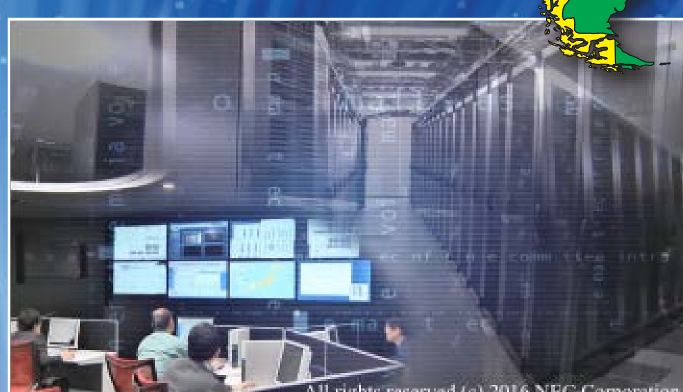
Data Centers and Broadband
for Sustainable Economic and Social Development
Evidence from Latin America and the Caribbean



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IDB

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Acronyms

LAC	Latin America and the Caribbean
SEA	Southeast Asia
IDB	Inter-American Development Bank
ICT	Information and communication technologies
SDGs	Sustainable Development Goals
NFV	Network function virtualization
DSL	Digital subscriber line
CIP	Critical infrastructure protection
WAN	Wide area network
SDN	Software-defined network
ISP	Internet service provider
IXP	Internet exchange point
FDI	Foreign direct investment
DCDI	Data Center Development Index
NDRI	Natural Disaster Risk Index
GRI	Geographic Redundancy Index
OpEx	Operational expenditure
SDDC	Software-defined data centers
USF	Universal service fund

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From 2G Connectivity to Broadband and Data Centers

Introduction

Information and communications technology (ICT) plays an important role in promoting and enabling social, economic, and environmental well-being worldwide. ICT not only contributes directly to GDP through the production of goods but also spurs innovation in the ways that goods and services are produced and delivered, leading to increased employment (WEF, 2013) and labor productivity (Javala and Pohjola, 2002; Pepper and Garrity, 2015).

Data centers, where information is stored and processed, are essential for the development of the ICT ecosystem. The speed of networks, security of the critical infrastructure and information, and the quality of public services, data, and systems all depend on the availability and quality of data centers. Due to their vital role, the design and development of these centers is a priority for both private stakeholders and governments in Latin American and Caribbean (LAC) countries.

Many organizations, including government agencies, operate their own IT and networking equipment and manage their own data and software independently. This can lead to significant challenges in coordinating and standardizing operations, maintenance, and technical protocols across different entities. The decentralization of ICT management can make it difficult to ensure that the facilities follow international best practices and that staff operating technical infrastructure are fully trained and coordinated. Furthermore, decentralized systems do not facilitate harmonization of policies and protocols, nor do they leverage the efficiency benefits of economies of scale and pooling of resources. Hence, data centers, which allow greater centralization, can help improve performance, security, and efficiency by providing better coordination.

In addition to better performance, stronger security, and higher efficiency, data centers can provide a broad new set of applications for governments. They facilitate information sharing across different branches of government and enable the public sector to develop innovative uses of data to better serve citizens.

Data centers allow LAC governments to improve their relationship with citizens and companies and find new solutions to old problems through big data analytics. This document discusses experiences in the region around key questions such as: Where should data centers be located? What are the public policy and regulatory implications? Who should pay for the infrastructure that supports them? What is the role of traditional telecommunications firms? How many data centers should a country have? How can policymakers promote the development of big data and Internet of Things (IoT)-based services and applications?

It provides a detailed assessment of data centers and related infrastructure across 26 IDB borrowing member countries, drawing comparisons with other countries around the world.

Benefits of ICT

ICT provides access to a whole new range of digitally enabled products and services that strengthen local economies, local innovation, and local communities (ITU, undated). In India, low-cost mobile phones have allowed fishermen to expand their markets and increase their profits by reducing information asymmetries about buyers and prices (Jensen, 2007).

ICT empowers people around the world by providing them with the information needed to make better decisions. ICT enables access to health information, educational resources, mobile banking, e-government, employment listings, and social networks. ICT is also crucial for achieving the Sustainable Development Goals (SDGs) (ITU, undated) listed in United Nations Resolution A/RES/70/1 of September 25, 2015. The SDGs set out three pillars of sustainable development: (i) economic development, (ii) social inclusion, and (iii) environmental protection. ICT enhances the capacity to measure progress toward achieving these pillars and provides opportunities to streamline and enhance the efficiency and effectiveness of activities working toward the SDGs.

ICT also plays an important role in enabling e-commerce and increasing the efficiency of the financial sector. Services such as mobile banking and electronic money transfers allow people to manage their financial assets faster and more easily than ever before. According to the World Bank (2015a), in LAC countries, almost 60 percent of adults send or receive domestic remittances digitally, with 32 percent using an account and 26 percent relying on over-the-counter transactions .

Beyond its economic benefits, ICT has also yielded considerable social benefits. ICT has been used to alert people to impending natural disasters and, in the aftermath of those disasters, has enabled them to contact emergency workers, find missing friends and relatives, and obtain food and water. Survivors and rescue workers have relied on ICT for disaster relief in the wake of major incidents all over the world, including earthquakes in Chile, Haiti, Japan, and New Zealand, the 2010 oil spill in the Gulf of Mexico, and the 2009 Australian "black Saturday" bushfire (OECD, ISOC, and UNESCO, 2011). Many people report feeling more secure in their ability to respond to emergencies when they have access to critical information that ICTs can provide (De Silva and Zainudeen, 2007).

Due to the vital social and economic benefits provided by ICT, the degree of development of ICT infrastructure is often used as a criterion for evaluating a country's global competitiveness. The development of more sophisticated infrastructure and networks has led to the emergence of a range of new ICT services. While early communication networks, such as 2G mobile networks, were originally designed to deliver voice and text (SMS) connectivity, 3G, 4G, and even 5G networks have brought with them improved performance that allows even greater innovation.

The evolution from 2G networks to 3G-4G-5G, from copper networks to DSL, and from fiber analogue cable to digital fiber, has brought with it a greater capacity to exchange various types of information in a variety of different formats. At the same time, network infrastructure is designed for the virtualization of many layers, a process known as Network Function Virtualization (NFV).[1] The development of data centers and cloud computing capabilities is crucial for NFV.

Broadband and IT infrastructure enable the interconnection of independent data silos such as hospital networks (in healthcare), and banking systems (in the financial sector). They also allow data sharing between different sectors. Thus, in the aftermath of a natural disaster, emergency

[1] For more information, see Chiosi et al. (2012), available at:0 https://portal.etsi.org/NFV/NFV_White_Paper.pdf.

response workers can merge healthcare, disaster monitoring, and geolocation data to help support and rescue survivors.[2]

The big datasets that result from these types of integration require reliable storage, security, low latency, and software analytics tools. The introduction of e-payment, m-banking, e-learning, e-health, e-government, e-commerce, and other online services requires secure, trusted servers for data transfer and storage.[3] It is also critical to protect the places where secure severs are hosted and to have countermeasures in place to recover the information stored on them. Following the Great East Japan Earthquake, the servers and backup drives stored in the municipal building of Rikuzen Takata city were damaged, and the citizen data stored on those servers and backup drives were lost. This created tremendous difficulties for the city, which needed to create and verify the lists of survivors. To fulfil their mission, municipal staff had to restore the data from paper-based and CD-based sources stored in the Resident Registry. Later, it was also possible to retrieve data from the central government data center in Tokyo after Internet connectivity was restored.[4] This shows how a single, poorly protected server room containing important information on the civilian population can be a source of additional problems after a disaster. From the standpoint of emergency situations, critical data are any data necessary for the sustainable functioning of society, or data that can help minimize negative effects and enable the fastest possible recovery.

Data produced or processed inside an individual country is called local content.[5] In general, the following types of important local content are sometimes defined and protected by laws:

- Government: taxes, national IDs, pensions, input-output tables, border control information, criminal records, judicial files, justice information, import/export control, healthcare, registration, (cars, qualification, companies) and country statistics.[6,7]
- Finance: banks, stock market accounts, and insurance
- Education: enrolled students, results of the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS) local tests
- Infrastructure: electric company records, network operator records, water, and railway and road traffic
- Natural environment: weather forecast, seismographic data, soil information, and disaster-related information
- Business: POS systems and e-commerce

Processing and managing big data require specially tailored ICT solutions and significant networking, storage, and processing infrastructure, including data centers. A data center is a special facility that includes the following:

[2] See http://www.itu.int/en/ITU-D/Statistics/Documents/events/wtis2015/BigData_Wetter.pdf.

[3] A secure server is a server that supports any of the major security protocols, such as SSL, that encrypt and decrypt messages to protect them against third-party tampering.

[4] Direction local government ICT to overcome the Great East Japan Earthquake, March 2012, Sendai City Information Policy Department. Available at JLIS: http://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/presentation/pdf/Sendai_City_Informaiton_Policy_Department.pdf; http://www.soumu.go.jp/main_content/000156851.pdf.

[5] This idea of relevant content in the speaker's own language is called local content. The subset of information that is relevant to an individual is often closely related to the knowledge within the community where she or he resides. UNESCO defines "local content" as expression and communication of a community's locally generated, owned, and adapted knowledge and experience that is relevant to the community's situation UNESCO (2001), "Public Service Applications of the Internet in Developing Countries, Promotion of Infrastructure and Use of the Internet in Developing Countries.", UNESCO, Paris.

[6] Environmental safety directly impacts local economies, such as inviting foreign companies, value of the real estimate. Border control and passport control are major issues for countries. The development of an immigration automated clearance system, which is both easy to use and fully automated, is required (see Box 4.5).

[7] The mission of the Western Identification Network is to promote and assist in the identification of individuals by providing accurate, timely, and cost-effective identification services by employing modern technology and widely accepted operating procedures.

- Network infrastructure
- Management system
- IT infrastructure: networked servers, remote storage, storage, and distribution of large amount of data
- Secured perimeter
- Disaster resistance system
- Electric power facility
- Cooling system

Data centers store, exchange, and process data either on premises or indirectly via virtualized services. Networked data centers, known as cloud computing, help address disaster relief and resiliency needs for managing critical data sets.

Big Data

Big data provides a unique opportunity to extract hidden value from huge amounts of data. Depending on the original goal, the extracted value can deliver economic (deeper understanding of inflation and unemployment rates, etc.) and social (epidemics forecast and control, natural disaster recovery, etc.) benefits as well as help increase business efficiency.

The IoT is an essential contributor in generating large volumes of data by digitizing the real world using numerous types of sensors. People are always interested in finding information within the shortest possible time. Having billions of online users and millions of online shoppers has made the problem of the Internet search especially important. The diversity of data types, which vary from plain text and numerical data (structured data) to audio, image, video, human language, semantic meaning, and sentiments, among others (unstructured data), exacerbates this problem.

Big data consists of "extensive datasets, primarily in the characteristic of volume, velocity and/or storage, manipulation, and analysis" (NIST, 2014: 22). Such a large volume of data requires specially tailored solutions for data management and storage. These solutions are usually based on a parallel distributed approach when smaller pieces of a big data volume are stored and processed at different nodes of the distributed cluster. The smaller pieces are processed independently, and intermediate results are then aggregated at a single node. This technique is known as Map-Reduce.

Big data analytics can provide deeper insights into business intelligence. This should result in cost reduction, greater business efficiency and effectiveness, more effective and efficient market strategies, and other benefits in the field of business.

Big data also encompasses analytical techniques that help identify and solve social problems. For example, analytic techniques have been applied to forecast influenza (Guzman, 2011) and dengue epidemics (Telenor Group, 2015) and gain deeper insights into unemployment (Askitas and Zimmerman, 2009) and inflation.

Other trends tightly bound to big data are emerging. These include the IoT and smart cities.

Internet of Things

Two important processes, digitization and datafication, are gaining momentum. Digitization implies conversion of analog information into digital machine-readable format. Datafication is the process of putting digital data into a quantified format so that they can be tabulated and analyzed (De Mauro, Greco, and Grimaldi, 2014).

Thanks to the broad availability of devices with connectivity functions and sensors, also known as the IoT, digitization and datafication processes have contributed to the generation of large data sets. According to the International Telecommunication Union (ITU)'s Telecommunication Standardization Sector (ITU-T), "the number of devices (…) that communicate with each other will be at least an order of magnitude larger than the devices connected to the current Internet" (ITU, 2012: 12).

In industry, many manufacturers have already deployed IoT in their production systems to achieve competitive advantage. Sensors gather data from each factory production line, so that operations are maintained in optimal condition. Real-time monitoring of operations and data analysis of plant sensors will predict and prevent malfunctions before they occur.

IoT transforms society. Combining data on individuals with data from the things that surround them enables people to live healthier, safer, and more convenient lives. People can connect anytime, anywhere, and use information seamlessly, whether in high-speed mobility or high conjuncture.

Smart Cities

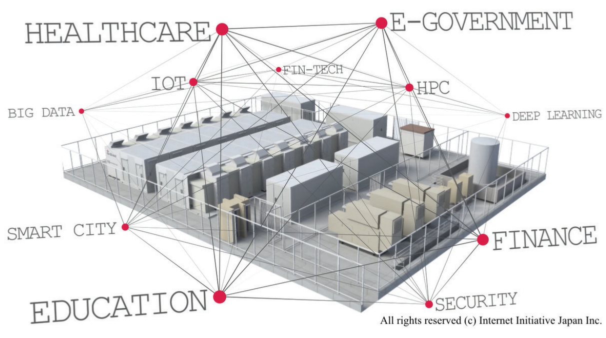
Traditionally, cities are areas of large population concentration. Cities have established dedicated infrastructures to satisfy everyday needs for water, energy, transportation, healthcare, and other services.

Applying sensors to digitize everyday city life and monitor real-time functioning generates a large volume of urban data, from video surveillance systems, energy monitoring systems, water distribution networks, and traffic monitoring systems. These various types of urban data can be analyzed in real time and used as inputs to create safer and smarter cities. As a result, city governments obtain deeper insights into their own day-to-day functions and can help identify and solve problems related to areas ranging from congestion and public safety to transportation and public health.

Data Centers for the Evolution of Sustainable Smart Cities

A city's infrastructure develops rapidly in response to industrial development and rising population

IMAGE 1.1 Data Centers in Smart Cities



Source: Internet Initiative Japan, Inc.

growth. Growth stabilizes the environment, and residents seek a higher standard of living by purchasing higher-quality goods and services, moving to the suburbs, and other actions. Mature cities undergo renewal to maintain services and enable further development (Image 1.1). These cities collaborate with other cities to meet new challenges.

To enable sustainable development of a city and seamless transition from one stage of development to the next, smart city solutions should be adaptive in architecture, scalable in size, and agile in speed of applying changes to instantly reflect the "on-demand" needs in the service of citizens. Adaptability, scalability, and agility are at the heart of cloud and software-defined networks (SDN). All these technologies converge at data centers, which themselves facilitate the agile and sustainable development of healthcare, government services, finance, and security. Data centers therefore play an increasingly central role in enabling the future growth of cities and environments and the future directions of industry, innovation, and social development.

2

What is a Data Center?

Definition of Data Centers

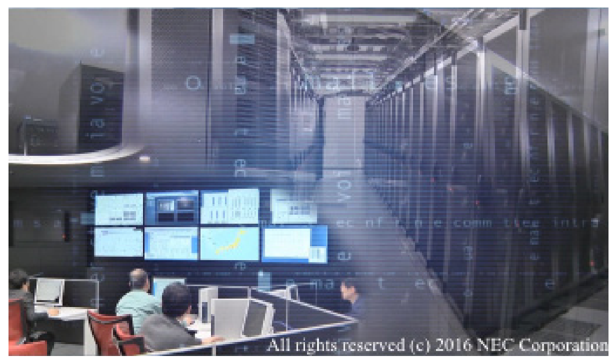
A data center is a facility that centralizes an organization's IT operations and equipment, and the location where it stores, manages, and disseminates its data. A single data center comprises an electric power system, including on-site emergency power generators, uninterruptible power supplies (UPSs), and a power line provided by a power company, as well as a cooling system, network infrastructure, and servers.

A data center typically houses servers, high-performance computers that process data and are stored in easy-to-manage and always available storage devices (Image 2.1). All these systems need to communicate with each other in a rapid and a highly agile manner to enable IT efficiency via networking. Networking connects all the servers and enables communication via the Internet.

Data centers are built to be robust and to withstand natural disasters as well as fire, theft, and intrusion. A number of tools and technologies provide redundancy at different levels of data center functional units.

Data centers can be integrated as part of a shared facility or built as stand-alone units. In general, data centers may be building-based or containerized.

IMAGE 2.1 **Example of a Data Center**



Source: NEC Corporation.

Data Center Services

Traditionally, there are three types of services provided by data centers. These are: housing (or co-location), hosting, and cloud services.

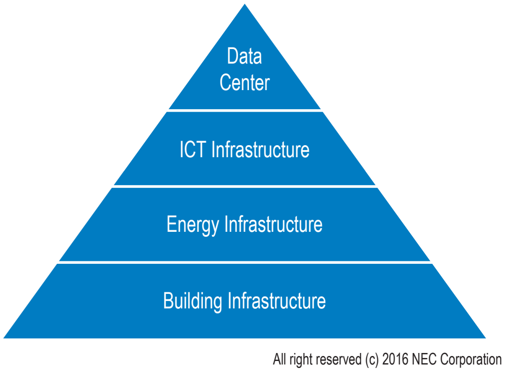
Housing (co-location) services provide customers the ability to locate their servers and maintain them on their own, while the data center owner provides ICT, power, and cooling infrastructure.

In a hosting service, the data center owner also maintains the client's servers.

Cloud services (NIST SP 800-145) provide customers with virtual computer resources via broadband network access. Cloud services can be delivered in three service models: Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS) or Infrastructure-as-a-Service (IaaS).

Cloud services can be delivered in the form of private, community, public, or hybrid deployment models. A private cloud implies a single customer for a given set of servers. A community cloud is provided for a specified group (community) of

FIGURE 2.1 The Data Center Infrastructure Pyramid



Source: NEC Corporation.
Note: The NEC presented the DCIP during the kick-off meeting at the IDB for the Joint Study of Data Centers in LAC.

IMAGE 2.2 Example of a Data Center

Source: Internet Initiative Japan, Inc.

customers. A public cloud is provided to the public. A hybrid cloud is any mixture of the former types.

Infrastructure Pyramid

Data centers provide the facilities necessary to enable reliable, uninterrupted storage, processing, and transmission of data. The Data Center Infrastructure Pyramid (DCIP) shows the different types of infrastructure that data centers bring together (Figure 2.1).

The first level of the DCIP is Building Infrastructure. This level is related to the issue of constructing a building for a data center or facilities for modular data centers.

The second level from the bottom is Energy Infrastructure. These include the energy networks outside the given data center.

The third level from the bottom is ICT Infrastructure. This includes wide area networks (WAN) to connect a data center to the outside world.

Finally, the top level is the data center itself (see Image 2.2). It contains the networks to enable intra data center connectivity, the cooling system, emergency power generators, and on-site batteries.

According to the DCIP, many factors should be taken into account when constructing a data center. These factors are crucial for maximizing the return on investment of the data center and meeting customers' requirements for computation power and quality of service.

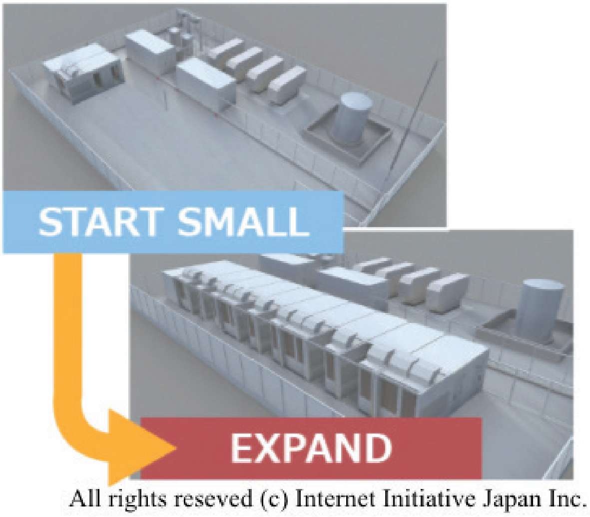
According to Intel (Mena et al., 2014), the following three main factors should be considered when selecting a site for a data center:

- *Environmental conditions*: the region's climate and history of natural disasters
- *Wide area network*: the availability and cost of fiber and communication infrastructure
- *Power*: availability and cost of electric power infrastructure

The power and WAN factors directly correspond to the energy infrastructure and ICT infrastructure, respectively, of the DCIP. This study addresses the power/energy infrastructure factor by analyzing the electricity prices in each country. The WAN/ICT infrastructure factor is considered through analysis of upload speed, network latency, fixed and mobile broadband penetration rates, and international internet bandwidth.

The environmental condition factor in this study is considered from the standpoint of natural disaster risk and geographic redundancy. Therefore, the discussion about environmental conditions refers to the likelihood of a natural disaster in a country and the redundancy needed for a local data center infrastructure to withstand a disaster. Other important geographical factors include humidity, elevation in meters above mean sea level, and temperature.

IMAGE 2.3 **Containerized and Modular Data Center**



Source: Internet Initiative Japan, Inc.

Containerized and Modular Data Centers

Data centers can be located in buildings, or they can be placed in a single standard-size cargo container, along with a power supply and cooling and fire alarm systems. Modular data centers are assembled from pre-manufactured modules. Such modules can be of the same type (containerized data centers) or specially designed for a specific functionality, such as cooling or power generation.

Containerized data centers require only a power supply and broadband connectivity to function. A single truck can transport them and can therefore move and deliver them quickly and easily.

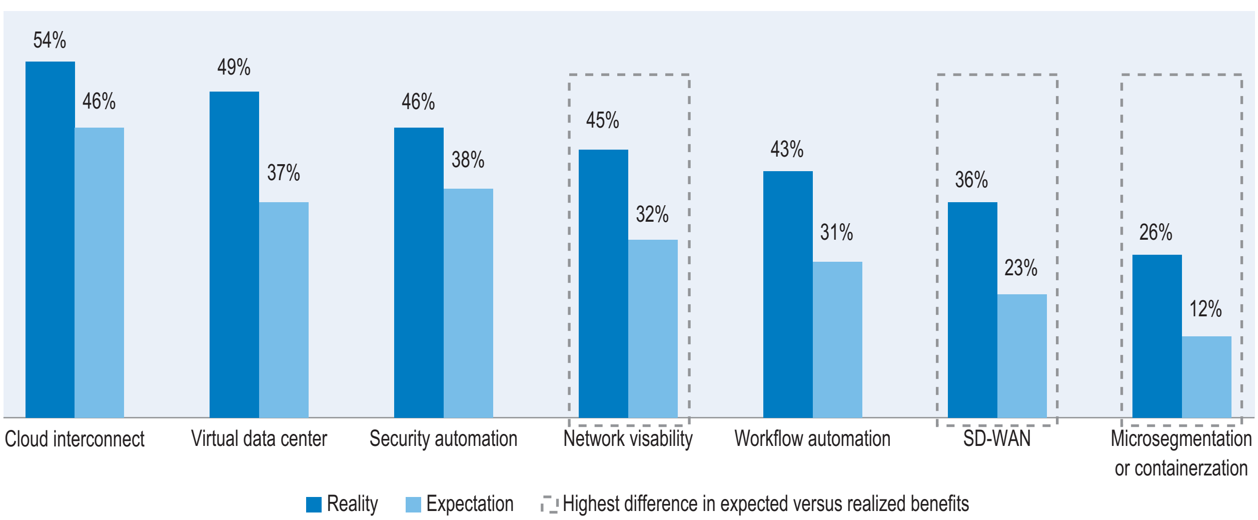
Advantages of the State-of-the-Art Data Center

Deployment of modern state-of-the-art data centers provides users with the following benefits (see Figure 2.2 for more detail):

- Carbon reduction when replacing older ICT infrastructures
- Energy savings when renovating obsolete ICT infrastructures
- Increase in computational capabilities enabled by sharing computational resources
- Network latency and workload reduction. The latest virtualization and centralized management technologies like cloud computing, SDN,[8] and Network Function Virtualization

[8] SDN is an architecture that enables the network to be controlled by software. Traditional networks are often hardware-based, static with fixed data paths and limited flexibility. SDN allows network to be controlled by software to realize a flexible and dynamic network environment. The benefits of SDN include ease of operation and

FIGURE 2.2 **Expected versus Reported Benefits of NFV Adoption**



Source: Adapted from Juniper (2016).

(NFV),[9] reduce use of hardware and reduce deployment time
- Mitigation of problems created by lack of skilled ICT engineers through centralized management of these resources

Telco Data Centers

A special type of data center is a telecom carrier (telco) data center. Along with standard procedures to process information about clients, telco data centers house special hardware equipment for telecommunication networks such as broadband remote access servers.

Increased virtualization is likely to significantly impact the operations and management of data centers, as well. Moving forward, it is likely that telco data centers will be composed more flexibly from a variety of different cloud computing environments that span different implementation models and operators. This will create an even more dynamic infrastructure that enables faster and more efficient resource scaling and infrastructure allocation, as well as real-time adjustments to changes in parameters and constraints. For example, the infrastructure might adapt the network topology and operating parameters to respond to fluctuations in energy costs.

Telco data centers can reduce operating costs by installing up-to-date technologies, such as cooling technologies, IT technologies, and operational software technologies, and reducing the total number of telco data centers. This transformation may require significant investment and take place over an extended period.

Digital Security

As more transactions become digital, many cybercriminals target data centers where personal data, financial information, and important government data are stored. A data loss can severely impact the success and operations of governments and can hamper their reputations. When an organization loses control over confidential data, it also suffers a loss of trust with its stakeholders and clients.

This means that data center cybersecurity provisioning must occur within minutes, not days or weeks. Data breaches invite scrutiny from stakeholders, and sometimes results in direct financial losses or suspension of operations. This problem is growing in scale, with Gartner projecting that by 2020, 60 percent of digital businesses will suffer major service failures due to their inability to manage digital risks.[10]

Data Centers and Local Content

Data centers help reduce backbone traffic and improve user experience by storing content closer to content consumers. Reducing latency can also result in increased Internet usage.

According to the Internet Society, in many developing countries and emerging regions, the majority of content accessed by local users is hosted abroad. To reach users in developing countries, content must traverse international links that are often expensive and underprovisioned. This can have a significant impact on the cost of internet access as well as on the user experience and quality of service.

In Rwanda, for example, most content for commercial websites was located abroad, causing high traffic costs and long latencies. Although content developers were saving about US$111 per year by hosting overseas, Rwandan ISPs were carrying approximately US$13,500 in transit costs to deliver the content from abroad to local users. Moving the content inside the country had a positive impact on

management, TCO reduction, and agility to changing business requirements.

[9] The NFV enables the replacement of specialized network devices like routers, firewalls, switches, and others, with software analogues. The software for each network component can be run on a dedicated VM on a server in a data center. This allows a reduction in the number of physical devices in the network and the use of more network cables to connect standardized commercial servers with each other.

[10] See http://www.gartner.com/newsroom/id/3337617.

internet usage, leading to an increase of 80 percent (Kende and Rose, 2015).

The Internet Society (udated) makes the following recommendations to policymakers for facilitating interconnection and local content (Internet Society, undated):

- Ensure adequate choice and flexibility for service providers in accessing the physical infrastructure needed for interconnections
- Eliminate restrictions and barriers that prevent network operators from entering into robust interconnection relationships. Do not require traffic to take a specific path
- Encourage the development of internet exchange points (IXPs), which help decrease interconnection costs and keep local traffic inside a country
- Engage in regional and subregional discussions to help develop policies for regional interconnections, particularly between neighboring countries, known as cross-border interconnections
- Promote the development of local content by fostering the local content industry and creating the conditions for hosting content providers and/or content delivery networks

Data Center Infrastructure versus Cloud Services Development

Using cloud services provided by foreign data centers may introduce longer latencies but is often cheaper in the short term for countries without data center infrastructure. By comparison, hosting content inside the country at local data centers is initially more expensive and requires more capital investment in local infrastructure and skilled workers, but it can ultimately improve the ICT infrastructure and increase demand for internet services. Policymakers should carefully weigh these two options, and policies should be flexible enough to allow the market to guide users and entrepreneurs toward the best option.

A country that relies fully on foreign cloud services will need to rely on international connectivity. On the other hand, a country relying completely on local infrastructure will require a high level of development of cloud services to justify the investment, due to overcapacity issues that are created in the absence of virtualization.

Thus, market-driven solutions, depending on cost efficiency and international internet flows, are expected to produce different combinations of cloud services and data center infrastructure in different countries.

However, other factors may drive investment to suboptimal combinations between local data center infrastructure and cloud service deployment. These factors include imperfect labor markets (lack of skilled engineers), non-competitive telecommunication markets (bottlenecks to network deployments), vulnerable communication networks (unexpected impacts on international connectivity), imperfect legislation related to data protection and security, critical infrastructure requirements, and environmental risks (natural disasters).

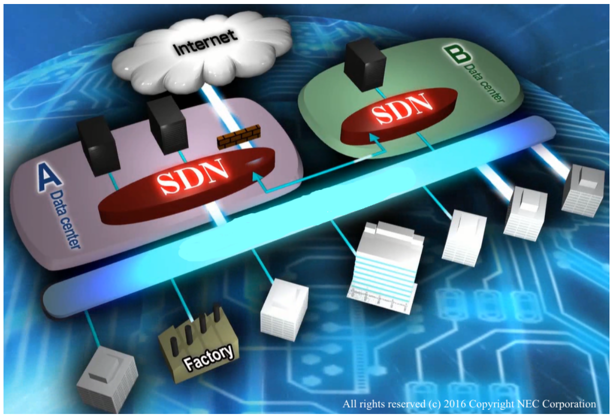
For example, deployment of local data centers may provide a basis for inviting big international companies. The presence of foreign and local companies may benefit both the companies' and the country's development. This kind of initiative would increase foreign direct investment (FDI).

ICT Industrial Parks for Sustainable Economic and Social Development

Data centers are the core of ICT industrial parks, where big international players coexist with local companies, producing an environment of cooperation and best-practice exchange. ICT industrial parks help disseminate cutting-edge technologies among local startups and innovative companies. These parks can help countries launch their domestic ICT industry. Thoughtful planning for such ICT industrial parks should include use of sustainable and renewable energy sources and development of physical plans that allow reuse of heat generated by the data centers.

Frequently, there are difficulties in establishing proper ICT infrastructure, including broadband and

IMAGE 2.4 **Example of a Schema of an ICT Industrial Park Employing SDDCs**



Source: NEC Corporation.

fundamental infrastructure (e.g., electricity, water supply) across the entire country. When this is the case, governments can provide ICT industrial parks with stable infrastructure, (e.g., electricity, water supply, broadband connectivity) to the industries to incubate the local ICT industry.

As shown in Image 2.4, these parks should minimize the risks related to starting new ICT businesses, enable small-start data centers, and meet the need for skilled ICT engineers in developing markets. This requires essential capital investments, which can come from the government, a business, or foreign investors. Capital investments, including FDIs, in stable infrastructure can have a long-lasting effect on GDP growth through amortization payments and the addition of high-value-added jobs for local engineers and skilled workers.

To identify those countries that have better conditions than others for local data center development, it is necessary to quantify and qualify such conditions. This analysis may also help policymakers gain a clearer understanding of the enabling policy measures for data centers and cloud services, as well as improved Internet service and penetration more generally.

3

Analysis of Data Centers and Related Infrastructure in LAC

Data Center Development Index

The Data Center Development Index (DCDI) was designed to analyze the current environment for data centers in LAC countries. This index consists of five main pillars, which are used to compute the overall DCDI value, and one auxiliary pillar. The auxiliary pillar contains indicators to transform original indicators into "per capita" and "per unit of area" form. The lists of pillars and indicators for each pillar are presented in Annex 1.

The five main pillars of the DCDI describe various aspects of a country's development. Pillar 1 measures Economic Development; Pillar 2 measures Fundamental Infrastructure, which includes electricity price, 3G/4G mobile broadband coverage and Telco operating expenditure (OpEx) per revenue; Pillar 3 measures connectivity; Pillar 4 assesses Data Center Infrastructure, including indicators of IXPs; and Pillar 5, called Critical Infrastructure Protection (CIP) and measures natural disaster risk resilience.

Table 3.1 presents values for each pillar and overall DCDI values for 26 IDB borrowing member countries. According to DCDI, the top seven LAC countries for the construction of data centers are Argentina, Bahamas, Brazil, Chile, Costa Rica, Panama, and Uruguay. Unsurprisingly, recent data center investments are occurring in most of these countries.

The value of indicators is computed according to the following rule: the value of "1" means good and "0" means poor among the countries. The 26 countries have been clustered into four groups. These clusters represent low (DCDI values 0.00–0.25), moderate (0.26–0.36), high (0.37–0.42), and very high (>0.42) development levels. These intervals are selected in accordance with the variability of pillar values.

According to this classification, Argentina, The Bahamas, Brazil, Chile, Panama, and Uruguay form Group 1. These countries exhibit very high values for economic development and connectivity.[11] Argentina, Brazil, Chile, and Uruguay have very high levels of fundamental infrastructure, while The Bahamas and Panama show moderate levels of that pillar. The level of data center infrastructure is very high for Panama, high for The Bahamas, Chile, and Uruguay, moderate for Argentina, and low for Brazil. Finally, values for the CIP pillar are very high for Bahamas, Brazil, Chile, and Uruguay, high for Argentina, and low for Panama.

Barbados, Colombia, Costa Rica, and Trinidad and Tobago are members of Group 2. Values of the Economic Development pillar are very high

[11] Throughout this chapter, the level of development is introduced in terms of normalization across 26 IDB borrowing member countries in the LAC region. Values of DCDI for 48 selected countries worldwide are presented in Annex 1.

TABLE 3.1 DCDI for LAC Countries

Country	P1	P 2	P3	P 4	P 5	DCDI
Argentina	0.51	0.66	0.52	0.34	0.38	**0.44**
Bahamas	0.63	0.31	0.24*	0.40	0.60	0.44
Barbados	0.51	0.20*	0.58*	0.33	0.33	0.39
Belize	0.38	0.27*	*0.19**	0.30	0.24	0.27
Bolivia	0.36	0.57	0.29	0.12	0.29	**0.27**
Brazil	0.82	0.46	0.55	0.13	0.65	**0.47**
Chile	0.63	0.68	0.64	0.40	0.45	**0.51**
Colombia	0.52	0.56	0.54	0.13	0.38	**0.37**
Costa Rica	0.48	0.26*	0.47	0.45	0.40	0.42
Dominican Republic	0.41	0.62	0.35	0.10	0.16	**0.25**
Ecuador	0.40	0.70	0.27*	0.14	0.24	0.28
El Salvador	0.38	0.49	0.28	0.04	0.09	**0.18**
Guatemala	0.38	0.55	0.25	0.03	0.02	**0.16**
Guyana	0.37	0.38	0.05*	0.01	0.16	0.13
Haiti	0.33	0.21	0.16*	0.02	0.15	0.14
Honduras	0.36	0.54	0.35	0.04	0.17	**0.22**
Jamaica	0.38	0.37	0.23*	0.13	0.15	0.20
Mexico	0.57	0.58	0.48	0.06	0.42	**0.35**
Nicaragua	0.35	0.30*	0.34	0.05	0.12	0.19
Panama	0.51	0.36	0.48	0.61	0.25	**0.44**
Paraguay	0.39	0.78	0.32	0.10	0.31	**0.30**
Peru	0.45	0.62	0.39	0.08	0.26	**0.28**
Suriname	0.44	0.38*	0.19*	0.06	0.21	0.20
Trinidad and Tobago	0.33	0.68	0.57*	0.30	0.25	**0.38**
Uruguay	0.58	0.70	0.85	0.41	0.66	**0.62**
Venezuela	0.47	0.66	0.11	0.03	0.34	**0.25**

Source: Analysis by NEC Corporation with IDB cooperation.
Note: *indicates that some data are not available.

for Barbados, Colombia, and Costa Rica, while the value for Trinidad and Tobago is moderate. For Fundamental Infrastructure, Colombia and Trinidad and Tobago score very high, and all countries of Group 2 score very high for Connectivity. The values of the Data Center Infrastructure pillar are very high for Costa Rica, moderate for Barbados and Trinidad and Tobago, and low for Colombia. Values of the CIP pillar are high for Colombia and Costa Rica, moderate for Barbados, and low for Trinidad and Tobago.

Belize, Bolivia, Ecuador, Mexico, Paraguay, and Peru represent Group 3. The values of the Economic Development pillar are very high for Mexico and Peru, and high for Belize, Bolivia, Ecuador, and Paraguay. Values of Fundamental Infrastructure are at very high levels for Mexico, Ecuador, Paraguay, and Peru. The values of the Connectivity pillar are very high for Mexico, high for Peru, and moderate for Bolivia, Ecuador, and Paraguay. Values for the Data Center Infrastructure pillar are moderate for Belize, and low for all other countries. Values

FIGURE 3.1 Results of the Data Center Analysis

Source: Analysis by NEC Corporation with IDB cooperation.

for the CIP pillar are high for Mexico, moderate for Bolivia, Paraguay, and Peru, and low for Belize and Ecuador.

Finally, the Dominican Republic, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Suriname, and Venezuela are members of Group 4. Values for the Economic Development pillar are very high for Suriname and Venezuela, high for the Dominican Republic, El Salvador, Guatemala, Guyana, and Jamaica, and others are moderate. Values for the Fundamental Infrastructure pillar are very high for El Salvador and Guatemala, high for Guyana, Jamaica, and Suriname, moderate for Nicaragua, and low for Haiti. The connectivity scores are moderate for El Salvador, Honduras, and Nicaragua and low for Guatemala, Guyana, Haiti, Jamaica, and Suriname. All countries exhibit low Data Center Infrastructure scores. CIP scores are moderate for Venezuela and low for all others in Group 4.

The graphic profile provided for each country illustrates their strengths and weaknesses. To compare the environments in LAC countries with countries outside the region, selected indicators were analyzed individually. This analysis is presented in the subsequent sections. Especially in the Data Center Infrastructure Pillar and the Critical Infrastructure Protection Pillar, there is a significant divide between the developed countries and the LAC countries.

Natural Disaster and Critical Infrastructure Protection

When natural disasters occur, protecting critical infrastructure and data centers storing critical information is vitally important. At that time, saving the lives of people and the fastest restoration of the critical infrastructure are the most important tasks.[12] Protecting critical infrastructure is the highest priority for a government. Critical infrastructure protection (CIP) covers preparedness for and response to serious incidents that involve critical infrastructure of a region or a nation.[13]

Data centers can store data directly related to critical infrastructure. Such data centers should be considered as elements of critical infrastructure and CIP should be applied to such data centers. A disaster can destroy a single data center; thus, it is necessary to build a network of data centers to have critical data duplicated at different locations. Such a network of data centers provides geographic redundancy and reduces the risk of critical

[12] Critical Infrastructure includes assets essential for the functioning of a society and economy such as gas and water production, transportation, and distribution; telecommunications; water supply; food production and distribution; public health; transportation systems; financial services and security services (https://en.wikipedia.org/wiki/Critical_infrastructure).

[13] https://en.wikipedia.org/wiki/Critical_infrastructure_protection.

FIGURE 3.2 Results of Data Center Analysis by Country

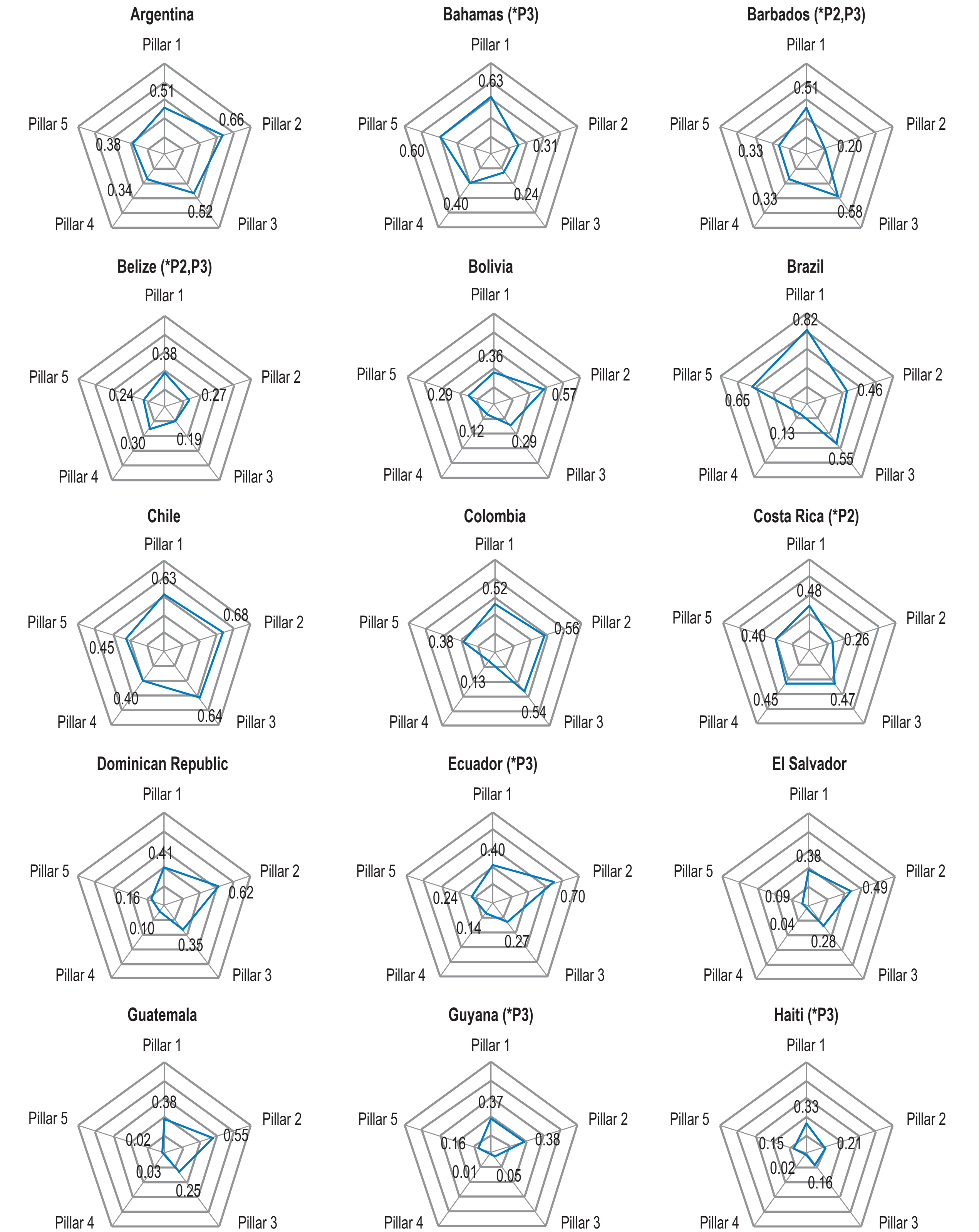


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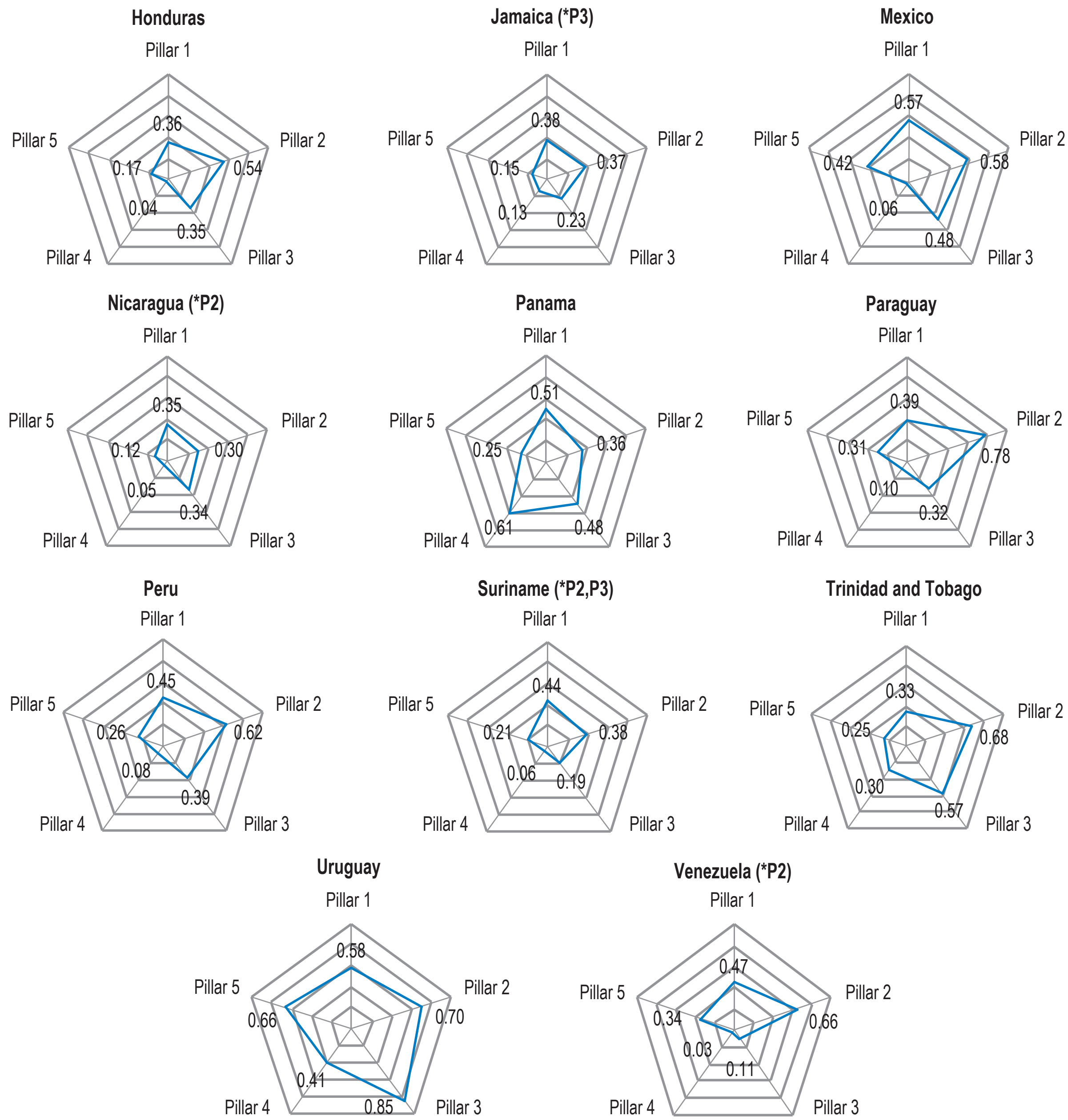
FIGURE 3.2 Results of Data Center Analysis by Country *(continued)*



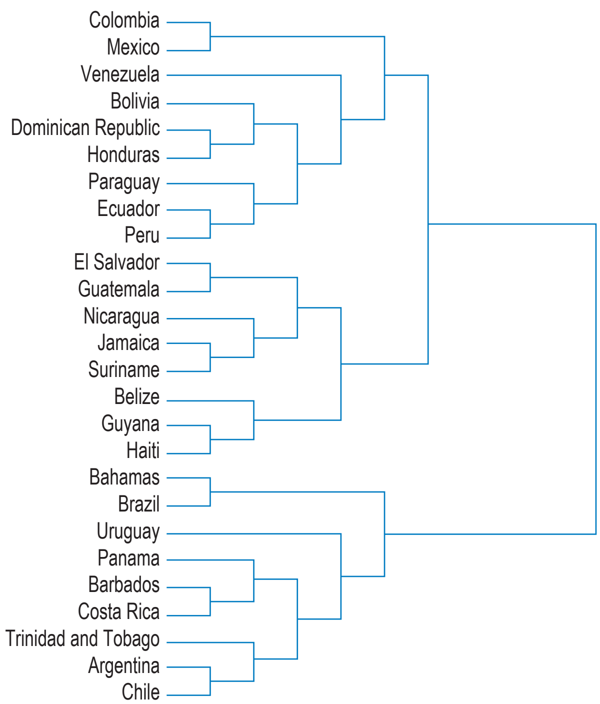
Source: Analysis by NEC Corporation with IDB cooperation.
Note: * indicates that data on some indicators are not available.

data loss. To evaluate and compare levels of geographic redundancy, the Geographic Redundancy Index (GRI) is employed.[14]

The GRI value ranges from 0 (low or no redundancy) to 1 (high redundancy). The idea behind the GRI is to provide multiple locations of data centers

[14] The GRI was designed by NEC to evaluate the degree of redundancy in the distribution of data centers across the region of interest. To compute GRI, the number of data centers and number of areas where data centers are deployed are used from DataCentermap.com. GRI is computed as a ratio between actual and maximum entropy. GRI is adjusted for country area and population size.

FIGURE 3.3 Similarity of LAC Countries regarding DCDI Pillars



Source: Analysis by NEC Corporation with IDB cooperation.

MAP 3.1 Natural Disaster Risk Index, Number of Data Centers and Geographic Redundancy Index for LAC Countries

Source: Analysis by NEC Corporation with IDB cooperation.
Note: Text is formatted as "Country [number of data centers; Geographic Redundancy Index]".

and evenly distribute the data centers across those locations. In Japan, for example, there are 40 data centers, deployed at 11 locations across the country. Of these, 24 (60 percent) are in Tokyo, five in Osaka, and three in Nagoya. There is a single data center at each of the eight remaining locations (Fukuoka, Hiroshima, Kawaguchi, Naha, Oyama, Sapporo, Sendai, and Yokohama). The GRI value for Japan is 0.625.

It is important to evaluate the natural disaster risk for each country. One way to do so is via the Natural Disaster Risk Index (NDRI). Figure 3.3 and Map 3.1 illustrate the NDRI together with the number of data centers and the GRI values for LAC countries.

In the LAC region, the countries with the highest value of NDRI are Chile, Costa Rica, the Dominican Republic, El Salvador, Guatemala, Guyana, Honduras, and Nicaragua (Figure 3.4). They have an NDR index value higher than 0.1.[15]

Another region with very high values of NDRI is Southeast Asia (SEA), as can be seen in Map 3.4. The highest value of NDRI (0.2852) for the region is in the Philippines, which is the third highest value of NDRI in the world after Vanuatu (0.3643) and Tonga (0.2823). The Philippines suffers from seasonal typhoons and consequent floods almost every year. The government of the Philippines has, accordingly, launched a Government Data Center

[15] Recent strong earthquakes in Japan (March, 2011), Chile (September, 2015), and Ecuador (April, 2016) illustrate how NDR value is related to disasters. The top nine countries with the highest NDRI values for LAC region are presented. It is easy to infer Guatemala (0.2088), Costa Rica (0.1694), El Salvador (0.1685) and Nicaragua (0.1489) have NDRI values higher than the one for Japan (0.1410). In contrast, the number of data centers and GRI values is lower than for Japan. Furthermore, Guatemala, El Salvador and Nicaragua have only one data center each. The Dominican Republic, Guyana, Honduras, and Jamaica do not have data centers. These countries are extremely vulnerable to losses of important data, if natural disaster strikes.

MAP 3.2 Number of Data Centers and Internet Exchange Points in LAC Countries

Source: Analysis by NEC Corporation with IDB cooperation.
Note: text is formatted as "Country [number of data centers; number of IXPs]".

Project. The Philippines' economy is healthy. Annual GDP growth in 2013 was 7.1 percent, and its expected GDP growth in 2016 remains 6.4 percent, according to the World Bank.

In Japan, following the Great East Japan Earthquake, the government has launched a program to deploy more data centers in locations throughout the country. Governments of countries with the top nine highest NDRI values in the LAC region should seriously consider the CIP and expanding the network of data centers.

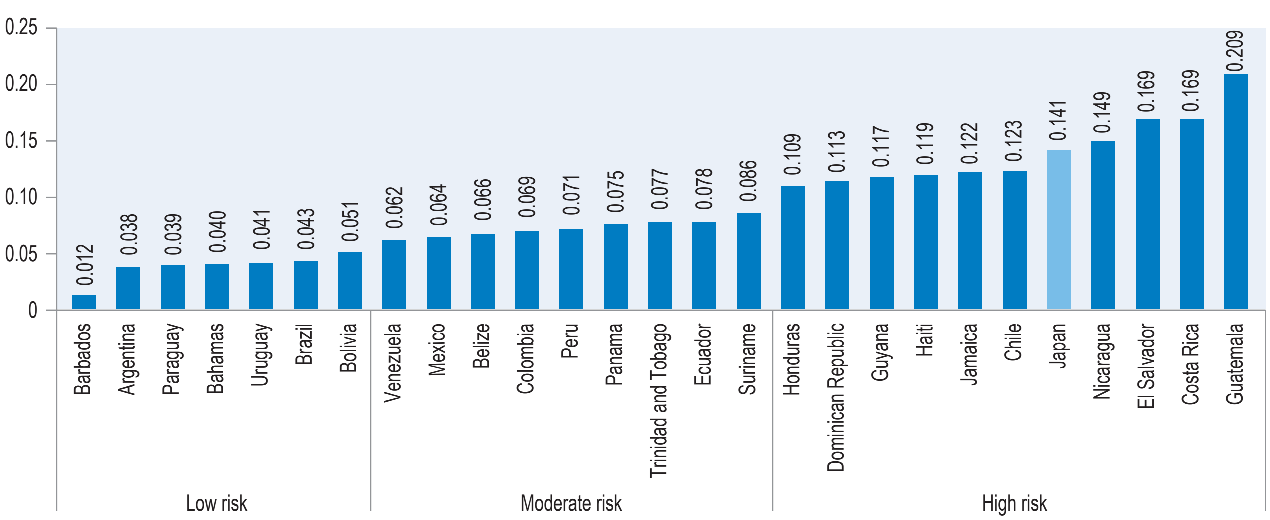
Besides data centers, IXPs are another important element of domestic connectivity. IXPs localize traffic inside a country by providing interconnections between separate domestic internet networks. If domestic internet networks are not well connected, this can lead to traffic being sent over international routes, resulting in high Internet access prices and long latencies.

The number of data centers and IXPs alongside NDRI values for LAC region is illustrated in Map 3.2. The landscape of IXPs, data centers, and corresponding values of NDRI in LAC countries resembles that of Vietnam and the Philippines.

CO_2 Emissions in LAC

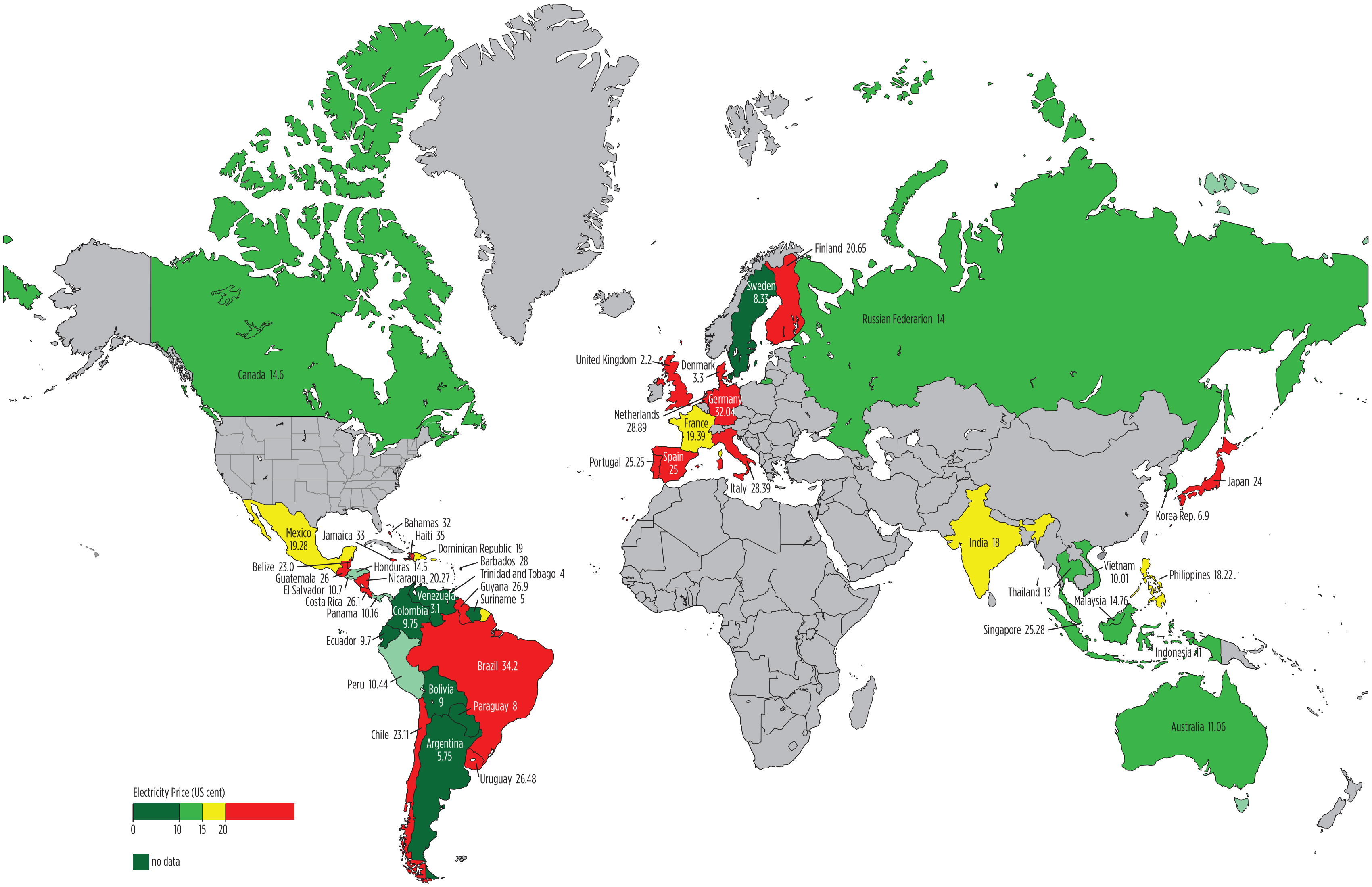
Regarding CO_2 emissions, Argentina, Brazil, Mexico, and Venezuela are the leaders, with more than 1 billion tons of CO_2 emitted every year. Chile, Colombia, and Peru follow these countries, with annual emissions between 500 million and 1 billion

FIGURE 3.4 Natural Disaster Risk Index in LAC Countries by Risk Zones



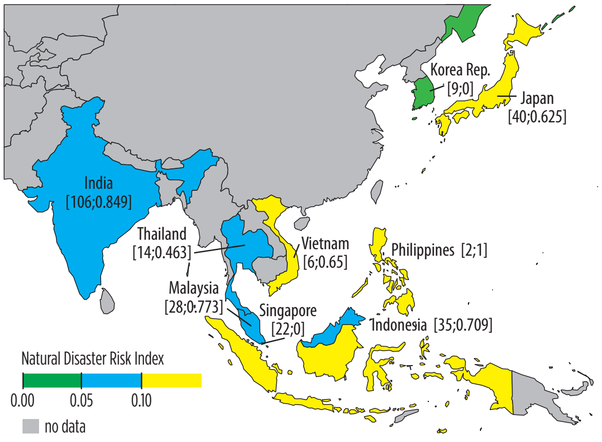
Source: Analysis by NEC Corporation with IDB cooperation.

MAP 3.3 Industry Electricity Prices in the World



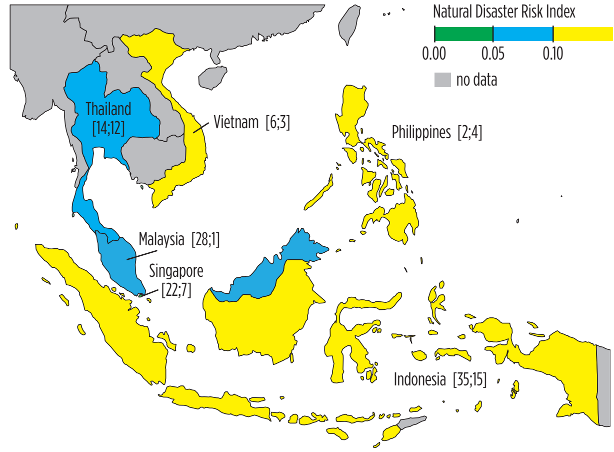
Source: Analysis by NEC Corporation with IDB cooperation.

MAP 3.4 **NDRI, Number of Data Centers, and GRI for SEA**



Source: Analysis by NEC Corporation with IDB cooperation.

MAP 3.5 **Number of Data Centers and IXPs in Southeast Asia**



Source: Analysis by NEC Corporation with IDB cooperation.

tons. Bolivia, the Dominican Republic, Ecuador, Guatemala, and Trinidad and Tobago each emit between 100 million and 500 million tons per year. Finally, the countries with the lowest CO_2 emissions are The Bahamas, Barbados, Belize, Costa Rica, El Salvador, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Suriname, and Uruguay, with annual emissions of less than 100 million tons (Map 3.7).

Box 3.1 **Government Data Center Project in the Philippines**

The government of the Philippines runs the National Government Data Center Project to integrate a number of agencies, which operate their own data centers. The goals of this project are to:

- Reduce government spending; and
- Improve and increase efficiency of IT infrastructure.

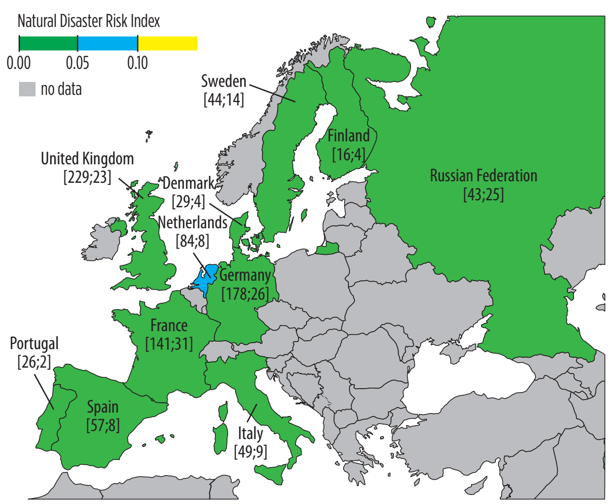
The government data centers should be deployed in a geographically redundant manner and have fully redundant systems on-site. Other existing government-owned data centers will likewise be connected to the network. This project is a part of the e-Government Project.

Source: http://i.gov.ph/ngdc/.

Electricity Prices in LAC

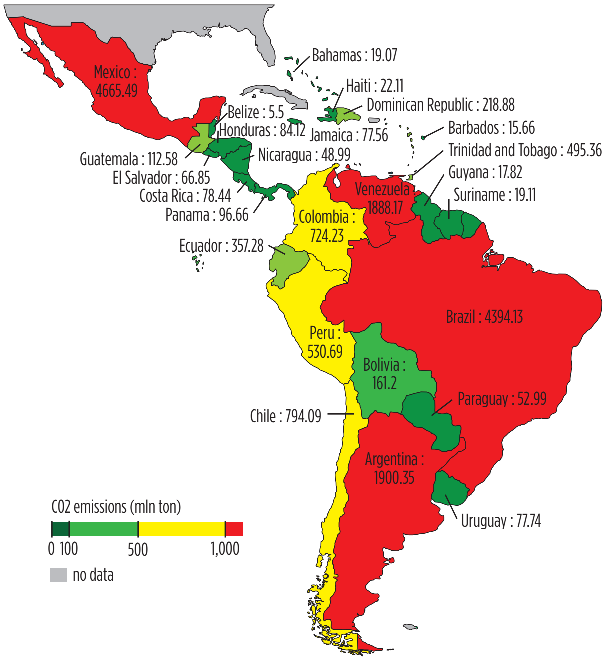
Data centers and communication networks require a lot of electricity. Electricity prices (in U.S. cents) in LAC countries are shown in Map 3.8. Prices in Argentina (5.75), Bolivia (8), Colombia (9.75), Ecuador (9.7), Paraguay (8), Suriname (5), Venezuela (3.1), and Trinidad and Tobago (4) are the lowest in the world. However, prices in The Bahamas (32), Belize (23.5), Brazil (34.2), Chile

MAP 3.6 **Number of Data Centers and IXPs in Europe (color; NDRI)**



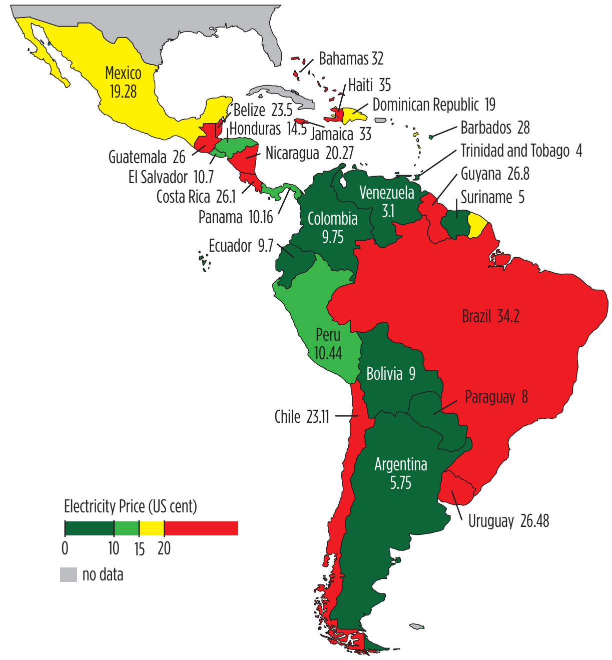
Source: Analysis by NEC Corporation with IDB cooperation.

MAP 3.7 **CO_2 Emissions in LAC Countries**



Source: Analysis by NEC Corporation with IDB cooperation.

MAP 3.8 **Electricity Prices in LAC Countries**



Source: Analysis by NEC Corporation with IDB cooperation.

(23.11), Costa Rica (26.1), Guatemala (26), Haiti (35), Jamaica (33), and Nicaragua (20.27) are higher—at the level of Germany (32.04), Japan (24), Netherlands (28.89), Portugal (25.25), Spain (25), and the United Kingdom (22).

The distribution of electricity prices across the LAC region is highly unequal. Making electricity more affordable in countries with higher prices may require the assistance of neighboring countries. For instance, in Central America, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama are connected to the Central American Electrical Interconnection System (SIEPAC).

Domestic and International Connectivity in LAC Countries

Domestic connectivity is characterized by (i) supply by telecom operators and (ii) demand for the communication services by population. Supply is assessed according to the median fixed and mobile upload speeds and the median fixed and mobile latencies.[16] Demand is evaluated according to the broadband (fixed and mobile) penetration rate and international connectivity.

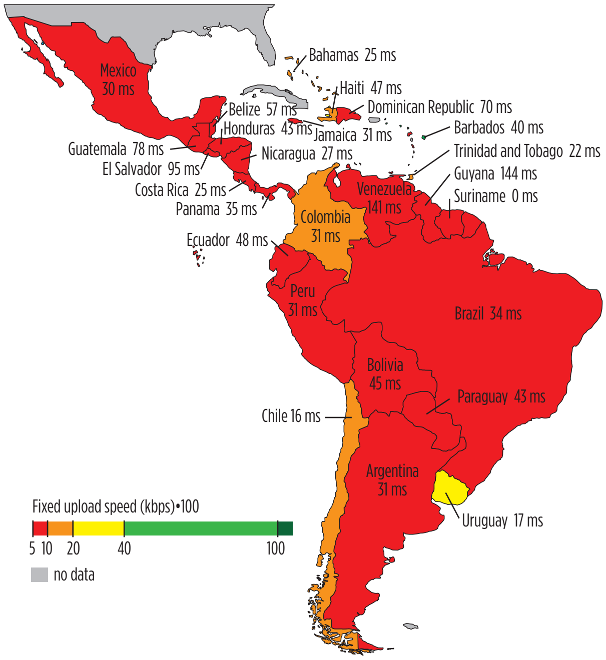
For data center usage, broadband network service cost, broadband network speed, and latency are important factors. Broadband speed is essential for understanding the capacity of local content access. Furthermore, distance plays an important role because longer distance introduces longer latencies and reduces throughput.

Domestic Connectivity: Supply

Most LAC countries demonstrate low upload speed for fixed channels. Only Chile, Colombia, and Uruguay exhibit upload speeds faster than

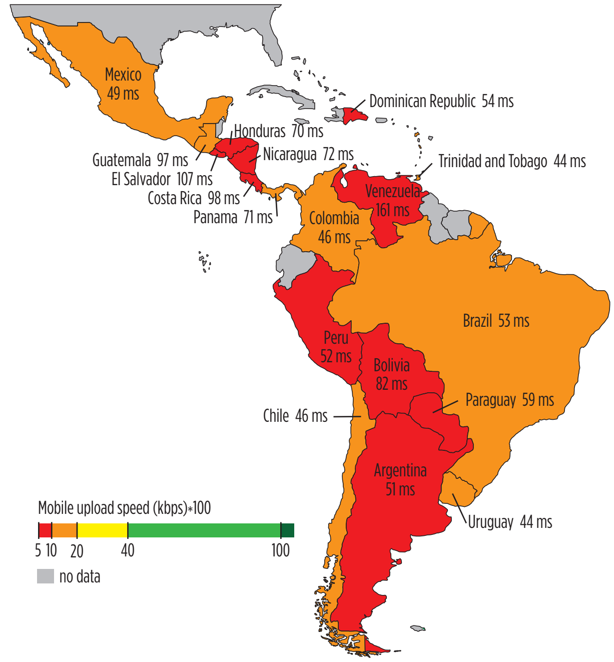
[16] The correlation between download and upload speeds in LAC countries are 0.79 (fixed) and 0.93 (mobile). The values for all the countries considered are 0.82 (fixed) and 0.97 (mobile). The regression models for upload vs. download speed exhibit very accurate approximation.

MAP 3.9 Fixed Upload Speed and Latency in LAC Countries



Source: Analysis by NEC Corporation with IDB cooperation.

MAP 3.10 Mobile Upload Speed and Latency in LAC Countries



Source: Analysis by NEC Corporation with IDB cooperation.

1,000 kpbs. Other countries are in the red zone, with median upload speeds less than 1,000 kpbs. In general, the leading countries, where fixed broadband upload speed exceeds 10,000 kbps, are Japan, Republic of Korea, and Sweden. Fixed broadband is also available in these countries with very low latency.

The median upload speed of a fixed channel in LAC countries is 3 and 15 times slower than in Western Europe and Central and Eastern Europe, respectively. When compared with Asian Pacific countries, the median upload speed is about 10 times slower. The median fixed channel latency in LAC countries is comparable to that of other countries (see Map 3.9).

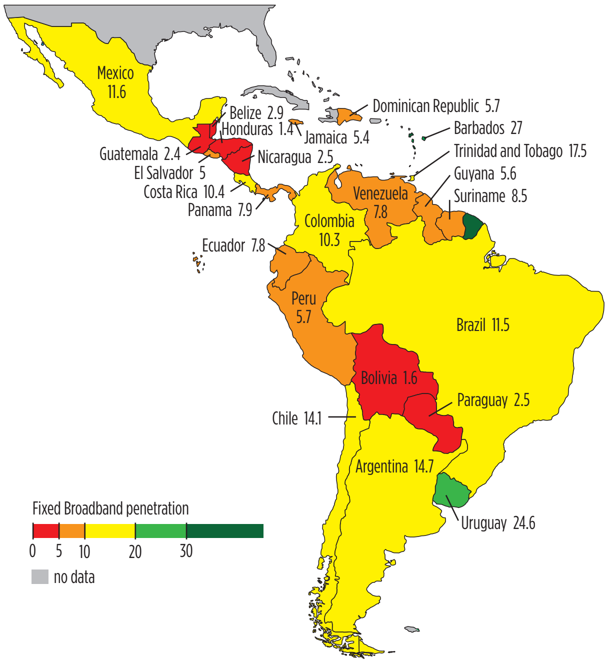
For Belize, the Dominican Republic, El Salvador, Guatemala, Guyana, and Venezuela, the median latency values exceed 50ms. In terms of median latencies, Guyana and Venezuela have extremely long latencies, of 144ms and 141ms, respectively.

Upload speeds for mobile channels in the region are a little more promising. Along with Chile, Colombia, and Uruguay, Brazil, Guatemala, Panama, and Mexico have also crossed the 1,000-kbps threshold for this metric. The median upload speed for mobile channels is 2.4, 3.5, and 3.3 times slower than in Western Europe, Central and Eastern Europe, and Asia Pacific countries, respectively (see Map 3.10).

The median latency for mobile channels is roughly 1.5 times longer than the latency for countries in Europe and Asia. However, there are also countries with extremely long latencies. These are El Salvador and Venezuela, with corresponding median latencies of 107ms and 161ms, respectively. According to GSMA (2014), the latency required for disaster alert systems is about 10ms.

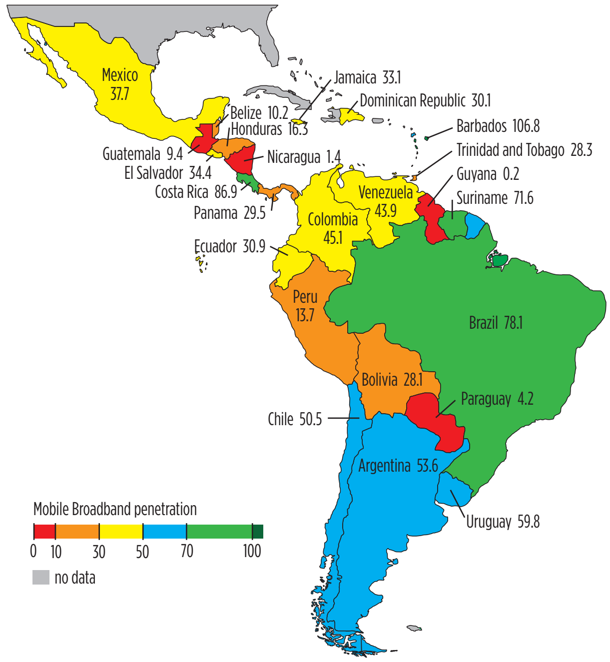
In general, the divide among LAC, European, and Asian countries in terms of latency is higher for mobile latency than for fixed connection latency. Upload speeds for both fixed and mobile channels in the LAC region are much slower than in European and Asian countries. Therefore, essential efforts to improve broadband connectivity in LAC countries are needed.

MAP 3.11 Fixed Broadband Penetration in LAC Countries



Source: Analysis by NEC Corporation with IDB cooperation.

MAP 3.12 Mobile Broadband Penetration in LAC Countries



Source: Analysis by NEC Corporation with IDB cooperation.

Domestic Connectivity: Demand

The fixed broadband penetration rate in LAC countries is much lower than in European countries, but comparable to the fixed broadband penetration rate in Asian countries such as Thailand and Vietnam.

Uruguay (24.6) has the highest penetration rate, similar to that of the Philippines (23.2). However, Bolivia, Guatemala, Honduras, Nicaragua, and Paraguay all exhibit fixed broadband penetration rates lower than 5. As in the case of fixed broadband, the mobile broadband penetration rate in LAC is lower than in European and Asian countries (see Map 3.11) Costa Rica (86.9) and Brazil (78.1) exhibit high mobile broadband penetration rates. Mobile broadband penetration rates in Argentina (53.6) and Chile (50.5) are comparable to those in France, Germany, the Netherlands, and the Russian Federation (see Map 3.13). Overall, mobile broadband penetration in LAC countries is similar to that of SEA countries (see Maps 3.12 and 3.14).

International Connectivity

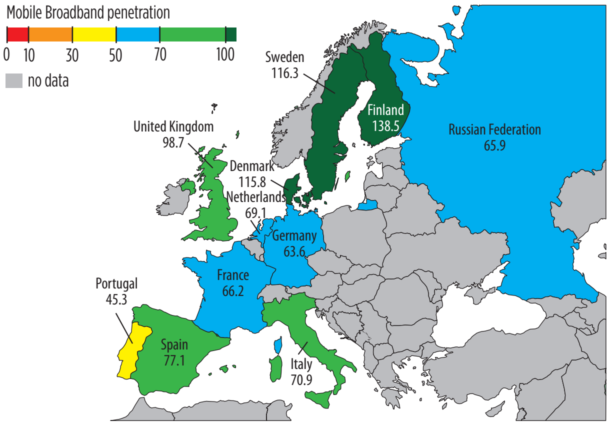
International connectivity is measured in terms of international internet bandwidth (Bit/s per internet user). Most LAC countries have bandwidth of less than 5,000 Bit/s per internet user.

Telco OpEx per Revenue in LAC Countries

OpEx as a portion of total company revenue (OpEx/rev) is the main key performance indicator (KPI) of business efficiency in the telecom sector. Lower values correspond to more efficient businesses. Since one of the issues for data center users is network service cost, OpEx per revenue is an important indicator of the ability of telcos to sustainably operate data centers.

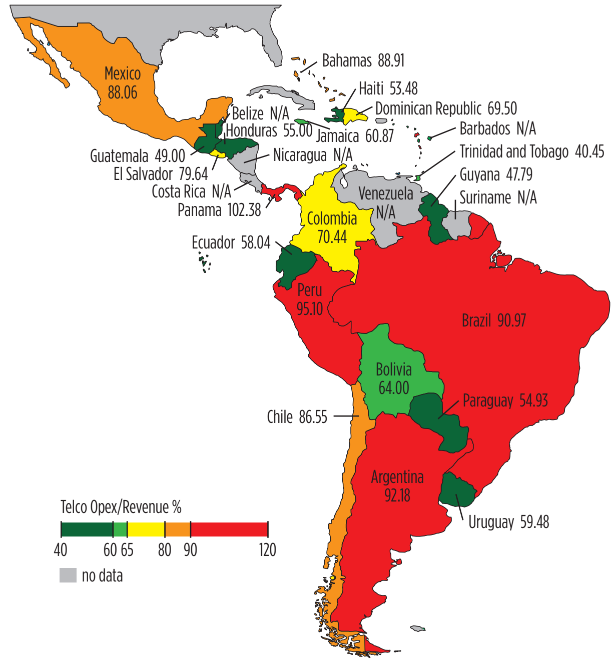
To increase data center usage and improve productivity, it is necessary to reduce operating costs by implementing the latest technologies. New virtualization technologies, that is, SDN and NFV, introduce a variety of opportunities to reduce

MAP 3.13 Mobile Broadband Penetration in Europe



Source: Analysis by NEC Corporation with IDB cooperation.

MAP 3.15 OpEx/Rev in LAC Countries

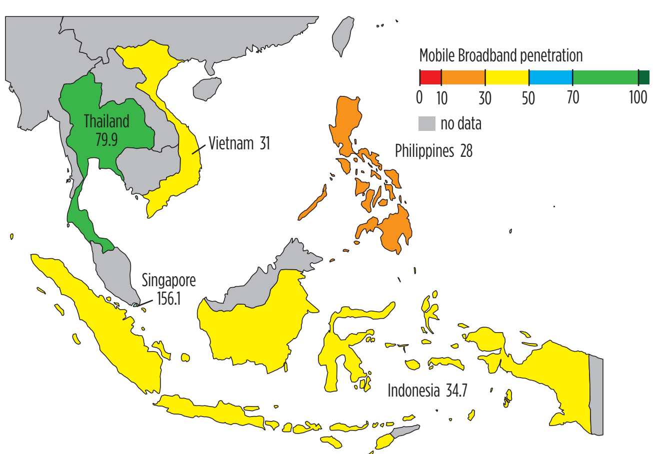


Source: Analysis by NEC Corporation with IDB cooperation.

the number of physical devices and telco-data centers and decrease operating costs. Having reduced operating costs, companies will be able to invest in innovation programs providing socially oriented solutions.

Countries with a OpEx/rev ratio value of less than or equal to 60 percent are colored green in Map 3.15. These countries are: Paraguay (59.48 percent), Ecuador (58.04 percent), Guatemala (49 percent), Guyana (47.79 percent), Honduras (55 percent), Trinidad and Tobago (40.45 percent), and Uruguay (59.48 percent). Jamaica (60.87 percent) has slightly exceeded the threshold of 60 percent. Colombia (70.44 percent), the Dominican Republic (69.50 percent), and El Salvador (79.64 percent) comprise the group of countries with OpEx/rev value within the 65 to 80 percent interval. Chile (86.55 percent) and Mexico (88.06 percent) exhibit moderately high OpEx/rev ratio values. The OpEx/rev ratio values for Argentina (92.18 percent), Brazil (90.97 percent), Panama (102.38 percent), Peru (95.10 percent), and the remaining countries are very high. In the case of Panama (102.38 percent), this ratio is higher than 100 percent, implying operating losses.

MAP 3.14 Mobile Broadband Penetration in SEA Countries



Source: Analysis by NEC Corporation with IDB cooperation.

Conclusions

The DCDI should be used to holistically monitor DCIP-related indicators. This would provide an overarching view of the current landscape for data centers in the LAC region. In the future, DCDI should serve as a tool to measure a country's progress in developing data center related infrastructure, including broadband.

This study also analyzed some of the DCDI indicators individually. For example, fixed broadband upload speed and latency in the LAC region are comparable to those of the rest of the world. However, there is a significant disparity in the mobile upload speed and latency between most LAC countries and the selected countries in other regions. This highlights essential problems on the supply side of the telecommunication services in LAC countries.

Regarding the number of data centers, Internet exchange points, and secure Internet servers per million, there is a huge divide between the LAC countries and selected advanced Western European countries, Australia, Canada, Japan, Korea, and Singapore. There is an intrinsic resemblance between LAC and SEA countries. For example, LAC and SEA countries share similarities in electricity prices and Natural Disaster Risk Index value. The top nine LAC countries with a Natural Disaster Risk Index value of more than 10 percent do not have enough geographical redundancy in data center locations, or lack adequate data center infrastructure. This makes these countries highly vulnerable to the loss of critical data if natural disasters occur. It may mean that these countries are excessively reliant on international connectivity if most of their sensitive data is located abroad on foreign servers.

Countries in SEA, including the Philippines, Thailand, and Vietnam, share similar risks of natural disasters, and related issues regarding low levels and geographical redundancy of data centers and relatively few IXPs. The Philippines and Vietnam take seriously the issues of critical infrastructure protection and critical infrastructure data preservation. These countries have established national ICT development master plans along with regional ICT master plans designed by ASEAN+3, and they have developed ICT industrial parks and local data centers, which are supported and managed by the governments.

Backbone infrastructure has been conceived at the heart of infrastructure. Many countries have devoted considerable resources to the development of a national backbone. However, few countries have evaluated the whole national IT infrastructure, including data center infrastructure and cloud development. This analysis invites policymakers to revisit their infrastructure assessments and consider the full picture of the infrastructure required to support national broadband plans and digital agendas.

4

Recommendations for Deployment of Data Centers and Related Infrastructure

Introduction

This chapter provides a set of good practices and recommendations for policymakers to help foster the development of data centers and related infrastructure.

Attracting Foreign Direct Investment

Foreign direct investment (FDI) is a major component of many national economies.[17] In recent years, FDI in data centers has witnessed considerable growth worldwide. Between 2009 and 2014, data center FDI has increased, on average, by almost 12 percent per year for projects and 3.5 percent for capital investments. The main reasons to invest in data centers are (i) to create highly paid and high value-added jobs; (ii) to increase tax revenue; (iii) to attract data-intensive sectors; (iv) to stimulate demand for broadband services; (v) to provide eco-friendly benefits; and (vi) to create indirect employment (fDi Intelligence, 2015).

It is often difficult to cover an entire country with data centers. An alternative strategy is to create oases of stable ICT connectivity and a robust supply of fundamental infrastructure needs, such as electricity. Establishing ICT industrial parks can encourage FDI from large international players and enable the adoption of global experience by local players. Therefore, senior government policymakers should consider focusing on data center FDI by establishing ICT parks.

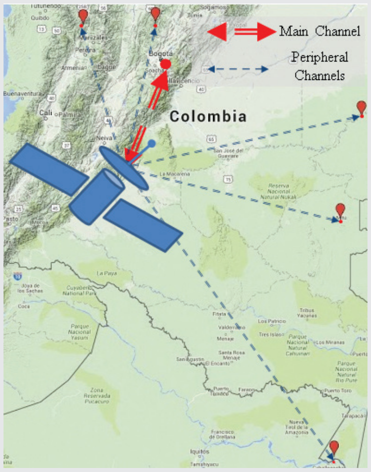
Free Flow of Information Across Borders

Governments should establish policies that positively impact data center infrastructure but that do not force investors to build infrastructure locally as a prerequisite to trade. Policymakers should work to facilitate cross-border data flows. Restricting international data flows with the intent of protecting access to data or ensuring security is ineffective and inefficient and slows the expansion of trade in all Internet-dependent services, as well as cloud

[17] The impact of FDI on productivity is presumed to occur through three primary channels: reallocation, technological externalities and linkage (Blomstrom and Kokko, 1998; Markursen and Maskus, 2001). The reallocation effect results from the entry of firms that are at the global technology vanguard. Technological externalities are associated with the absorption of technology from foreign companies by suppliers, customers, and competitors. The linkage effect is associated with the increase in quality and variety of inputs resulting from FDI in those sectors.

Box 4.1 **Colombian Government is Successfully using Kioscos Vive Digital**

The Colombian government effectively employs satellite access to global channel and local distribution using wireless technologies through Kioscos Vive Digital. Through this initiative, the government is creating public internet access points (Kioscos), usually located in schools and other common areas, in remote rural zones throughout Colombia to promote the nationwide spread of broadband internet and narrow the country's digital divide. Today, thanks to the 6,889 Kioscos installed, nearly every Colombian has access to ICT and fully participates in life as a digital citizen.



Source: NEC and MinTIC of Colombia.

services. Establishing strong and binding policies for cross-border data flow ensures that service suppliers, or customers of those suppliers, can access and move data freely subject to important safeguards, such as privacy regulations. These commitments preserve the free flow of global information and data that drive the digital economy over the Internet. Unrestricted cross-border data flows promote Internet innovation and preserve the benefits of a globally connected digital economy.

Disaster Prevention and Critical Infrastructure

Disasters increase demand for residential infrastructure and efficient ICT solutions for decision making and broadcasting. Moreover, CIP-related data must be safely stored and easily accessible during and after a disaster.

Governments need to share central and regional disaster information, facilitate rapid decision making and on-site support for disaster countermeasures, and allow residents to provide government and municipal agencies with disaster information. Private companies need a business continuity plan. It is important for governments to take a leading role and work together with civil society and the private sector to improve the ICT environment in emergency situations. Deploying a network of data centers with high GRI value will facilitate achievement of these objectives.

Government Cloud

Governments may implement centralized cloud infrastructure for citizens and government offices to reduce infrastructure duplication and enable the development of data centers and cloud services.[18] Governments need to have a clear policy on the security and protections needed for different types of data. For instance, email accounts for public servants at specific government offices do not have the same security requirements as criminal records.

Sustainability Goals

Few industries have as much potential as the ICT industry to reduce CO_2 emissions and reach climate change goals, LAC governments should adopt policy frameworks that accelerate their migration toward

[18] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2410270.

Box 4.2 Data Centers Significantly Contribute to Reduced Greenhouse Gas Emission

The annual greenhouse gas emissions, estimated in 2012, from 1.02 million servers located in Tokyo were about 1.7 million tons. According to the Japan Data Center Council (JDCC), consolidation of these servers in data centers can lead to a 15 percent (250,000 tons) reduction in annual greenhouse gas emissions. Virtualizing and consolidating servers in data centers would result in an estimated 40 percent (680,000 tons) reduction in emissions.

Source:
http://www.dir.co.jp/souken/research/report/esg/es/09073101law.pdf.
https://www.itscj.ipsj.or.jp/hasshin_joho/hj_forum/files/20120521.pdf.

low-carbon networked societies. For example, consolidation of servers in data centers and virtualization will allow reductions in the physical number of devices and amount of energy consumed. Such reductions lead directly to lower CO_2 emissions.

Specialized data center cooling and power equipment deployed to keep servers and other IT equipment up and running can incur significant energy costs. Overheating problems in data centers are a leading cause of downtime resulting in loss of operations. In general, the IDC estimates that for every US$1 spent on new servers, US$0.50 is spent on energy to power and cool them.

Energy consumption is a critical issue. This, combined with the move toward reducing carbon emissions, has spurred development of "green data centers." The benefits of green data center solutions include the following:

- Energy efficiency leading to higher performance
- Lower exposure to energy prices
- Improved reputation and brand value: companies that demonstrate effective and measurable green initiatives earn greater customer loyalty
- Sustained growth, requiring sustainable operations

Long-term Sustainable Economic Development and Infrastructure Maintenance and Expansion

Sustainable economic development intensively employing ICT infrastructure and data center networks is only possible when these networks are built with potential growth and expansion in mind. Since ICT infrastructure and network data centers require essential capital investments, it is important that they allow for growth to meet the uptake in demand for more resources. The same is true of a single data center. Communication networks inside and outside data centers, such as fiber optic networks, are required for most capital investments.

Therefore, the fiber optic network that connects the different components within the data center and between data centers must supply the increased bandwidth needed for the future. Since a fiber cable plant is often a major cost, it needs to be designed appropriately. Investments in SDN instead of physical fiber cable plant may be a more cost-effective means of providing current fiber cable plant while also providing for future upgrading. Also, the optical transceivers and networking devices that provide optical connectivity should allow for upgrading.

The network architecture that provides the foundation of the data center must be designed to meet application requirements. It must allow flexibility and scalability to service different types of applications and to meet future demands with minimal additional investments.

Fundamental Infrastructure

The high cost of electricity is an important issue. Estimates of wholesale prices in Central America are around $150 per megawatt-hour compared to $50 for other countries. The software-defined data centers (SDDCs) and the latest cooling technology enable the following cost reductions:

- Power consumption per core processor: 50 percent lower

- Air conditioning electricity: 30 percent per rack lower
- Delivery time: 80 percent lower
- Operating costs: 50 percent lower
- Labor costs: 60 percent lower

Some governments have established working groups for resilient infrastructure. Cloud service, SDN, and NFV are expected to be the main means of developing robust and resilient ICT infrastructure.

Tax Policy

Regulations and tax incentive programs can be implemented to transform SDDCs and SDN/NFV-based broadband networks to enable faster recovery of ICT with limited human resources following natural disasters. Tax incentives will not only improve investment in disaster-resistant areas but will also stimulate the initial investments in ICT infrastructure that may not exist at all in some areas. For example, the government of Japan provides tax incentives for data center operators who decide to invest in data centers in areas other than the Greater Tokyo Area. Data center operators with government-approved investment plans are eligible for corporate tax incentives in the form of a 10 percent special depreciation of the electrical communication facilities (servers, routers, switches, UPS, and emergency power generation).[19] This activity should improve the nation's ICT infrastructure and make it more disaster-resistant by increasing geographic redundancy.

"Dig Once" Policy

The "dig once" policy implies that the physical structures built to establish infrastructure, such as electrical networks, gas, petroleum pipelines, and highways, could be used to carry and embed elements of ICT infrastructure, such as cables. Governments can use infrastructure maps as a tool to coordinate investment projects for new roads as well as power transmission, gas, oil, and water and sewer lines to include fiber optic cables. For example, SIEPAC is the electricity grid of Panama, Costa Rica, Honduras, El Salvador, Guatemala, and Nicaragua, completed to connect to Mexico. It is already operating commercially and will also be connected to Colombia and Belize.[20]

The privately owned Central American Telecommunications Network (REDCA) operates and markets the optical ground wire (OPGW) fiber within the power cables owned by SIEPAC. SIEPAC and REDCA cover more than 2,150 km within the network, which links the power grids of Panama, Costa Rica, Nicaragua, El Salvador, Honduras, and Guatemala.[21] SIEPAC and REDCA integration is an example of the "dig once" policy.

The Digital Divide

In all countries, there is a stark digital divide between rural and urban areas. Satellite and other wireless solutions (see Box 4.1 on Kioskos Vive Digital) can provide network connectivity to remote rural areas. Universal Service Fund (USF) and other government funding initiatives can be used to improve broadband infrastructure and network coverage and reduce the digital divide. For instance, Costa Rica established the Connected Home program, utilizing USF to connect and equip low-income families with broadband and computers.

Support for Integration at the Regional and Subregional Level

One of the greatest obstacles to data center development in the LAC region is the high cost of infrastructure projects. Sharing the costs with neighboring countries through subregional integration is a way to overcome this obstacle.

There are already examples of subregional integration for infrastructure projects. For example, Chile,

[19] See http://www.soumu.go.jp/menu_seisaku/ictseisaku/datacenter/.
[20] See http://www.eprsiepac.com/contenido/.
[21] See http://www.lightwaveonline.com/articles/2016/03/redca-enhances-central-american-opgw-fiber-optic-network.html.

Box 4.3 USF Funds Connected Homes Initiatives in Costa Rica

The Connected Homes Program is a joint initiative among different state institutions, including the Vice Presidency and Telecommunication Secretary, implemented by telecommunications companies and supported by NGOs and other institutions. It is one of the largest private-public initiatives in Costa Rica. As part of the "Bridge to Development Strategy," the main goal is to combat the poverty, inequity, job creation and economic through the increasing of information technology in vulnerable groups. The objective is to provide up to 80 percent subsidies for computer and broadband to almost 150,000 low-income families, or around 15 percent of Costa Rica homes. The Telecommunication Secretary (SUTEL) through its USF (FONATEL) leads the program. The total budget is approximately US$128M over five years.

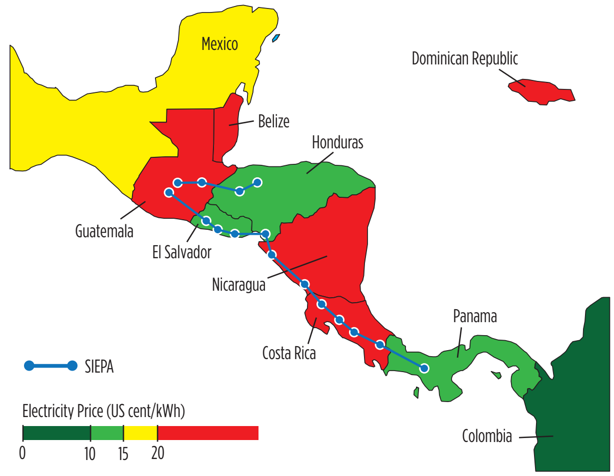
Source: POSTULACION 2016 WSIS PRIZES, Hogares Conectados.

Colombia, Mexico, and Peru are all in the Pacific Alliance. Another example is the initiative for the Integration of Regional Infrastructure in South America, a technical forum for South American physical integration to support South America Infrastructure and Planning Council (COSIPLAN). Caribbean countries are united in the Caribbean Community and Common Market (CARICOM) and the Caribbean Customs Law Enforcement Council (CLEC).

The IDB recognizes global, regional, and subregional integration as a key strategy to facilitate development of LAC countries.[22] The IDB identified three challenges that LAC should tackle to achieve regional and global productive integration and connect to the international value chain (WTO, 2015):

- Implement and take advantage of free trade agreements (FTAs)
- Reduce logistics and transportation costs
- Promote productive integration

MAP 4.1 SIEPAC Network in Central America



Source: Analysis by NEC Corporation with IDB cooperation.

The Mesoamerican Project is an IDB-supported initiative that carries out integration initiatives for energy, telecommunications, transportation, and trade facilitation among 10 countries (Belize, Colombia, Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Panama) (see Map 4.1). Development projects coordinated by the Mesoamerican Project include the International Network of Mesoamerican Highways (RICAM), SIEPAC, REDCA, and the International Transit of Merchandise (TIM). Therefore, there are patterns of subregional infrastructural projects that can be further used for deploying ICT infrastructure, data centers, and public services.

Free cross-border information flows should facilitate subregional integration between LAC countries. Deployment of data centers can be a very expensive project for a single country, especially for small countries. However, when costs are shared, it is possible to deploy data centers across several countries with low electricity prices,

[22] See http://www.iadb.org/en/topics/regional-integration/competitive-global-and-regional-integration-strategy,2802.html; http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=35824823.

low land rental fees, and developed broadband infrastructure.

Neighboring countries without data centers can then use data center services, for example via cloud services. Therefore, the overall cost to deploy ICT infrastructure and data centers in a subregion rather than within a single country can help save money and increase efficiency.

Subregional Analysis and Recommendations

This section describes analyses of subregional groups of countries. It also provides recommendations for each subregion.

Countries from Central America

The first subregional group consists of five Central American countries—Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua—and Mexico. Among these six countries, Costa Rica has the largest number of data centers and the highest values of connectivity and DC infrastructure. However, Costa Rica also has the second highest NDRI value in the LAC region. Guatemala has the highest NDRI value, El Salvador has the third highest, and Nicaragua has the fourth highest in LAC. Although Honduras has the lowest NDRI value in this subregion, it falls in the high-risk zone.

Mexico, the third largest country in LAC in terms of land area, has 11 data centers and only 1 IXP. In the number of secure servers per million, Mexico ranks 14th among 26 LAC countries.

Among these six countries, Costa Rica is the most developed in terms of adjusted DC number and DC infrastructure. Costa Rica has a NDRI value. Therefore, it is reasonable for it to provide content and cloud services to neighboring countries. Neighboring countries could invest in connectivity infrastructure. With the exception of Mexico, the countries in this subregion are small and at high risk for natural disasters. It might, therefore, make sense to use shared data center infrastructure and backup sites outside the subregion to strengthen resilience.

Guatemala has a very high NDRI value and high electricity prices. It is therefore reasonable for it to use cloud services provided by data centers located outside the country. Data centers should be used as backup storage for CIP information and transported to disaster areas to facilitate information accessibility.

Countries in this region should consider simultaneous development of ICT and electricity infrastructure, along with human capital development to prepare skilled engineers and content developers. They should also consider establishing a subregional center for data deployment. This cooperation is already ongoing through the SIEPAC energy network and the REDCA fiber optic network in major cities. In the more remote areas, these countries should consider expanding the topology of power and communication networks.

Countries from the Northwest of South America and Panama

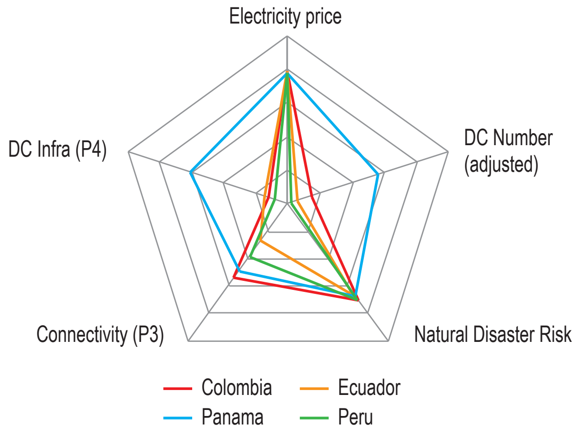
The second subregion includes Colombia, Ecuador, Panama, and Peru. All the countries in this group have moderate values of the NDRI. These countries also have very similar values of other indicators, with the exception of DC infrastructure (see Figure 4.1).

Box 4.4 Interstate Collaboration to Support Justice

The Western Identification Network (WIN) is a nonprofit organization that provides reliable, effective, leading-edge identification services to law enforcement agencies and citizens of its member states—Alaska, California (as an interface member), Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. Starting in 2012, WIN moved to highly fault-tolerant architectures. Key elements of the new architecture are cloud-based services, such as FBI Criminal Justice Information Services (CIJS)-compliant data centers.

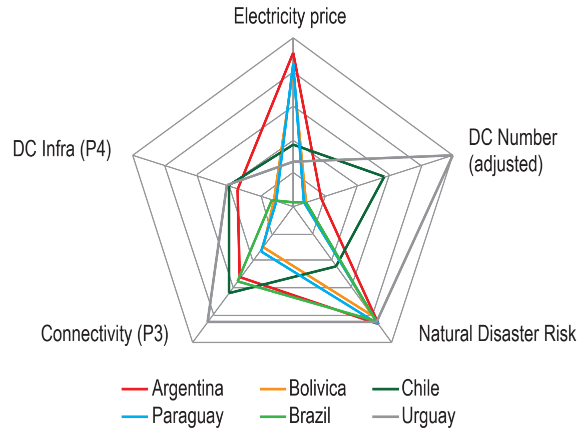
Source: http://www.winid.org/winid/who/.

FIGURE 4.1 Indicators in the Andean Region



Source: Analysis by NEC Corporation with IDB cooperation.

FIGURE 4.2 Indicators in the Southern Cone



Source: Analysis by NEC Corporation with IDB cooperation.

Panama has the most developed data center infrastructure in this group. Colombia and Panama have seven and six data centers, respectively. Although Panama has four IXPs, Colombia has only two IXPs.

Peru and Ecuador each have only one data center. Therefore, these countries should make efforts to deploy data centers along with developing network connectivity. As shown in the e-Kiosk example, the high mountains and jungles in these countries introduce natural obstacles to developing power and communications networks.

Status quo in the Andean Region

In this case, deployment of data centers and IXPs can help reduce expensive backbone traffic that is transmitted through satellite and submarine cable. Another important consideration is the future development plan of electricity infrastructure, electricity inter-connections and optical fiber network in the subregion to use cloud services and to improve development effectiveness.

Countries at the Heart of South America

The third subregion includes Argentina, Bolivia, Brazil, Chile, Uruguay, and Paraguay. In this subregion (Figure 4.2), Chile is characterized by a high NDRI value and high electricity prices. Most of the country's terrain is mountainous.

Argentina, Bolivia, Brazil, and Paraguay have very low NDRI values, and, with the exception of Brazil, relatively low electricity prices. In this subregion, Uruguay and Chile have the largest number of data centers, as well as the highest values of DCI and connectivity. Argentina has good connectivity, 10 data centers and 18 IXPs with cheap electricity prices and low natural disaster risk. Therefore, it might make sense to provide cloud services or backup sites for Chile from Argentina (or Paraguay and/or Bolivia if connectivity there is improved).

Brazil has 43 data centers and 36 IXPs with good connectivity and a low risk of natural disasters. However, because of its huge land area and large population, the values of adjusted numbers of data centers and adjusted numbers of IXPs in Brazil are less than those in Argentina, Chile, and Uruguay. The number of secure servers per million people in Brazil is about half the number in Chile.

For Bolivia and Paraguay, it would make sense to improve connectivity and data center infrastructure together with the overall number of data centers, IXPs, and their geographical distribution. If these countries improve their infrastructure, they may be able to provide backup sites to countries with high NDR index values and cloud services to countries with high electricity prices. In general, all the countries in the LAC region with low connectivity, especially the Caribbean countries, should invest in broadband infrastructure, including telco data centers and submarine cables, to connect to data centers.

Human Capital Development

Globally, the lack of ICT engineers is a critical issue. Governments, universities, companies, and nongovernmental organizations (NGOs) should collaborate to develop human capital in the LAC region. Education and innovation reforms should be implemented to ensure equal opportunities for access to high-quality education. This will, in turn, lead to a workforce with better skills—better matched to the needs of the labor market. Investment in human capital drives long-term economic growth and is an essential part of any growth strategy. The LAC region's productivity in recent years has been disappointing compared to that of OECD countries and emerging economies. Stronger productivity would lead to more inclusive growth and reduce the high inequality and poverty rates. Table 4.1 summarizes the main barriers hampering the development of the data center ecosystem in the region along with the proposed recommendations.

TABLE 4.1 Main Barriers to the Development of a Data Center Ecosystem

Barriers	Recommendations
Low investment and poor infrastructure	Attract foreign direct Investment
	Fundamental infrastructure
	Tax policy
Low regional integration	Free international flows of information
	Support to integration at the regional and sub-regional level
Inefficient government technology and risks of natural disasters	Disaster prevention and critical infrastructure protection
	Government cloud
Low economic development	Sustainability goals
	Long-term sustainable economic development, infrastructure maintenance, and expansion
Low adoption and use of ICT services	"Dig once" policy
	The digital divide
	Human capital development

Source: Authors' elaboration.

5

Regulatory Framework and Next Steps

Introduction

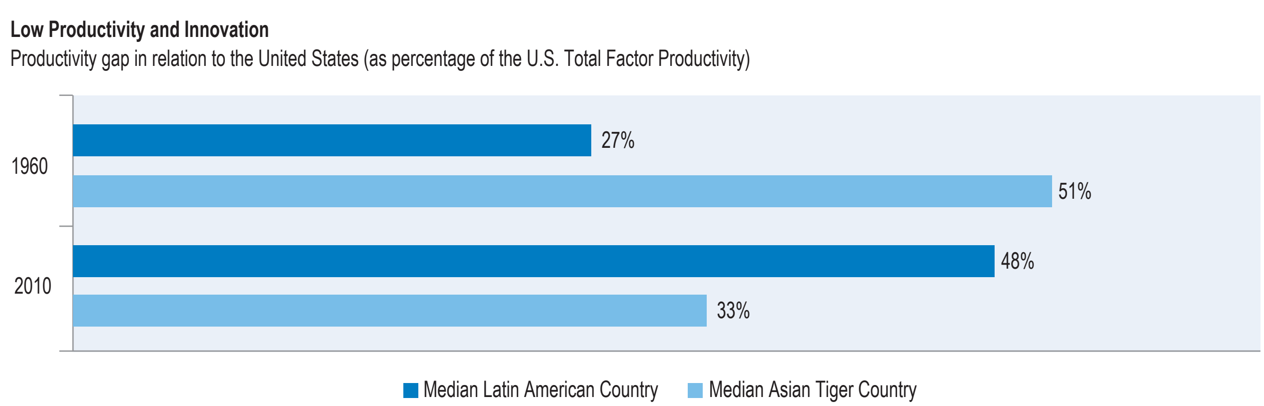
This chapter discusses the regulatory framework needed to enable economic and social development in LAC. Currently, the laws regarding ICT in the region are a complex mosaic of regulations which often impose incompatible or duplicate requirements and are enforced by poorly coordinated institutions.[23]

A comparison of productivity in LAC countries to the Asian Tiger countries (Hong Kong, Singapore, South Korea, and Taiwan) shows that the productivity gap has increased in LAC countries by 21 percent since the 1960s. By contrast, the productivity gap in the Asian Tiger countries has declined by 18 percent since then (IDB, 2015). Singapore is also a member of ASEAN, which has established a centralized governance structure to harmonize ICT sector development (ASEAN, 2015).

The analysis presented in Chapter 3 of this study indicated several similarities between LAC and ASEAN countries. Therefore, the current LAC subregional organization scheme, such as the Mesoamerican project, COSIPLAN, should be extended to create a subregional ICT strategy like the centralized governance structure established by ASEAN, and to provide a Subregional Cloud Service following the International Transit of Merchandise of the Mesoamerican Project.

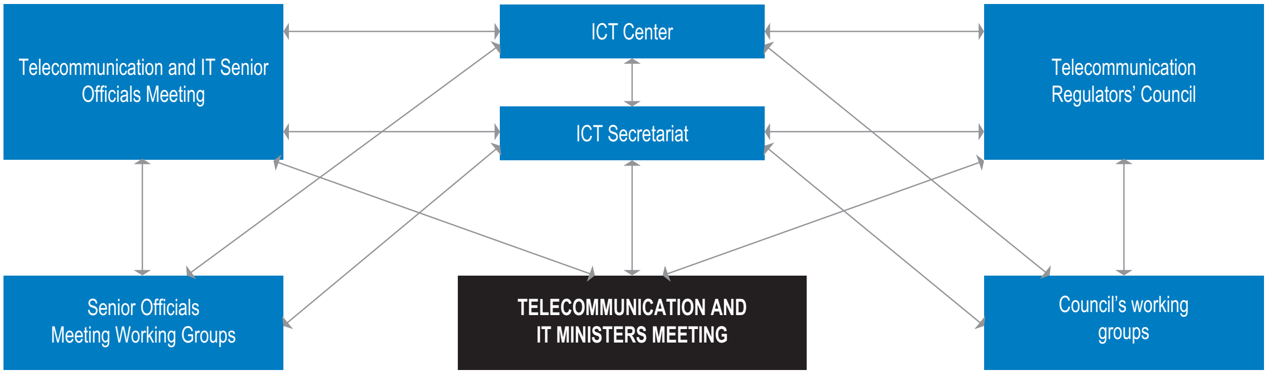
[23] See www.iadb.org/digilac.

FIGURE 5.1 Evolution of Productivity LAC versus Asia



Source: IDB (2015).

FIGURE 5.2 **ICT Master Plan for the LAC Region**



Source: Authors' elaboration.

ICT Master Plan for the LAC Region

A master plan for the LAC region can be implemented by establishing seven entities that break down the complex tasks of regional ICT development and management into zones of responsibility (ASEAN, 2015) (Figure 5.2). The first entity is a Telecommunication and IT Ministers Meeting. This should formulate the vision and goals of the plan. Two more entities should be formed to work with the first entity: a Telecommunication and IT Senior Officials Meeting and a Telecommunication Regulators' Council.

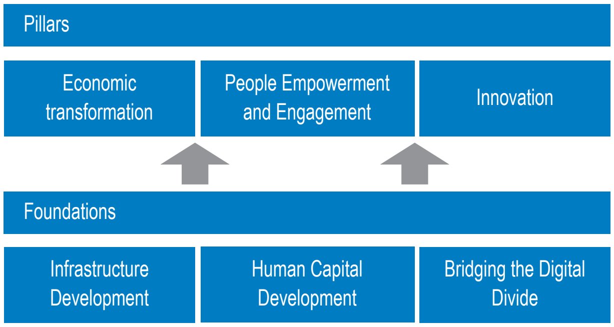
The Telecommunication Regulators' Council should advise the Ministers Meeting and should consist of chief executives and commissioners from telecommunication regulatory agencies in LAC countries. The Telecommunication and IT Senior Officials Meeting would implement activities mandated by the Telecommunication and IT Ministers Meeting. The Telecommunication and IT Senior Officials Meeting comprises senior telecommunication and IT officials from LAC countries.

Working groups established under the Senior Officials Meeting should carry out policies and projects for developing ICT in the region. Working groups established under the Telecommunication Regulators' Council should implement regulatory and technical projects toward developing ICT.

The working groups established under the Telecommunication Regulators' Council should draft legislation and regulatory rules, while the working groups established under the Senior Officials Meeting should implement projects governed by legislation and regulations set by the Council's working groups.

Another entity is the ICT Secretariat. Its main role is to support and monitor project KPIs. The secretariat carries out its role by continually interacting with and synchronizing the work of the Ministers Meeting, the Senior Officials Meeting and its working groups, and the Regulators' Council and its working groups. Finally, the LAC ICT Center coordinates and monitors the programs launched by the Ministers Meeting.

FIGURE 5.3 **Key Components for the Development of a Sound ICT and Data Center Program**



Source: Authors' elaboration.

Development Framework

With a master plan in mind, the design of national ICT and data center development programs should be centered on the following six components (ASEAN, 2015) (Figure 5.3):

- Economic Transformation: to promote investment and entrepreneurship in the ICT sector and build an ICT engine for transformation
- People Empowerment and Engagement: to enhance quality of life through affordable and equitable ICT
- Innovation: to nurture a creative, innovative, and green ICT sector
- Infrastructure Development: to provide the next-generation infrastructure backbone and enabling policies and legislation
- Human Capital Development: to develop a skilled ICT workforce and knowledgeable community
- Bridging the Digital Divide: to elevate countries and people through ICT capabilities

Box 4.4 Interstate Collaboration to Support Justice

Component 1 Economic Transformation

Economic Transformation includes creating a conducive business environment in LAC that helps to attract and promote trade, investment, and entrepreneurship in the ICT sector. Additionally, countries should leverage investments in ICT to create an ICT engine that will transform other sectors and promote economic growth. It is necessary to facilitate inter-country cooperation for sharing and exchange of business information among LAC countries by: (1) engaging business communities to identify ICT needs; (2) nurturing the development of digital content and IT applications; (3) enabling dynamic and inclusive economic growth; and (4) developing a globally competitive business environment, and a framework to facilitate transparent and harmonized ICT regulations.

Component 2 People Empowerment and Engagement

People Empowerment and Engagement focuses on the enhancement of the quality of life for all LAC people through affordable ICT. This is especially true in areas with low standards of living, where mobile and broadband services are considered luxuries. To achieve these goals, the following actions should be taken: (1) facilitate affordable ICT products; (2) ensure affordable and seamless e-services, content, and applications by identifying gaps and determining e-services to be developed with the help of grants or other incentives; and (3) build trust by promoting secure transactions within LAC, along with an awareness of online security and ensuring personal data protection. Finally, there are many small ethnic communities populating LAC countries. These communities should be provided equal opportunities (World Bank, 2015b).

Component 3 Innovation

Innovation focuses on developing a creative, innovative, and green ICT sector in all LAC countries. It challenges LAC governments to create policies and forums to share expertise between countries with different core competencies. These goals can be achieved by establishing centers of excellence, developing a LAC digital content exchange, and promoting intellectual property rights. It is also important to recognize and reward ICT innovators.

Component 4 Infrastructure Development

Infrastructure development focuses on providing the infrastructure backbone to enable ICT services to all communities in LAC. It is also necessary for LAC countries to enable policies and legislation to attract business and investment to the region. Infrastructure development could include establishment of a LAC broadband corridor and deployment of IXPs and data centers to provide seamless e-services and data flow.

(continued on next page)

Box 4.4 Interstate Collaboration to Support Justice *(continued)*

Component 5 Human Capital Development

Human Capital Development helps eliminate gaps in digital literacy and should start from a very young age. Therefore, countries should provide proper digital education in schools and train teachers in digital education. Digital education in schools should include basic skills of computer usage and should provide insight into professions that require computers and ICT as a daily tool. Besides eliminating digital illiteracy, governments should pay close attention to promoting skilled ICT workers to foster the sustainable growth of ICT services, communication infrastructure, and data centers in a country.

Component 6 Bridging the Digital Divide

To bridge the digital divide within a given country, governments should review Universal Service Obligation policies and include ICT components and ICT skills training to stimulate demand as a part of the Universal Service Fund distributions. These activities will most likely require collaborative efforts by various ministries. To bridge the digital divide between LAC countries, governments must collaborate at the ministerial level to promote equal ICT access and adoption in the region.

In general, Economic Transformation, People Empowerment and Engagement, and Innovation form the group of pillars that represent the development highways. Infrastructure development, human capital development, and bridging the digital divide are fundamental requirements to enable construction of these development highways.

IDT and data centers provide enormous economic and social benefits to countries. It is essential, therefore, for governments in LAC, their partners, and ICT industries to work together to promote and nurture the expansion of ICT and data centers.

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Annexes

Annex 1: Data Center Development Index

TABLE A1 **DCDI Pillars and Indicators**

Indicator	Source
Pillar 1: Economic Development	
GDP per capita	2014, World Bank
Foreign direct investment	2014, UNCTAD
CO_2 emissions per capita	2011, World Bank
Pillar 2: Fundamental Infrastructure	
Industry electricity prices	Various sources
Telco OpEx per revenue	2Q 2015, GSMA Intelligence
3G network coverage, population	2Q 2015, GSMA Intelligence
4G network coverage, population	
Pillar 3: Connectivity	
Median fixed upload speed	2014, Cisco Global Cloud Index
Median fixed latency	
Median mobile upload speed	
Median mobile latency	
Fixed broadband penetration	2014, ITU
Mobile broadband penetration	
International internet bandwidth	
Pillar 4: Data Center Infrastructure	
Number of secure servers per mil.	2015, World Bank
Number of data centers	DataCentermap.com
Number of internet exchange points (IXPs)	Packet Clearing House

(continued on next page)

TABLE A1 DCDI Pillars and Indicators *(continued)*

Indicator	Source
Pillar 5: Critical Infrastructure Protection	
Number of data center locations	DataCentermap.com
Adjusted Geographic Redundancy Index	Designed by NEC[a]
Natural Disaster Risk Index	2013, UNU-EHS
Auxiliary Pillar	
Land area	2015, World Bank
Population size	2014, World Bank
Percentage of individuals using the Internet	2014, ITU

Notes: Unavailable data was computed as "0 (poor)."[b]
"Pillars and Indicators of DCDI" and "Methodology of DCDI Analysis " will be discussed in ITU (forthcoming).
[a] Computed using DataCentermap.com accessed on May/2016.
[b] Pillar (2) Telco OpEx per revenue; Barbados, Belize, Costa Rica, Nicaragua, Suriname, Venezuela, Vietnam. 4G network coverage, population; Barbados, Belize, El Salvador, Guyana, Haiti, Jamaica, Panama, Suriname, Trinidad and Tobago, Vietnam.
Pillar (3) Fixed upload speed and latency; Suriname Mobile upload speed and latency; Bahamas, Barbados, Belize, Ecuador, Guyana, Haiti, Jamaica, Suriname. Fixed Broadband penetration; Haiti
Mobile Broadband penetration; Bahamas, Haiti
International Internet Bandwidth; Bahamas, Haiti

TABLE A2 DCDI for 48 Countries

Country	P1	P 2	P3	P 4	P 5	DCDI
Argentina	0.39	0.60	0.33	0.10	0.32	**0.29**
Australia	0.76	0.79	0.45	0.29	0.40	**0.45**
Bahamas	0.41	0.27	0.14*	0.04	0.31	0.20
Barbados	0.37	0.19*	0.33*	0.05	0.33	0.24
Belize	0.34	0.25*	0.12*	0.05	0.26	0.18
Bolivia	0.34	0.55	0.21	0.02	0.29	**0.22**
Brazil	0.66	0.40	0.34	0.05	0.39	**0.30**
Canada	0.73	0.83	0.48	0.25	0.48	**0.47**
Chile	0.47	0.58	0.35	0.05	0.21	**0.26**
Colombia	0.43	0.54	0.31	0.02	0.28	**0.25**
Costa Rica	0.38	0.24*	0.31	0.03	0.15	0.18
Denmark	0.61	0.57	0.68	0.39	0.43	**0.50**
Dominican Republic	0.35	0.57	0.23	0.01	0.21	**0.20**
Ecuador	0.35	0.67	0.16*	0.02	0.26	0.22
El Salvador	0.34	0.46	0.16	0.00	0.14	**0.16**
Finland	0.60	0.60	0.57	0.32	0.37	**0.44**
France	0.59	0.57	0.48	0.59	0.71	**0.60**
Germany	0.52	0.49	0.46	0.72	0.73	**0.63**
Guatemala	0.35	0.54	0.14	0.00	0.09	**0.15**
Guyana	0.33	0.37	0.02*	0.00	0.20	0.13

(continued on next page)

TABLE A2 DCDI for 48 Countries *(continued)*

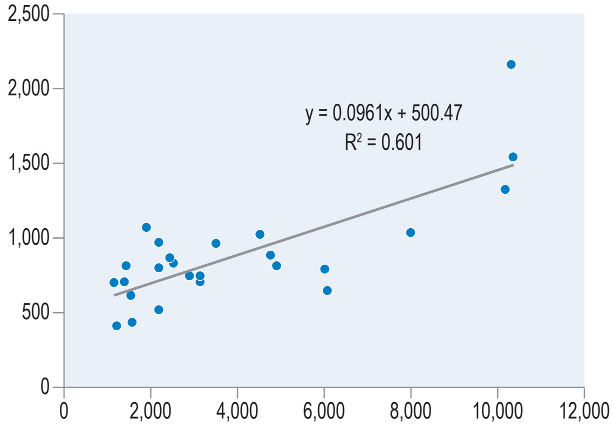
Country	P1	P 2	P3	P 4	P 5	DCDI
Haiti	0.33	0.21	*0.11**	0.00	0.20	0.14
Honduras	0.34	0.54	0.21	0.01	0.21	**0.20**
India	0.48	0.35	0.20	0.00	0.38	**0.24**
Indonesia	0.43	0.61	0.24	0.01	0.30	**0.25**
Italy	0.52	0.65	0.36	0.16	0.45	**0.37**
Jamaica	0.34	0.35	*0.17**	0.02	0.19	0.17
Japan	0.45	0.68	0.66	0.40	0.27	**0.45**
Korea, Rep.	0.42	0.74	0.74	0.39	0.29	**0.47**
Malaysia	0.37	0.63	0.30	0.07	0.36	**0.29**
Mexico	0.46	0.53	0.30	0.01	0.31	**0.25**
Netherlands	0.66	0.60	0.60	0.67	0.58	**0.62**
Nicaragua	0.34	*0.30**	0.22	0.01	0.17	0.16
Panama	0.39	0.34	0.27	0.06	0.26	**0.22**
Paraguay	0.35	0.71	0.21	0.01	0.31	**0.24**
Peru	0.39	0.55	0.26	0.02	0.26	**0.23**
Philippines	0.37	0.57	0.30	0.02	0.01	**0.16**
Portugal	0.45	0.68	0.44	0.10	0.38	**0.35**
Russian Federation	0.38	0.69	0.53	0.04	0.34	**0.33**
Singapore	0.91	0.68	0.85	0.29	0.32	**0.51**
Spain	0.55	0.57	0.41	0.20	0.47	**0.39**
Suriname	0.35	*0.37**	*0.10**	0.01	0.24	0.17
Sweden	0.65	0.82	0.68	0.53	0.45	**0.58**
Thailand	0.38	0.76	0.34	0.06	0.29	**0.29**
Trinidad and Tobago	0.12	0.65	0.33	0.03	0.26	**0.23**
United Kingdom	0.85	0.67	0.58	0.81	0.97	**0.80**
Uruguay	0.41	0.60	0.40	0.02	0.32	**0.28**
Venezuela	0.34	0.55	0.07	0.00	0.28	**0.19**
Vietnam	0.37	*0.21**	0.30	0.02	0.20	**0.19**

Source: Analysis by NEC Corporation with IDB cooperation.

Additional Analysis of Indicators

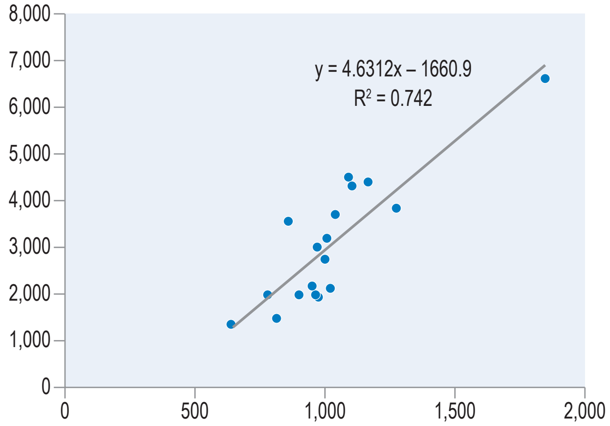
Cisco Cloud Index measures median download and upload speeds in kbps and median latencies in milliseconds for both fixed (wired) and mobile (wireless) channels. There is a strong correlation between download and upload speeds for LAC countries. The correlation values are 0.79 and 0.93 for fixed and mobile channels, respectively, in LAC countries, see Figure A1. The values for all the countries considered are 0.82 and 0.97 for fixed and mobile channels, respectively (see Figure A2). Furthermore, regression models for upload vs. download speed show very high approximation quality.

FIGURE A1 **Fixed Upload and Download Speeds and Regression Model Approximation for LAC Countries**



Source: Analysis by NEC Corporation with IDB cooperation.

FIGURE A2 **Mobile Upload and Download Speeds and Regression Model Approximation for LAC Countries**



Source: Analysis by NEC Corporation with IDB cooperation.

Annex 2: Examples of Data Center-Related Policies

Data Centers and Greenhouse Gas Emissions[24]

In 2006, the Tokyo Metropolitan government announced the Tokyo Climate Change Strategy, which will slash its greenhouse gas emissions by 25 percent by 2020 from 2000 levels. To achieve this goal, the Tokyo Metropolitan government revised its environmental regulation and set the Tokyo Cap and Trade, which was Japan's first regulation mandating companies and citizens to reduce greenhouse gas emissions.[25] The first compulsory reduction target rate from 2010 through 2014 was set at 8 percent for the industrial sector, including office buildings.

Data centers consume a considerable amount of electricity, and saving energy in data centers is a major challenge. Thus, data centers are required to comply with emissions reduction targets.

The estimated annual greenhouse gas emissions from 1.02 million servers located in Tokyo in 2012 was 1.7 million tons. The Japan Data Center Council (JDCC) estimated that, if consolidated, these servers in data centers would reduce annual greenhouse gas emissions by 15 percent, or about 250,000 tons. Furthermore, virtualizing and consolidating servers in data centers would cut emissions by 40 percent or approximately 680,000 tons.[26] Given the high greenhouse gas emissions from data centers, the contribution of data centers with higher energy efficiency is clearly highlighted in a quantitative way.

The Environmental Bureau set up the recognition system of environment-conscious data centers for data center operators. It also devised a financial incentive program for small and mid-sized companies, which covers one-third of their ICT asset relocation expenses from their on-premise environment to data centers.

Colombian Government: Using Kioscos Vive Digital for Rural Development

The Colombian government, through the Ministry of Information Technology and Communications, is promoting an initiative called Kioscos Vive Digital. The initiative provides public internet access points (Kioscos), usually located in schools and other common areas, in remote rural zones in Colombia. To date, 6,889 Kioscos have been installed.

It is impossible to establish communication infrastructure in the jungles and high in the mountains. Therefore, satellite access to global channels and local distribution using wireless technologies schema is the only way to connect remote rural communities to Internet highways.

People in remote communities can connect to the Internet and receive free training in the use and appropriation of ICT. In addition, users can access other services, such as telephony, scanning, printing, and copying. Mainly, internet and telephony access is provided using satellite communication between each remote location and the service provider in the capital cities across the country. Today, thanks to Kioscos Vive Digital, nearly every Colombian has access to ICT and fully participates in life as a digital citizen.

Corporate Tax and the Decentralization of Data Centers[27]

The Ministry of Internal Affairs and Communications of Japan (MIC) promotes the decentralization of data centers currently centralized in the Greater Tokyo Area. In 2016, about 60 percent of Japan's data centers were located in the Tokyo Area. Given the forecast that Tokyo inland earthquakes will occur with 70 percent probability in the next 30

[24] This example is provided by the Tokyo Metropolitan government and Japan Data Center Council (JDCC).

[25] See http://www.dir.co.jp/souken/research/report/esg/es/09073101law.pdf.

[26] See https://www.itscj.ipsj.or.jp/hasshin_joho/hj_forum/files/20120521.pdf.

[27] This example is provided by NEC with the cooperation of the Ministry of Internal Affairs and Communications, Japan.

years, it is necessary to promote backup of these data centers from the Tokyo Area to other areas.

However, data centers located in other areas are more expensive than in the Greater Tokyo Area in terms of communication pathways.

In addition, investing in backup facilities often does not guarantee profitability. This hinders the establishment of new data centers in other areas. MIC provides tax incentives for data center operators who decide to invest in building data centers in other areas. This activity should improve the nation's ICT infrastructure and make it disaster-resistant by increasing geographic redundancy.

Data center operators with an investment plan approved by the government are eligible for a corporate tax rate that provides a 10 percent special depreciation of electric communication facilities (servers, routers, switches, UPS, and emergency power generation). Equipment eligible for the 10 percent depreciation should be purchased in accordance with the operator's investment plan approved by MIC.[28]

Connected Homes Initiative in Costa Rica

The Connected Homes Program is a national social program that uses ICT to achieve some of the main strategic SDGs for Costa Rica. The Vice Presidency, the Presidential Social Council, and the Ministry of Human Development and Social Inclusion lead this program. The goal for 2018 is to lift 55,000 families out of poverty. This represents almost 250,000 people (5 percent of population).

The Role of Continuously Enhanced e-Government in Increasing Disaster Resiliency

The government of the Philippines formed its E-Government Master Plan (EGMP) and has been promoting digitized government all over the country.[29] It is envisioned to create "a digitally empowered and integrated government that provides responsive and transparent online citizen-centered services for a globally competitive Filipino nation."[30] In the master plan, the Integrated Government Philippines (iGovPhil), led by the Department of Science and Technology (DOST), is the most important activity. The goal of iGovPhil is to improve public administration, transparency and accountability, citizen services, and citizen's participation in government activity by implementing e-government. The Government Data Center Project, which is a part of the e-Government Harmonization and Development Program, integrates a number of agencies that operate their own data centers or outsource their data centers, and optimizes ICT resources and operations.

Furthermore, the Philippines has been ranked third in the world in terms of high natural disaster risk, according to the Institute for Environment and Human Security of United Nations University (UNU-EHS) (UNU, 2015). The government of the Philippines has sophisticated ICT-based disaster prevention systems, which play an important role at each stage of disaster risk reduction and management (DRRM), namely, prevention and mitigation, preparedness, response, and recovery and rehabilitation.

[28] See http://www.soumu.go.jp/main_content/000352762.pdf.

[29] See http://i.gov.ph/wp-content/uploads/2015/12/egmp-2.0-popular-version_final.pdf.

The EGMP's first period is 2013 through 2016; the second period is from 2016 through 2022, as the EGMP 2.0 preliminarily revealed at the end of 2015.

[30] See http://www.dict.gov.ph/introduction-and-overview-of-e-government-in-the-philippines/.

IDB