry with detailed information on salaries, typical years of experience, and the difficulty firms have filling positions.

Country coverage: One country

LAC country coverage: Colombia

Which digital skills are covered?
This study is oriented toward occupations: the positions in the software and IT industry collected from firms responding to the 2018 survey, the qualifications needed, and the difficulty firms face in finding qualified people for these positions. Since the study is conducted in the software and IT industry, digital skills are probably needed in all of the positions, but the positions listed below are the ones for which advanced digital skills are assumed to be the main component of skills.

Positions specific to the production area: operations manager, development manager, software architect (senior, standard, junior) development leader (senior, standard, junior), quality leader (senior, standard, junior), development engineer (senior, standard, junior), configuration administrator, specifying analyst / functional / business (senior, standard, junior), database administrator, test analyst (senior, standard, junior).

New positions not covered in previous Fedesoft studies: infrastructure manager, business intelligence analyst, data scientist, information security engineer, security analyst, big data engineer and data modeler. There is also information about positions specific to customer service and business, but these are not included here, because advanced digital skills are likely to be a smaller component that skills associated with customer service or business.

[25] See: https://fedesoft.org/quienes-somos/ for more information.

Accessibility of the data: This report appears to be available via a subscription with CENISOFT research center specialized in the software sector.[26]

Quality of the data/information: The information included in this report is very valuable for policymakers and anyone interested in understanding which roles are hardest to fill in the software and IT industry in Colombia. The level of detail in the report and the methodology described reinforce the likely reliability of the data. The data are limited to Colombia and to the firms in the software and IT sector that responded to the survey. The report does not specify the exact skills needed for each position. It would be difficult to know, for example, if the skills needed in this sector are essentially the same ones needed for a software development architect in another sector in Colombia. Additional information for other increasingly digital sectors would be useful.

INTAL, CIPPEC, and UIA (Argentina – Six Industries in the Manufacturing Sector)

INTAL (Institute for the Integration of LAC, part of the IDB's Integration and Trade Sector) collaborated with the Center for Implementation of Public Policies for Equity and Growth (Centro de Implementación de Políticas Públicas para la Equidad y el Crecimiento, or CIPPEC), an independent non-profit organization in Argentina, and the Argentine Industrial Union (Union Industrial Argentina, or UIA) to survey 307 firms in 6 industries in the manufacturing sector in Argentina in 2018. The selection of sectors, the conceptual framework, and the first block of survey questions, about the current and expected adoption of technologies over the next decade and actions and investments toward technological upgrading, follow the guidelines established in the Industria 2027 study recently conducted in Brazil (IEL, 2018). INTAL, CIPPEC and UIA developed a second block of survey questions and added them to the first block of questions in the survey. The second block of questions asks responding firms how new technologies are changing the company's demand for skills.

Type of data: Report based on a survey of firms conducted in Argentina in the manufacturing sector in six industries (processed foods, steel and metalworking, light vehicles and parts and accessories, textiles, farm equipment, and biopharma). Stratified random sampling was used to select firms using 12 sample strata that arise from the combination of the 6 industries and 2 company size-profiles determined by number of employees (11-50 employees and more than 50 employees). The objective was to get 25 responses from firms in each of the 12 combinations for a total of 300 responses. Lists of firms were drawn from a variety of sources (i.e., business registries, the chamber of commerce, Voices database, etc.), and the survey aimed for widespread geographical coverage across the country (Autonomous City of Buenos Aires, Buenos Aires, Cordoba, Santa Fe, Tucuman, and Mendoza). Although 307 firms were surveyed, a final sample of 293 firms was used

[26] See https://cenisoft.org/estudio/ for more information.

in the analysis presented in the Travesía 4.0 report. Surveys were conducted in person or over the phone. The entire questionnaire can be found in Annex 4 of the report (Albrieu et al., 2019).

Country coverage: One country

LAC country coverage: Argentina

Which digital skills are covered?
Block 2 of the survey asks firms, Referring to the last two years, to what extent were the following types of skills important when hiring personnel in your company? The respondent was presented with a Likert-scale response grid with the following options: very important, somewhat important, less important, not important, and don't know. The same question with the same answer choices are repeated, but asks the respondent to base their answers on thinking about the next five years.

1. Internet of things / Internet industrial communication, etc.)
2. Skills for managing large databases (big data)
3. Skills for preventive maintenance of equipment and processes
4. Skills related to technologies applied to the management of productive stock and logistics
5. Additive manufacturing/3D printing
6. Cloud computing
7. Smart sensors
8. Advanced robotics
9. Security management of the company's digital data (cybersecurity)
10. Knowledge in AI/machine learning
11. Augmented reality
12. Other skills? Which?

The survey also asks firms about the relative importance of soft skills (ability to work in a team, flexibility, good interactive skills); personal-computer skills (knowledge, design, adaptation and use of new technologies); STEM skills (science, technology, engineering and mathematics), and skills in repetitive tasks and/or manuals (plant operations, assembly, accounting, etc.). Respondents were asked to answer this thinking of two different timeframes (the past two years and the coming five years).

In the first block of questions, firms were asked about their principal and second most important obstacle to adopting new technologies in the firms (similar to innovation surveys). One of the possible response choices is lack of adequate human resources.

Accessibility of the data: Results are presented in tables and charts in the Travesía 4.0 report with some analysis incorporated. The report is easily and freely accessible online. One author of Travesía 4.0 was contacted for the purpose of getting more information for

the present inventory. The author responded almost immediately. This distinguishes this resource from other resources that surveyed firms in LAC region but did not respond to e-mail inquiries requesting further information (i.e., ManpowerGroup and PwC).

Quality of the data/information: This is an excellent resource. The report presents all the relevant methodological information about the survey in a clear and concise manner. It is easy to understand exactly which company profiles have been surveyed (by industry and size). Requests for further information were handled expeditiously and with precision. The entire survey questionnaire is presented in the Annex of the Travesía 4.0, and it is therefore possible to ascertain which questions are being used to generate the tables and charts in the report. The data are limited to the two company size-profiles in the six industries in the manufacturing sector in Argentina, as described above. It is a relatively narrow sample, but there is greater depth of information in the report about firms' perceptions of their advanced digital skills needs than can be found in the crosscutting country surveys of large firms (such as those of ManpowerGroup or PwC) described in this inventory. This is partially because the industries and firm size-profiles are clearly articulated in the Travesía 4.0 report and partially because of the precision with which the questions about advanced digital skills are asked. For countries in the region interested in implementing a survey similar to the one conducted by INTAL, CIPPEC, and UIA (described in the Travesía 4.0 report), the approximate cost is US$30,000, which is less than a third of the cost of the employer side of the STEP survey.

Boston Consulting Group (Argentina)

Boston Consulting Group (BCG), together with Argentina's Secretariat of Productive Transformation in the Ministry of Production, carried out an online survey of 78 executives from 66 large industrial firms in different economic sectors in October 2017 (Nieponice et al. 2018). The objective of the survey was to learn about the challenges encountered by firms when implementing new technologies.

Type of data: Report based on a survey of executives from 66 large industrial firms in Argentina. The executives interviewed belong to large companies: 41 percent of the companies in the sample have more than 1,000 employees, 18 percent have between 501 and 1,000 employees, 28 percent have between 101 and 500 employees, and 13 percent have 100 or fewer employees. It is not clear from the report in which exact industries the firms are operating.

Country coverage: One country

LAC country coverage: Argentina

Which digital skills are covered?
The survey asked executives, "In the future, to what extent will the following capacities be necessary in the personnel?" (skills that were not related to digital skills were removed from this list).

1. Data science (i.e., big data of the client and device data)
2. Programming (i.e., machine programming, automation, robots, integrated systems)
3. Analytics (i.e., algorithms for predictive maintenance, simulations)
4. Data security (i.e., information security architecture, defense mechanisms)
5. Human-machine interface (i.e., service support activities, collaborative robotics)
6. Data management (i.e., data integration and storage)
7. Control of the production process (i.e., human-machine interfaces supervision and management)
8. Machine-machine communication (i.e., process control, autonomous part recognition)
9. Software development

Apparently, respondents could select answers along a Likert scale: much more necessary, more necessary, no change, less necessary, much less necessary, not applicable. The survey also asked executives "To achieve Industry 4.0 in your company, to what extent do you think the following challenges are important?" One of the possible response choices is lack of qualified personnel.

Accessibility of the data: The report is freely available online. The results are presented in simple percentages in bar charts.

Quality of the data/information: The data are simple indications of the perceptions of 78 executives from 66 large firms in Argentina. The report does not indicate which exact industries the executives represent. The report provides some comparisons between responses from Argentinean executives vis-à-vis German and French executives. The BCG report states that 1,500 executives in different countries have been surveyed, but without specifying all the different countries or the number of responses from each of the other countries. In general, the main question about skills is framed in a similar manner as the INTAL-CIPPEC-UIA survey, which was also conducted in Argentina. But BCG seems to target larger firms and does not specify the timeframe when asking generally about the future, whereas the INTAL-CIPPEC-UIA asks respondents to think about the past two years and project five years into the future (separately) which might be more useful for discerning recent trends. On the other hand, since there are similarities between the two sources with respect to the way the questions about advanced digital skills are framed, policymakers could look at the results from both reports to determine whether they are loosely consistent or inconsistent. Compared with ManpowerGroup and PwC, the BCG report clearly specifies the number of Argentinean executives who have been surveyed, and in all likelihood, BCG reached more executives in large firms in Argentina than the other two sources.

Halpern and Castro (2018) and Survey of Digital Talent: Fundación Chile (Chile)

This section presents two distinct sources that are both specific to Chile. The first is a study conducted by Halpern and Castro in 2018 in Chile. Halpern and Castro (2018) used a three-part methodology to (i) conceptualize, (ii) systematize, and (iii) operationalize digital skills. To conceptually identify the main digital skills, more than 1,500 academic papers were reviewed and then, drawing on classification systems such as the European Commission's DigComp 2.1, the digital competencies were classified into three categories. Then, a panel of 15 Chilean experts (12 of whom were human resources professionals) was formed to validate the relevance of the digital competencies identified in the literature for the Chilean context. The concepts were then operationalized in a survey that asked Chilean workers whether they possess the digital competencies and asked respondents to evaluate how important they believe each competency is in their workplace. The survey was sent by e-mail either via TrenDigital, a platform with 22,000 professionals in Chile, or to a sample of workers from Trabajando.com, a platform with 150,000 workers in the country. There were 6,650 respondents from a diverse age range, work profile (junior rank to managerial level), and pay grade. There was a relatively even split for gender, with just over 50 percent of the respondents being female.

There is also a Fundación Chile Digital Talent Survey under way to assess the demand for digital skills in Chile. Firms are encouraged to participate in survey and, in exchange, firms will receive access to a database of IT professionals developed through a digital skills training initiative.[27] This project is just being launched, and while it is possible to access the survey online,[28] firms are meant to fill it out online. An inquiry requesting more information about the survey and the methodology has been sent to info@talentodigitalparachile.cl.

Type of data: The results from the Halpern and Castro (2018) study, as well as more details regarding the methodology, are freely available in report format online.

Country coverage: One country

LAC country coverage: Chile

Which digital skills are covered?
The Halpern and Castro (2018) study asks workers about a range of skills separated into three main categories: generic digital competencies, contextual and complementary competencies, and specialized digital competencies, which the authors emphasize, are not

[27] It is assumed that the initiative mentioned in the call for survey respondents is the digital skills training initiative being implemented by Fundación Chile and Fundación Kodea: https://fch.cl/talento-digital-para-chile-una-nueva-e-inedita-iniciativa-publico-privada/

[28] See https://es.surveymonkey.com/r/EncuestaTD. It is not possible to view the complete questionnaire without filling in the fields on the first page, which might compromise data collection efforts, so this was not done. Instead, an e-mail was sent requesting more information.

required for everyone. The specialized digital competencies are at the advanced end of the digital skills spectrum but, as described by Halpern and Castro (2018), have some managerial elements infused, are as follows:

- Vision for e-commerce, including the digital tools to comprehensively respond to user needs
- Management and development of digital content
- Management of online communities
- Digital data analysis

The contextual and complementary competencies identified by Halpern and Castro (2018) are as follows: ethical and social awareness for technology use, critical thinking, creativity and innovation, predisposition to change, committed, proactive and responsible (accountable), continuous learning, digital strategic vision, and computational thinking.

Accessibility of the data: The Halpern and Castro (2018) report is freely available online. It seems that the Fundación Chile Digital Talent Survey is ongoing and so, currently there is limited information available.

Quality of the data/information: The methodology Halpern and Castro (2018) used to identify and systemize the digital competencies was very rigorous. The three categories (generic, contextual and complementary, and specialized digital skills) make a lot of sense for identifying different types of digital skills relevant for the workplace. Using a panel of local experts to validate digital competencies ascertained from international literature is a sound methodological approach. On the other hand, the channels for distribution of the survey (via two online platforms) limits the representativeness of the sample of the respondents and the relatively small sample of respondents (vis-à-vis the number of workers contacted via the platforms) highlights the chance that there may be some self-selection bias in those who elected to complete the survey (i.e., people who are more confident about their own digital skills might have been more likely to respond).

For the Fundación Chile Digital Talent Survey, it is too early to tell.

ECCTI Hipatia (Costa Rica)

Hipatia is an interactive data portal for ECCTI (Estado de las Capacidades en Ciencia, Tecnologia e Innovación) in Costa Rica. The data portal provides a snapshot of the country's science, technology and innovation (STI) capabilities. Information about the presence of some advanced digital skills is stored under technical talent, which includes data about the number of graduates from education programs, for example, in the development and analysis of software and applications and design and administration of networks and databases. The data are available annually (or as a total count) from 2014 to 2017.

Type of data: Interactive portal where it is possible to explore and filter data. The filters can show the number of graduates from (for example) studies in development and analysis of software and applications by: education institution, training center, province, canton (locality in Costa Rica), and year. Graphs are generated (depending on filter choices) showing the number of graduates by education level (professional degree, average technician, technician, specialized technician and skilled worker) and by gender. A graph is also generated that shows the number of graduates in a broad area by specialization. For example, in development and analysis of software and applications, the largest number of graduates are specialized as web page programmers.

Country coverage: One country

LAC country coverage: Costa Rica

Which digital skills are covered?
The data in the Hipatia portal for technical talent covers graduates from many different areas of study: some are clearly affiliated with advanced digital skills and others may require standard (or basic) digital skills as part of the formation, but not advanced digital skills.[29]

Accessibility of the data: The data are easily accessible online, and the user is able to pursue the data using the filters to explore details (location of graduates) of interest. For the purposes of this inventory, only the areas of study that are likely to require mostly advanced digital skills are highlighted here.

- Development and analysis of software and applications
- Design and administration of networks and databases
- Audiovisual techniques and production for media (with specialization in 3D digital animation, for example)
- Electronics and automation

Quality of the data/information: The information in the portal is very useful. Employers seeking potential employees with education and training in these particular areas (and in the specializations associated with those areas) can access a lot of information: where (location) the schools are located, the number of graduates by specialization and from which educational institutions (or training centers) people with particular specializations are graduating. It is also possible to ascertain from the portal the supply of potential workers with training in these areas and specializations. If the information on this site could be matched with job postings or employers who are seeking advanced digital skills in these areas (and perhaps others), it would be extremely valuable. From the introduction on the portal, it seems that part of the goal of the website is to bring the supply of qualified

[29] For example, computer use appears to be mostly training in office applications and computer use, which would not be classified as advanced digital skills.

human resources closer to the technological demand. This may be happening in another way, but at the moment on the website it is not possible to see the employers seeking employees with particular education and training (for example, in 3D digital animation).

Mexico's Ministry of Economy (Mexico)

Crafting the Future: The Ministry of Economy of Mexico produced a roadmap for Industry 4.0 in 2016 (Crafting the Future, 2016). The report provides an overview of the state of affairs in Mexico with respect to Industry 4.0 technologies. The report documents companies and universities operating in each area.

Type of data: Report based on the consolidation of many sources of data

Country coverage: One country

LAC country coverage: Mexico

Which digital skills are covered?
The report identifies the following education areas with affinity toward Industry 4.0: computer sciences, mechanical engineering, electronics and automation, physics, and mathematics and statistics. The report provides statistics on the number of students in the country enrolled across the country in these areas of study in 2014-2015 in bachelors and technical programs. The report also highlights programs that are geared toward advanced manufacturing, sometimes including a headcount of the number of people engaged. It highlights government research centers engaging in work on Industry 4.0 technologies.

Accessibility of the data: The report is freely accessible online.

Quality of the data/information: While this report does not focus exclusively on advanced digital skills, many of the technologies associated with Industry 4.0 are technologies that require advanced digital skills. By seeking to identify the education institutions, corporate and public initiatives generating human capital capable of working with these technologies as well as documenting the status of these technologies in the country and the presence of companies working with a subset of the technologies, the report contains a lot of relevant information. The focus of the report seems to be on digital technologies (education and initiatives) that are affiliated with advanced manufacturing and less focused on information related to software development or more generally computer programming skills in the country.

4.12. Alternative Sources

There are several sources which could give an indication of the presence of advanced digital skills. These sources can indicate the presence (or absence) of advanced digital skills, but in general they are aimed at tracking other information. Therefore, the presence of digital skills must be gleaned as a byproduct of their original intent or purpose. Bearing in mind this caveat, these sources can potentially be used to identify some particular advanced digital skills.

Gaming industry (interactive map): The World Economic Forum (2018a) developed an action plan to solve the construction industry's digital talent gap, which recommends recruiting people from the gaming industry whose digital skills can be transferred to building information modeling (BIM) and virtual and augmented reality. The action plan cites two big companies in the infrastructure and urban development industry that have successfully recruited from the gaming industry (WEF, 2018a). While the International Game Developers Association (IGDA)[30] indicates that, unfortunately, no one source has a comprehensive listing of game companies worldwide, their website suggests Gamedevmap as a starting point. The interactive map displays a live map of game development organizations. The criteria to appear on the map are studios with at least five or more staff, studios with previously published games, and studios under a publisher's contract. Individual talent, consultants, mod groups, middleware companies, service providers, and schools are not currently being tracked by Gamedevmap and do not appear on the map. Click on the map to go the website. Clicking on a red square leads to a display of the game organizations in that location. While this map does not contain an exhaustive list, the presence of game development organizations in a particular location (according to WEF, 2018a) indicates a potential pool of digital talent that could be tapped by other industries.

Map 4.2. **Interactive Gamedevmap: Potential Sources of Transferrable Digital Skills**

Source: https://www.gamedevmap.com/

[30] See: https://www.igda.org/page/faqs#general-industry for more information.

GitHub: GitHub is an online community where software developers can post code for review and ask questions about their code. It supports more than 36 million people and 2.1 million organizations. It is a user-driven platform that is free (for the basics), or costs US$7 per month (for pro tools for advanced developers). Github produces Octoverse (Github, 2018), a short summary of the people, projects, and other information (for example, about the number of bug bounty hackers who have helped to resolve bugs and the average number of days it took to resolve the issue). While detailed location information is not available, Octoverse tracks the countries with the most code contributions each year (from 2014 to 2018). In 2018, Brazil became number 7 (from number 10 in 2014) and is home to the majority of contributors in South America. According to Octoverse, in El Salvador the number of repositories on Github doubled from 2017 to 2018, which makes it one of the countries with the fastest growing number of repositories. While not designed to facilitate the analysis of the presence (or absence) of advanced digital skills in software development, Github is a go-to resource for programmers around the world, and it can give an indication of where software developer activity is concentrated and growing.

Revelo: Revelo is an online recruiting platform in Brazil that caters to digital talent (developers, online marketers, business intelligence (BI) and data, and design) (Revelo, n.d.). The platform uses machine learning techniques to match professionals with firms that want to hire them. The aim is to test professionals (for example, software developers) in the areas in which they claim expertise to screen them more effectively for human resource professionals who may not have a deep understanding of the skills developers need to have to do their jobs well. According to an article in Exame in early 2018, Revelo has 140,000 registered applicants and, in the first quarter of 2017, Revelo observed that the demand (from the companies registered on their website) for developers and software developers more than doubled, and the demand for search engine optimization analysts, growth hackers, and web analytics increased six times (Costa, 2018). While Revelo is a start-up company in Brazil and does not use its platform to collect or report data on advanced digital skills per se, it could be a useful resource for ascertaining both the demand and supply of digital talent professionals in Brazil.

Robotics data: The International Federation of Robotics (IFR)[31] tracks data on the sales of robots by industry and by country. IFR also tracks the stock of operational industrial robots and the density (units per 10,00 employees). The IFR sells data on industrial and service robots for 2,000 euro. It is not clear from the material freely available online how much information could be gleaned specifically with regard to digital skills, but the IFR 2018 executive summary offers the following statements (among others) about the prospects for robot installations:

The digitalization of production (Industry 4.0), linking the real-life factory with virtual reality, will continue to play an increasingly important role in global manufacturing… the range of industrial

[31] See https://ifr.org/worldrobotics/ for more information.

robots continues to expand…Cloud Robotics – storing data from multiple robots performing the same processes in the cloud provides a storage of data on which to apply machine learning to optimize robots' performance. (IFR Executive Summary, 2018: p. 20).

While the IFR data might not indicate the presence or absence of the digital skills necessary to work with industrial or service robots, the increase (or lack thereof) of sales, stock, and shipments could provide an indication of trends and types of advanced digital skills that will be needed to complement robotics that might be at least as revealing as the perceptions of executives of large companies.

CIPPEC AI Series: Microsoft Latin America commissioned a series of studies from CIPPEC to analyze the impact of AI on economic growth in Latin America. These studies have been conducted for Argentina, Chile, Colombia, Costa Rica, Mexico, and Peru. Each study in the series is unique to the country, but they tend to follow a common format. They begin with an assessment of overall economic trends over time (GDP per capita, total factor productivity indexed to 1980) and growth after the 1st, 2nd and 3rd industrial revolutions. These overall trends are followed by some assessment of the digital adoption of businesses in the country and four different scenarios of how automation will affect the combination of capital and labor (positive, neutral, negative, and today). This is followed by an analysis that calculates projections of the effect of different amounts of technological uptake on the country's GDP (aggregate effect). Each study makes use of country specific data to ascertain the occupations (or amount of employment) susceptible to automation and the structure of the labor market according to the probability of automation (following the methodology used by Frey and Osborne, 2017). Frey and Osborne begin with "hand labeled 70 occupations, assigning them a 1 if automatable and a 0 if not" (Frey and Osborne, 2017: 263). They then use this and other information contained about each occupation in O*NET to make an algorithm to determine the probability of computerization for 702 occupations. They categorize this probability into low, medium, and high and ascertain estimates, using data from the Bureau of Labor and Statistics, for how much of the workforce might be susceptible to automation (computerization). The CIPPEC series is useful to anticipate some of the changes that might occur in the labor market due to automation, but projections tend to concentrate on how much employment could be eliminated by computerization without accounting for any employment creation that might occur because of new digital technologies. The AI skills present (or absent) in the country are not a focus of the CIPPEC series, but the series provides a useful assessment of the percentage of the labor market that might be susceptible to computerization (with low to high probabilities, as assessed in the Frey and Osborne analysis).

World Economic Forum: The World Economic Forum' report on the Future of Jobs (WEF, 2018b) surveys 313 executives in 20 economies. Three economies are in LAC: Argentina, Brazil, and Mexico. Based on these surveys, the individual country profiles describe new technology (many are digital technologies) adoption (share of companies surveyed that responded the company is likely or very likely to adopt the technology by

2022), emerging job roles, average reskilling needs by share of company's employees (2018 to 2022), emerging skills, and company responses to shifting skills needs. For Argentina, Brazil, and Mexico the country profile pages might be useful to gain some insights into the perceptions of around 15 executives in their countries regarding technology adoption, reskilling needs, and emerging skills and how these companies are responding.

5. Critical Discussion

There are advantages and shortcomings for each of the sources of data described in the inventory section. This review is a first approximation of the sources of data on digital skills (or talent) in LAC and focuses specifically on advanced digital skills. Each source was reviewed for its merits and limitations, with the goal of speculating as to whether, taken together, the sources can tell a complete story of the presence (or absence) of advanced digital skills in LAC economies.

To summarize: most of the sources available fall into the following broad categories.

1. **Large-scale platform data:** These data have some promising features, especially with regard to the level of detail and the speed with which they can be updated. Currently, there are some rather severe limitations that partially offset the advantage of harvesting these data. Namely, platforms like LinkedIn only cover (depending on the age group) about 1 to 10 percent of the workforce in the LAC region. Secondly, the self-reported nature of the data currently relies on users' tenacity to update their profiles, and there is currently no mechanism for assessing mastery of skills. Nevertheless, there are numerous efforts to use this data, because of the advantages they offer. Methodological approaches are varied, but what can already be done is quite impressive and has large potential policy utility. With so many bright minds working with the data, kinks and methodological issues are likely to be worked out (with time and use), but coverage issues are more of a concern.

2. **Household survey data:** Initiatives such as the one undertaken by the ITU to collect representative household data regarding the distribution of skills have almost the opposite advantages and disadvantages as the large-scale platform data. The main advantage of the ITU data is that they can be considered representative of the entire population for each economy that submits data. The primary disadvantage (at least with the sources identified in this review) is that the data collected at the advanced end of the digital spectrum are relatively broad with just one advance skill measured: writing a computer program. Like large-scale platform data, household survey data are self-reported and are therefore subject to social desirability bias and cannot tell us about the respondents' mastery of the skills in question. The digital skills data collected by the ITU are similar to the data collected via Eurostat. The ontological frameworks in the EU (DigComp 1, DigComp 2, and DigComp 2.1) underlying the Eurostat data collection are evolving to include more precision at the advanced end of the digital skills spectrum, introducing the notion

of specialized skills (beyond advanced on the spectrum). The operationalization of the frameworks and the measurement in the survey instruments can also be expected to evolve. Currently, the distribution of digital skills data along the digital spectrum (basic to advanced) can be very useful for policy issues related to equality. Since platform technologies rely on users/consumers' basic skills to engage, the data at the basic end of the spectrum may be useful for considering potential uptake and reach of digital platforms, but sources of data on basic digital skills and use (i.e., online shopping, social media) fall outside the scope of this review.

3. **Large-scale assessment data:** (PIAAC). Advantage: This is internationally comparable measure of the mastery of the digital skills and designed to be representative samples of the country's population. Disadvantage: Like other household/individual surveys, there is more information collected toward the basic end of the digital skills spectrum and far less information at the advanced end. Large-scale assessment surveys are relatively costly and time consuming, and while it is always advantageous to have internationally comparable results, the relatively slow speed with which they are implemented (Fernanda Prada and Rucci, 2016) might be a big challenge for measuring relevant advanced digital skills in a timely fashion. While they offer the unique advantage of measuring skill proficiency, they can take years before updating the information. For example, the first round of PIAAC data was collected in 2011/2012, which means that these data are now seven or eight years old. The speed of change in digital technologies makes them already outdated. Only one country from the first is scheduled to participate in the third wave of data collection (2016–2019),[32] which indicates that these data are slow to update.

4. **Executive leadership survey data on digital skills shortages:** Advantage: They give a sense of general tendencies about the digital skills that are missing or needed for a slice of firms. This can yield helpful insights about general trends. Disadvantage: The data are often presented in report format either in aggregate statistics or with analysis and manipulation of the raw data already infused. The survey methodology (i.e., target population, sampling frame, and response rate) are often presented in vague terms or not discussed, making it difficult to ascertain which slice of firms have been covered (especially by country). The firm surveys are also subjective because they are a self-assessment of their digital skills needs. Small and medium-sized firms (SMEs) may have very different needs than large firms in the market. One well-documented phenomenon is that digital uptakes tends to be mitigated by firm size (Goldfarb and Tucker, 2019). This limits the utility of the information.

[32] See http://www.oecd.org/skills/piaac/aboutpiaac.htm for more information.

5. **Country-specific or particular advanced digital skill-specific:** Advantage: These are always more specific and useful for the country. Disadvantage: It is not possible compare the results. For example, while the Fedesoft study is useful for understanding which positions are hard to fill in the Colombian software and IT industry, the study does not reveal whether the skills needed in these positions cut across other industries that are digitalizing. Furthermore, when firms (especially SMEs) report they are in need of advanced digital skills, it may be a reflection of their inability to attract or properly compensate the talent they seek, rather than a shortage of supply of skills.

Taken as a whole, there are gaps in information. In the region, there are not massive unified traditional labor market data. Ospino (2018) clearly documents that while on the one hand it could be useful to have this kind of information, on the other hand, generating a database like O*NET is a monumental undertaking, and these massive databases are also relatively slow to update, especially considering the pace at which digital technologies are reshaping skill needs and even creating new occupations.

Sometimes the people writing the job descriptions do not know which skills are needed to fill new (or, old but digitally enhanced) roles. Traditional labor market data have a hard time keeping up. This makes it challenging to define or redefine the talent profiles and requisite advanced digital skills. This is problematic, because for firms, a thin grasp on the digital skills needed can cause delays in hiring (Citro, 2018). Table 5.1 presents an example of at least six new roles associated with machine learning that have emerged since 2011.

Table 5.1. **Six New Roles in Machine Learning since 2011**

Proliferation of Roles

Machine learning in 2011	Six new roles by 2018
Software engineer	Machine Learning Engineer, + 235%
Data engineer	Deep Learning Software Engineer, + 300%
Program manager / project manager	Mobile Intelligence Engineer, + 200%
	Machine Learning Scientist, + 325%
	Data Scientist, 175%
	Machine Language Researcher, + 200%

Source: Excerpted with slight adaptation from Citro (2018).

Even though there has been a proliferation of roles related to advanced digital technologies (for example the number of roles related to machine learning have more than doubled since 2011, in the context of the U.S. in 2017 almost half of the job postings for large companies (S&P 100) in were for the same 37 roles, because many firms are seeking the same digital skills (Citro, 2018). This means that endeavors to identify the crosscutting

skills needed at the advanced end of the digital skills spectrum are worthwhile and, so far, in LAC while there are resources for information, it is not clear that any of them are providing high-quality information about that slice of digital skills.

A recent field visit to Ecole 42, a coding (computer programming) school with an innovative pedagogy, underscores the possibility that once people learn how to learn how to code in a problem-based educational setting (rather, than a computer-language-specific setting), they can apply their skills in a variety of computer programming language contexts. Furthermore, they can evolve any program specific knowhow alongside new developments in programming technology. Akin to the old argument for a good liberal arts education, this rationale suggests that the important thing is that people have the skill to learn computer programming skills, which can then be applied across a wide range of digital technologies.

The experience and expertise of Ecole 42 suggest that there may be value in developing a taxonomy which is transparent and identifies the core *advanced digital skills* and competencies that are transferable between occupations. Such a taxonomy could be a useful tool for policymakers to evaluate opportunities for strategic public support to entities supplying education and training in these skills. Going a step further, such a taxonomy could be developed into a mechanism of assessment toward validation and certification of crosscutting advanced digital skills.

6. Preliminary Conclusions and Recommendations

The preliminary conclusion is that, given the currently publicly available sources of data in most LAC countries, it is not possible to get a complete picture of advanced digital talent in the region. As in the rest of the world, there are currently no databases that (i) can keep up with the rate of change in digital technologies and (ii) have sufficient coverage to be representative. While there are new or emerging sources that can be used, limited coverage constrains the possibility of having a complete story. Traditional sources of data, even the best ones, are not sufficient to get a clear picture of the advanced digital skills base in any economy. In short, the taxonomies and skills classifications outlined in Ospino 2018 cannot (in their current form) be updated quickly enough for the labor market to be precise about the very advanced end of the digital skills spectrum. But that does not mean that they will not be soon.

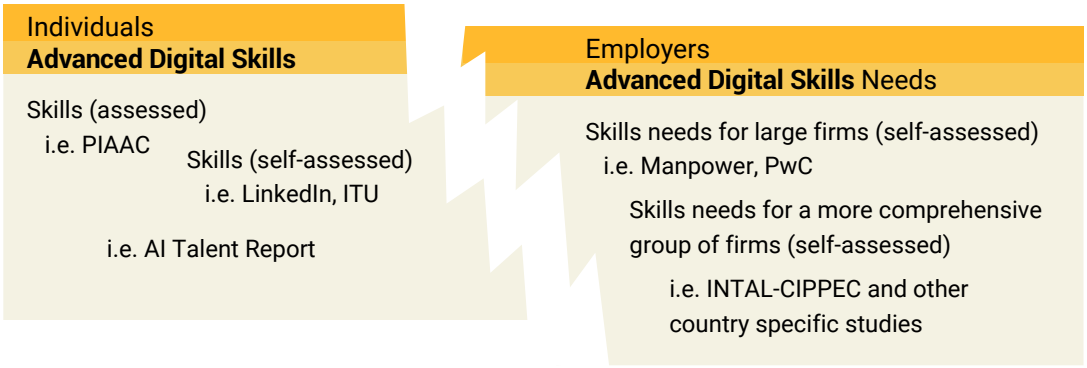
Bright minds and reputable institutions are working on iterative improvements and ways to collect more meaningful data. Resources are proliferating in such a way that a great deal of information is being generated about different pieces of the puzzle. Many of these resources post the results of their data collection efforts online. While the sources might not allow access to the raw data, some analyzed results are freely accessible in report format. To get a sense, in broad strokes, of the current state of affairs with respect to some advanced digital skills (in a particular industry, or in large firms), it is possible to consult these sources and piece together some parts of the puzzle.

The recommendations here focus on a tradeoff well known in computer science: explore versus exploit. New and more data are needed, but data collection is an expensive and time-consuming process. Considering that numerous initiatives (albeit imperfect ones) are under way, perhaps the most efficient strategy in some cases is to focus on interventions that can improve what already exists: exploit. In the context of data about the presence (or absence) of digital skills, the exploit strategy usually involves the formation of alliances to harvest information from different pieces of the puzzle and try to make them more readily digestible for policymakers. Therefore, for the purposes of this report, the exploit strategy should really be termed the alliance strategy. Since many data collection efforts fail to cover the LAC countries that are most in need of more information, as can be observed in Table 3.1, it may be important to focus on interventions that go where others are not going: explore. The proposed recommendations offer ideas for both options—explore and alliance—in the short, medium, and long term.

6.1. Short-run Strategy

Explore: The first recommendation is to hold focus groups, or high-level roundtables, and use Delphi methods described as a useful method for anticipating skills demand by Gonzalez-Velosa and Rucci (2016). The IDB is uniquely positioned to convene such meetings and bring together groups of people from a wide variety of sectors with in-depth knowledge of the LAC region. One primary inquiry of interest would be, which types of data would be most useful should an effort be undertaken to collect new data? For example, would it be more useful for policymakers and employers to have information about crosscutting advanced digital skills? Or, is data specific to particular skill or sector, within a country, more useful? Also, how important is it to employers to have a mechanism for assessing mastery of skills? Is this something they can easily do through their own processes for screening applicants? Is it better to focus on collecting information and data about the presence (or absence) of advanced digital skills, or to direct the funds to the generation of generic advanced digital skills, such as computer programming? The answers might depend on the country.

Figure 6.1. **Sketch of (Missing) Information: Skills Shortage, Gap, or Mismatch?**



Source: Authors' elaboration based on the review of resources.

The figure above is a rough sketch of the kind of essential information that is available. A key missing piece of information is exactly how big the schism is between employers needs and the supply of advanced digital skills in the labor market. As part of the round table focus groups, or pilot case studies, within interested countries, a systematic approach to gather representatives from firms with the following profiles should be included.

- Firms from at least four different sectors (manufacturing, services, construction, and infrastructure),
- Firms of each size (micro, small, medium, and large) within each sector
- In two combinations: digital adopters and non-adopters

This group of firm representatives could be asked a structured set of questions following the who, what, when, where and why approach, recently used by a UNIDO industrial development report.[33] In this case, potential starting points could be:

• Who (from the perspective of the firms) needs advanced digital skills: potential or incumbent employees?
• What digital skills do they need?
• When are there hiring delays or obstacles to attracting the digital talent the firms need?
• Where do firms currently look for people with the digital skills they need (which websites, professional recruiting agencies, etc.)?
• Why do they think they would be more successful (i.e., productive) as a firm, if they had the advanced digital skills they need?

Alliance: Use existing sources of data, such as LinkedIn, and forge partnerships that would make such data exploitable.

[33] See https://www.unido.org/sites/default/files/files/2019-11/IDR_2020_Booklet.pdf for more information.

6.2. Medium-run Strategy

Explore: Based on the information gathered via focus groups and high-level round table discussions, consider launching a survey. Important considerations: Employer-based surveys should clearly outline their methodology and profiles of the firms surveyed, and they will be ahead of a lot of the large-employer-based skills shortage surveys (i.e., ManpowerGroup and PwC) that have been reviewed in this inventory. Secondly, ensure that questions ask about the most relevant skills individually (not grouped). Using the Industry 2027 (IEL, 2018) as a starting point for the most relevant technologies (consider adapting for economies less digitally developed than Brazil's economy), develop a questionnaire similar to INTAL-CIPPEC, which includes a block of questions about digital skills. Another option could be to consider the Halpern and Castro (2018) survey, which asks workers about their digital skills as a starting point. Based on the country's needs and industrial structure, consider expanding the number of industries surveyed and expanding beyond the manufacturing sector.

Alliance: Create a dashboard of existing resources and add new ones as they come along. This could be a landing spot, or news feed, with links to different sources as they release updates or new material about the existence (or absence) of advanced digital skills in the region. Interest in the existence (or absence) of advanced digital skills is not going away any time soon. Many of the sources reviewed in the inventory are only going to improve from here. There are already quite a few resources for some countries in the region, and perhaps these countries can monitor the sources via a digital dashboard and get the information they need. Since many of the resources covered (i.e., Coursera, IDC, or ManpowerGroup) might be proprietary, each source would need to be approached to ask for consent and whether it would be possible to add links to their latest publications. The criteria for inclusion could be that the source has at least some LAC country coverage and at least one advanced digital skill covered to appear in a LAC Advanced Digital Skills News Feed.

Sources may be linked (or not) depending on their preferences and can also choose to provide a short statement about the value-added of the latest publication. The dashboard could be constructed in such a way that it houses results from large-scale platform data in one tab, individual or household surveys in another tab, and employer-based skill shortage surveys in another tab. For the original producers of the reports, it could be a good visibility opportunity that helps their publication gain more publicity. For policymakers, it could provide a landing pad specific to advanced digital skills but assessed from a variety of methodological approaches. It could be a single place to go to find the latest statistics from different resources on advanced digital skills in LAC. One concern is that some LAC countries are barely covered by these existing resources; these countries would have to consider another strategy.

6.3. Long-run Strategy

Explore: Consider launching a competition among computer programmers in the LAC region to design a digital infrastructure that could capture the most relevant advanced digital skills. Many coders are members of Github. For software developers and coders, Github collects and offers descriptive information about its members (i.e., top contributing countries). Github coders may be interested in building a structure where their coding skills could be displayed. Insider knowledge would be advantageous in establishing gradations of advanced digital skills.

What do advanced computer programmers have in their skills toolkits that less advanced programmers do not have? If a digital platform were created that could collect information about a range of advanced digital skills and only advanced digital skills, it could help narrow the focus. Programmers could be challenged to design a platform that people would want to self-populate with some mechanism for screening or evaluating their actual skills (a game with levels and top scorers showing their points?). Revelo, for example, collects information about professionals with digital talent who want to join their platform to be seen and recruited by employers in Brazil. The same website collects information about companies who want to recruit people with digital talent, but might not have insider knowledge about what skills a software developer really needs. Building a digital infrastructure to efficiently collect the best information about advanced digital skills in the LAC region is an open challenge to all coders in the region.

Exploit: As is known in computer science, if one is planning on the long run, it is better to explore than to exploit. Ultimately, the dominant strategy identified in the short and medium run is a strategy of alliance. Sources of information are already springing up naturally to assess the extent to which digital skills are present (or absent) in several LAC countries. The major exception, at least in the short and medium run, is when these independent sources, for whatever reason, do not have the incentive to cover small countries in the region. Small countries in the Caribbean and Central America are facing a deficit of pertinent information about advanced digital skills. In those countries, from a public policy perspective, it may be important to employ the explore strategy. Analogous in a way to covering the last mile, the pieces of the information puzzle that are missing in under-covered countries may continue to be black holes, unless public sector initiatives facilitate data collection efforts. From an equity perspective, it could be important to know demographically who has (or does not have) the digital skills assessed by the different sources. Gender, for example, could be an important consideration. Some sources, mainly household survey data such as the OECD's PIAAC data and ITU'a ICT skills data, have information in their background questionnaire about gender, age, and a variety of other demographic characteristics. This information could be used to ascertain whether there are particular groups of people who have greater or lesser advanced digital skills. From a policy perspective of exclusion and inclusion, it may be worthwhile to fortify existing data collection information

with specific questions related to which people (within countries) have or do not have advanced digital skills. In particular, the sources that are based on employer (skill shortage) surveys did not tend to indicate subgroups of people that may be underrepresented in the advanced digital skills arena. Initiatives to fortify existing sources to collect this additional and relevant information could also be considered as part of the alliance strategy.

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Appendix A: Eurostat Digital Skills Indicator (for comparison)

The following information has been **excerpted** from the Eurostat Digital Skills Indicator metadata, available at: https://ec.europa.eu/eurostat/cache/metadata/en/tepsr_sp410_esmsip2.htm.

Items that appear in almost the same terms in the ICT digital skills indicator are highlighted in yellow.

> Digital skills indicators are composite indicators which are based on selected activities related to internet or software use performed by individuals aged 16–74 in four specific areas (information, communication, problem solving, software skills). It is assumed that individuals having performed certain activities have the corresponding skills. Therefore, the indicators can be considered as proxy of the digital competences and skills of individuals.
>
> According to the variety or complexity of activities performed, two levels of skills ("basic" and "above basic") are computed for each of the four dimensions. Finally, based on the component indicators, an overall digital skills indicator is calculated as a proxy of the digital competences and skills of individuals ("no skills", "low", "basic" or "above basic").

1. Information skills

Definition in Digital Competence Framework: *identify, locate, retrieve, store, organise and analyse digital information, judging its relevance and purpose.*

Activities used for calculating the information skills:

- Copied or moved files or folders;
- Saved files on Internet storage space;
- Obtained information from public authorities/services' websites;
- Finding information about goods or services;
- Seeking health-related information.

Levels of information skills

- Basic: one activity (I_DSK_I_B);
- Above basic: more than one activity (I_DSK_I_AB).

2. Communication skills

Definition in Digital Competence Framework: *communicate in digital environments, share resources through online tools, link with others and collaborate through digital tools, interact with and participate in communities and networks, cross-cultural awareness.*

Activities used for calculating the communication skills:

- Sending/receiving emails;
- Participating in social networks;
- Telephoning/video calls over the internet;
- Uploading self-created content to any website to be shared.

Levels of communication skills

- Basic: one activity (I_DSK_C_B);
- Above basic: more than one activity (I_DSK_C_AB)

3. Problem solving skills

Definition in Digital Competence Framework: *identify digital needs and resources, make informed decisions as to which are the most appropriate digital tools according to the purpose or need, solve conceptual problems through digital means, creatively use technologies, solve technical problems, update one's own and others' competences.*

Activities used for calculating the problem solving skills:

List A – **Problem solving**

- Transferring files between computers or other devices;
- Installing software and applications (apps);
- Changing settings of any software, including operational system or security programs.

List B – **Familiarity with online services**

- Online purchases (in the last 12 months);
- Selling online;
- Used online learning resources;
- Internet banking.

Levels of problem solving skills

- Basic: one or more activities only from A or only from B (I_DSK_PS_B);
- Above basic: at least one activity from A and B (I_DSK_PS_AB).

4. Software skills (for content manipulation)

Definition in Digital Competence Framework: *Create and edit new content (from word processing to images and video); integrate and re-elaborate previous knowledge and content; produce creative expressions, media outputs and programming; deal with and apply intellectual property rights and licences.*

Activities used for calculating the software skills (for content manipulation):

List A

- Used word processing software;
- Used spreadsheet software;
- Used software to edit photos, video or audio files.

List B

- Created presentation or document integrating text, pictures, tables or charts;
- Used advanced functions of spreadsheet to organise and analyse data (sorting, filtering, using formulas, creating charts);
- Have written a code in a programming language.

Levels of software skills

- Basic: one or more activities form list A and none from list B (I_DSK_S_B);
- Above basic: at least one activity from list B (I_DSK_S_AB).

Overall digital skill indicator

Individuals with **"above basic"** (I_DSK_AB) level of skills:

- "above basic" in all 4 domains.

Individuals with a "basic" (I_DSK_B) level of skills:

- at least one "basic" but no "no skills" in all 4 domains.

Individuals with **"low"** (I_DSK_L) level of skills (missing some type of basic skills):

- from one to three "no skills" in the four domains.

Individuals with **"no skills"** (I_DSK_X):

- Four "no skills" (no activities performed in all four domains, despite declaring having used the internet at least once during last 3 months).

Individuals for whom the **digital skills could not be assessed** (I_DSK_NA):

- Individuals that have not used the internet in the last 3 months).

(For formula and references to original variables collected by the survey on ICT usage by households and individuals, please see Eurostat methodological manual).

Unit of measure: % of the total number of individuals aged 16 to 74.

Reference Period: Calendar year.

Source: The following information has been excerpted from the Eurostat Digital Skills Indicator metadata, available at: https://ec.europa.eu/eurostat/cache/metadata/en/tepsr_sp410_esmsip2.htm

Appendix B: Glossary of Terms

As noted in the ITU Digital Skills Toolkit Glossary (ITU, 2018b), many of these terms may not be internationally agreed. Following the approach taken in the toolkit, many of these definitions have been excerpted from and can be found online at the Cambridge English Dictionary. Other definitions have been gleaned from other sources and references are provided. Terms are constantly evolving, so checking for the most current definition online is advised.

Artificial intelligence: the study of how to produce machines that have some of the qualities of the human mind, such as the ability to understand language, recognize pictures, solve problems, and learn.[34]

Big Data: very large sets of data that are produced by people using the internet and that can only be stored, understood, and used with the help of special tools and methods.[35]

Cloud computing: the use of services, computer programs, etc. that are on the internet rather than ones that can be purchased and uploaded onto a computer.[36]

Computer-aided design (CAD): the use of computers to design objects.[37]

Computer programming: the activity or job of writing programs for computers.[38]

Distributed and additive manufacturing: While there is no standard definition for distributed manufacturing (DM), Srai et al. (2016) describe the evolution of the term in different contexts. Paraphrasing from the definitions they provide, distributed manufacturing has its roots computing where distributed nodes rather than centralizing hubs became the foundation of robust decentralized networks. 3D printing, for example, is characterized as an additive process in distributed manufacturing and facilitates the personal manufacturing dimension to DM, which is cited as one of its most disruptive characteristics (Srai et al., 2016).

Internet of Things (IoT): objects with computing devices in them that are able to connect to each other and exchange data using the internet… the internet of things might, for example, involve smart bins that can signal when they need to be emptied.[39]

[34] https://dictionary.cambridge.org/dictionary/english/artificial-intelligence.
[35] https://dictionary.cambridge.org/dictionary/english/big-data.
[36] https://dictionary.cambridge.org/dictionary/english/cloud-computing.
[37] https://dictionary.cambridge.org/dictionary/english/computer-aided-design.
[38] https://dictionary.cambridge.org/dictionary/english/computer-programming.
[39] https://dictionary.cambridge.org/dictionary/english/internet-of-things.

Robotic process automation (RPA): software that is programmed to do basic tasks across applications just as people do. The robot can be taught to execute a multiple step workflow.[40]

Software: the instructions that control what a computer does; computer programs.[41]

Virtual reality: a set of images and sounds, produced by a computer, that seem to represent a place or a situation that a person can take part in.[42]

[40] https://www.investopedia.com/terms/r/robotic-process-automation-rpa.asp.
[41] https://dictionary.cambridge.org/dictionary/english/software.
[42] https://dictionary.cambridge.org/dictionary/english/virtual-reality.


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