MEXICO SOUTHERN STATES STUDY

SECTOR ASSESSMENT: ICT IN YUCATÁN

WORLD BANK GROUP
THE WORLD BANK IBRD • IDA
IFC International Finance Corporation

Mexico Southern States Study

Sector Assessment: Information and Communication Technology in Yucatán

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Cover and interior design: Designed for Humans, LLC, Alexandria, VA.

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Acknowledgments

The Mexico Southern States Deep Dives were prepared by a team composed of Fernando Blanco, Carlos Zafra, David Bassini, Enrique Cruz, and Karla Petersen, with support from Sean Lothrop and Patrick Ibay for editing, design, and publication.

Sector-specific, in-depth contributions were provided by Gabriela Olvera Cravioto, Sophia Herrou, Andres Garcia-Novel, Alejandro González Morgado, Diana Ruan Hernández, Ken Ijichi, William Sonneborn, Stevon Darling, Ami Dalal, and many other colleagues from the International Finance Corporation (IFC) industries.

The team is grateful to private sector representatives who generously shared their time and insights.

World Bank and IFC peer reviewers Jose Ernesto López Cordova, Eduardo Olaberria, Santiago Justel, Rafael Muñoz Moreno, Viviana Vallejo, Maria Paulina Mogollon, and Emmanuel Pouliquen provided valuable comments.

The team is grateful to Tatiana Nenova for her support and guidance throughout the preparation of the report. The team would like to thank Alfonso García Mora, Martin Spicer, Juan Gonzalo Flores, and Mona Haddad for their support and valuable insights, as well as Zeinab Partow and Miles McKenna for their help in the publication process. The team also thanks Adriana Arreaza Coll and Elizabeth Ann Marcano for the support they provided in the lead-up to the publication of the report.

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A forthcoming Country Private Sector Diagnostic (CPSD) will provide a broader view on the main challenges and opportunities for private sector development in Mexico, complementing the findings of these Deep Dives at the regional level. The CPSD and the Deep Dives will be mutually reinforcing, as the national coverage of the former will offer a more comprehensive view of the economic structure, constraints and opportunities for private sector investment in the country while the latter offers more granular analytics on the state of the economy and the private sector in Mexico's poorest region.

Abbreviations

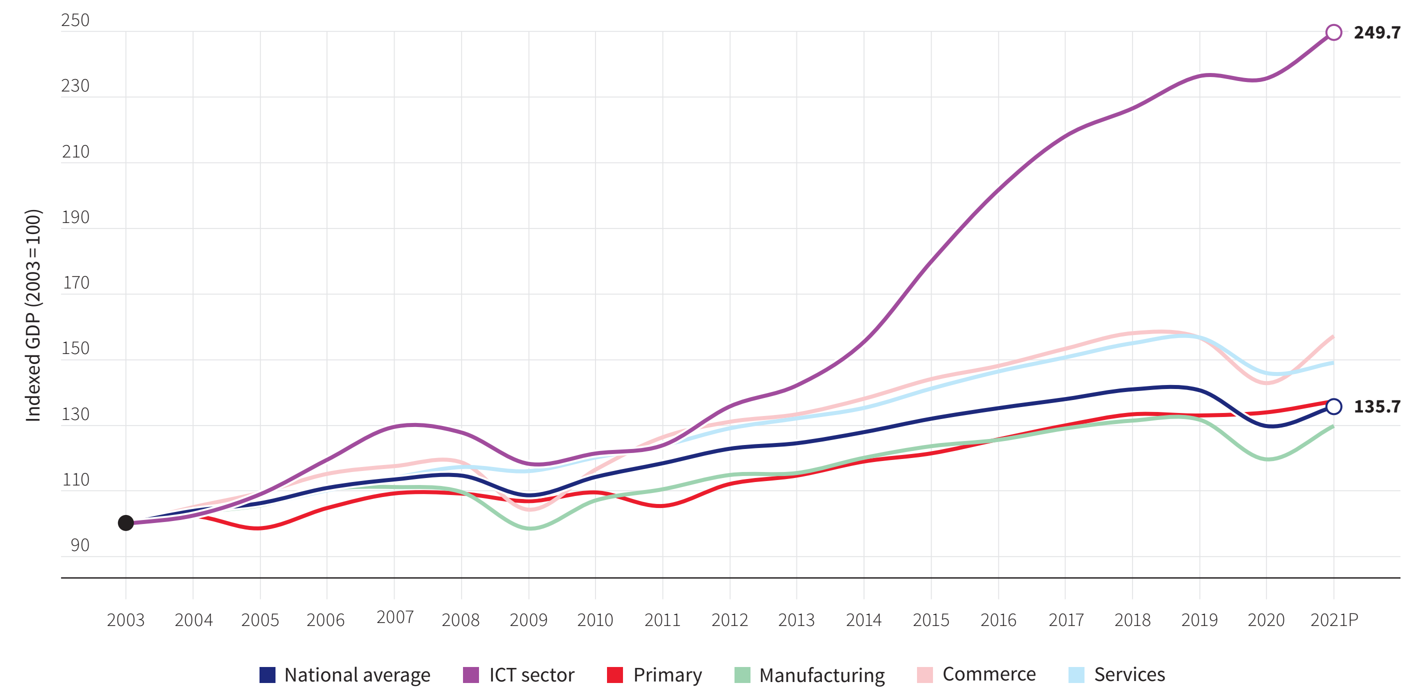
2G	second generation
3G	third generation
4G	fourth generation
5G	fifth generation
Bancomext	*Banco Nacional de Comercio Exterior*
BPO	business process outsourcing
CFE	*Comisión Federal de Electricidad* (Federal Electricity Commission)
CNBV	*Comisión Nacional Bancaria y de Valores*
DENUE	*Directorio Estadístico Nacional de Unidades Económicas*
EBITDA	earnings before interest, taxes, depreciation, and amortization
EDUTIH	*Encuesta Nacional sobre Disponibilidad y Uso de Tecnologías de la Información en los Hogares*
ENCRIGE	*Encuesta Nacional de Calidad Regulatoria e Impacto Gubernamental en Empresas*
FDI	foreign direct investment
GDP	gross domestic product
GVCs	global value chains
HS	Harmonized System
ICT	information and communication technology
IFT	*Instituto Federal de Telecomunicaciones* (Federal Telecommunications Institute)
IT	information technology
ITO	information technology outsourcing
KPO	knowledge process outsourcing
Nafin	*Nacional Financiera*
NAICS	North American Industry Classification System
OECD	Organisation for Economic Co-operation and Development
PPP	public-private partnership
Prosoft	*Programa para el Desarrollo de la Industria de Software y la Innovación*
SC	*Secretaría de Cultura* (Secretariat of Culture)
SEZ	special economic zone
SIIDETEY	*Sistema de Investigación, Innovación y Desarrollo Tecnológico del Estado de Yucatán* (Yucatán State Research Innovation, and Technological Development System)
SMEs	small and medium enterprises
SMS	short message service
UNCTAD	United Nations Conference on Trade and Development

Overview

In 2019, the global information technology sector registered a market value of US$4 trillion, representing 4.4 percent of global gross domestic product (GDP). During 2007–19, the sector grew 1.5 times faster than global GDP. Moreover, it stands at the center of the digital economy, which was already worth more than 15 percent of global GDP in 2016 and is projected to exceed more than 25 percent by 2025. In line with these global trends, information and communication technology (ICT) sector in Mexico has seen rapid expansion in recent decades. Between 2003 and 2021, the sector concentrated approximately 8 percent of total foreign direct investment (FDI) received by the country. During the same period, the total value added generated by the sector increased by 150 percent (figure O.1), fueled by a 537 percent expansion in the telecommunications industry that contributed to 91.1 percent of this growth (figure O.2).

FIGURE O.1

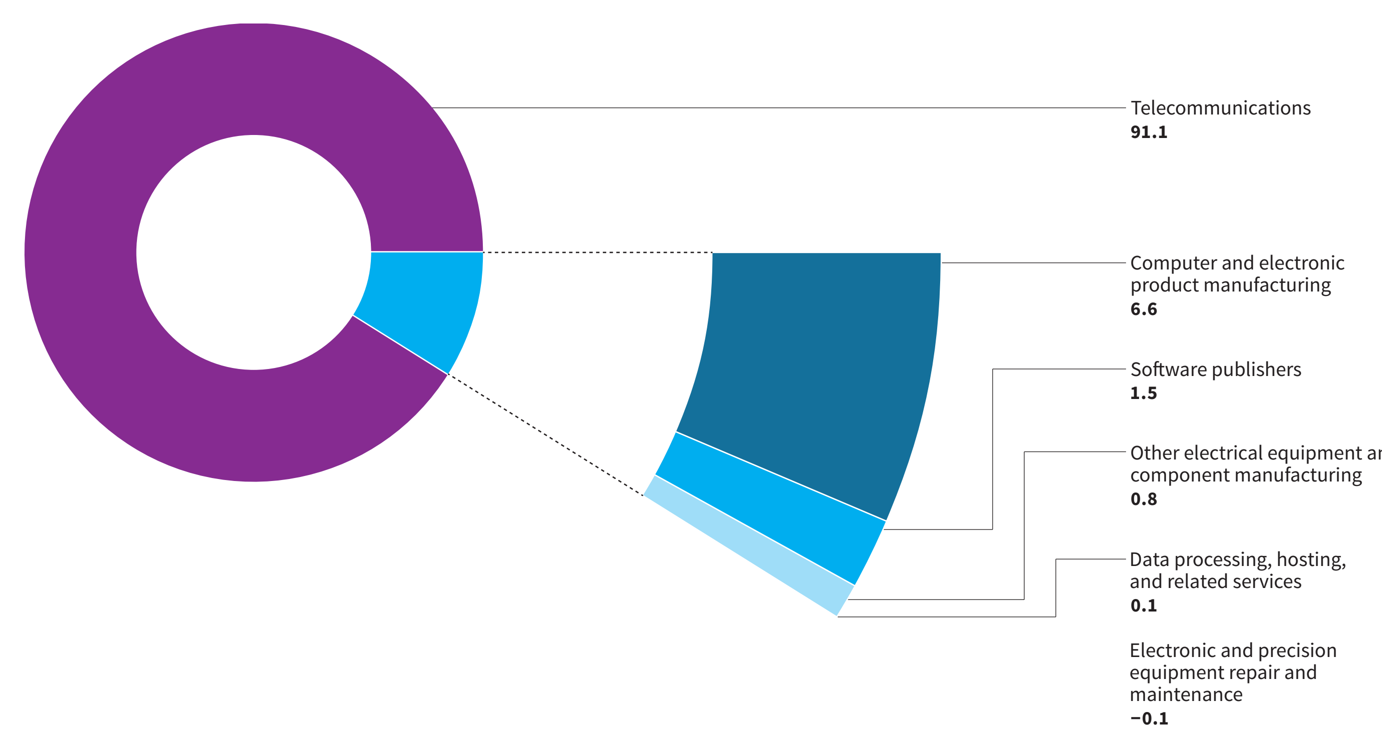
Growth of the Mexican ICT Sector



Source: Based on data from INEGI's National Accounts (various years).
Note: GDP = gross domestic product; ICT = information and communication technology; P = preliminary.

FIGURE O.2

Decomposition of the ICT Sector's Growth, 2003–21



Source: INEGI's National Accounts (various years).
Note: ICT = information and communication technology.

Yucatán holds the potential to become a key player in the domestic and global ICT markets. When analyzing the ICT sector, two large segments are considered: ICT manufacturing and ICT services. Between 2003 and 2021, the value added generated by the ICT sector in Yucatán grew by 143.4 percent, with the majority corresponding to ICT services. However, on a national level, Yucatán's ICT sector remains relatively modest, contributing only 2.3 percent to the sector's value added generated in Mexico. Although the state's ICT-related manufacturing industry is still in its early stages of development, Yucatán's emerging "knowledge economy" ecosystem fosters a robust ICT sector growth. The state boasts sector-enabling infrastructure, including a dozen of public academic and research institutions, two industrial innovation centers, two ICT-related industrial parks, and 25 higher education institutions with ICT-compatible curriculum. The latter include the *Universidad Politécnica de Yucatán*, a bilingual university created in 2016 to meet the labor demand in ICT industries through a curriculum defined in collaboration with the private sector.

MARKET ANALYSIS

In 2021, ICT goods exports represented 13.1 percent of global merchandise trade, while ICT service exports accounted for 14 percent of total trade in services. Between 2000 and 2021, global ICT goods exports grew by 4.1 percent per year, while global ICT service exports grew annually by 10.7 percent since 2005. The highly modular nature of the ICT manufacturing value chain and the high value-to-weight ratio of intermediate and final ICT products have enabled the rapid expansion of ICT value chains on a global scale. Mexico ranks among the top ten global ICT goods exporters, accounting for 3.1 percent of the global market. Three products account for more than 90 percent of Mexico's ICT exports: computers and peripheral equipment (49.9 percent), consumer electronics (25.9 percent), and communications equipment (17 percent). By contrast, Mexico accounts for just 0.01 percent of the global ICT service exports, and its market share declined between 2005 and 2021.

When compared to other leading countries in the global ICT industry such as France, Germany, the Netherlands, and the United States, Mexico has a cost advantage of 14.8 percent in manufacturing ICT goods and 34.4 percent in providing ICT services. The 2013 Telecommunications Reform in Mexico helped create a more competitive market, strengthened the institutional framework of the sector, introduced a shared broadband network (the *Red Compartida*), and played a key role in laying the foundation for a knowledge-based economy. Yucatán, especially in Mérida, hosts several research and academic institutions available to support the development of the ICT sector.

ICT goods make up 15.2 percent of Mexico's total goods imports, indicating that there is considerable scope to expand the domestic production of these inputs. Three goods—electronic components, computers and peripheral equipment, and communications equipment—have been identified as immediate opportunities for import substitution based on their import value and existing production capabilities in the state. Yucatán's labor productivity in manufacturing computers and peripheral equipment already exceeds the national average, ranking ninth among Mexico's 32 states. Furthermore, Yucatán's proximity to the Caribbean and Central America, as well as its connectivity to key markets in the eastern United States, can be leveraged to position itself as a regional ICT hub.

Yucatán is strategically positioned to capitalize on the growing domestic and global ICT market. The state has developed an environment conducive for a knowledge-based economy, which is supported by strong coordination between industry and academia, as well as active engagement from the state government. The presence of leading firms in the state demonstrates the viability of the industry. Moreover, large local firms have shown interest in implementing large-scale projects with ICT components in Yucatán. A forward-looking analysis conducted prior to the pandemic identified several potential investors in Yucatán's ICT sector, mostly in the services component, provided some conditions were met. Several international firms, mainly from China, and startups from economies with advanced technologies, have also shown interest in establishing operations in Mexico. Yucatán is well-positioned to attract a portion of this investment, with the nearshoring trend potentially serving to catalyze these opportunities.

Yucatán performs relatively well in state-level indicators of ICT competitiveness. Despite its location in a less developed region of the country, Yucatán is in the middle position in terms of economic innovation, internet access, and scientific and innovation capabilities, ranking 17th overall, and stands in third place for e-government procedures. The recent installation of the country's second internet exchange point node in Yucatán has increased data center efficiency, potentially attracting new related investments. Finally, the inclusion of the ICT sector in the state's 2018–24 Development Plan reinforces ongoing efforts of the government to transform Yucatán into a strategic ICT hub.

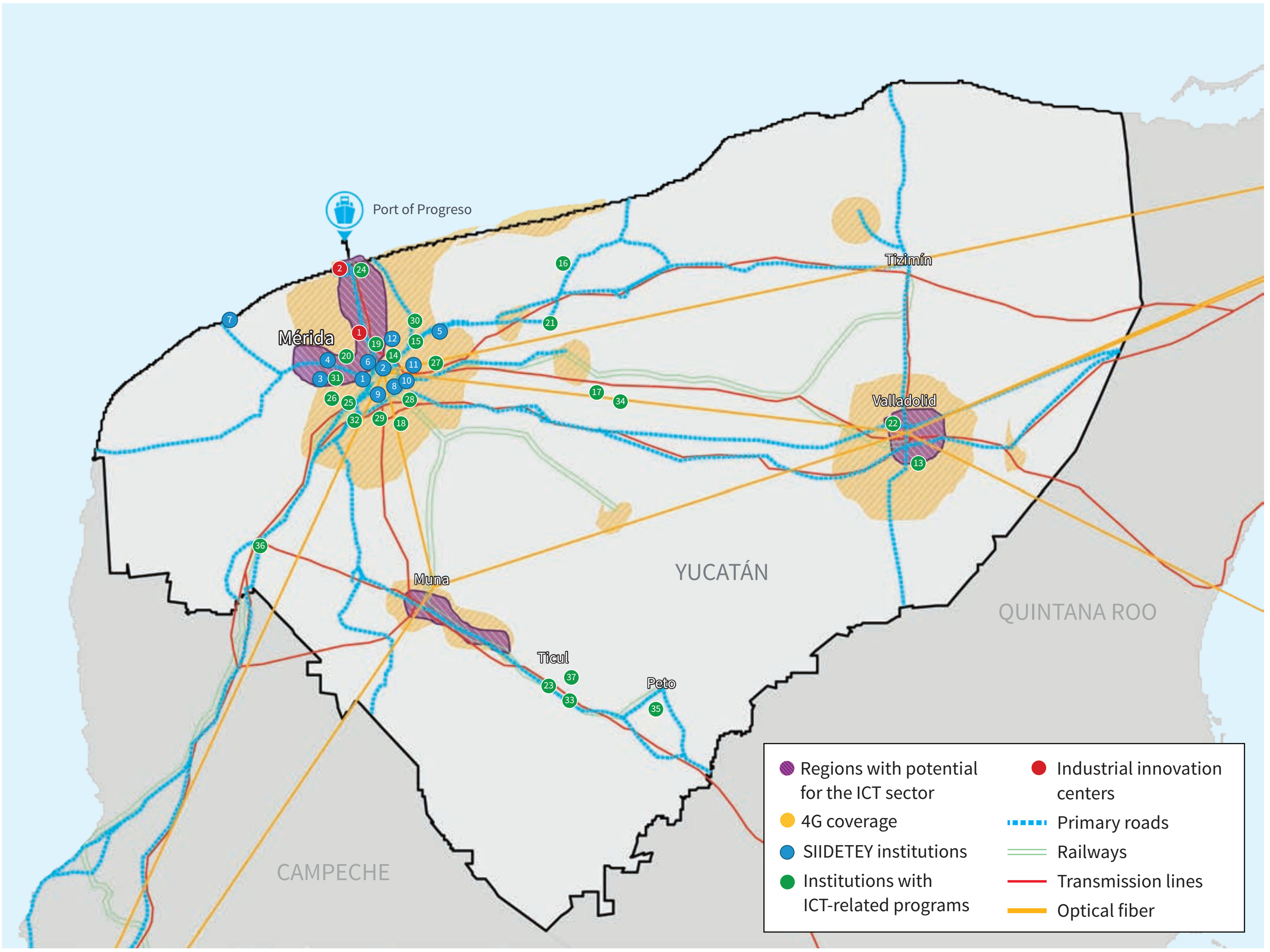
Within Yucatán, Mérida and its surrounding regions, along with the Mérida-Progreso corridor, present the most potential for ICT industry development (map O.1). The Mérida-Progreso corridor shows especially strong potential for ICT industry components manufacturing. These locations fulfill three key criteria: (1) adequate population density to ensure strong local demand and ample labor supply; (2) access to necessary transportation, energy, and telecommunications infrastructure; and (3) proximity to education and innovation centers (figure O.3).

ECONOMIC POTENTIAL

Advancing the ICT industry in Yucatán can stimulate economic diversification and increase private sector competitiveness by enhancing the efficiency of existing economic activities. Evidence shows that a 20 percent increase in ICT investment is associated with a 1 percentage-point rise in GDP growth.[1] For emerging markets, a 10 percent increase in broadband penetration is associated with a 1.4 percentage-point surge in GDP growth.[2] Investing in ICT boosts the capital available for workers, increases efficiency, spurs innovation, facilitates knowledge transfer and commercial collaboration, and expands access to new markets. As the Mexican economy continues to evolve, its demand for ICT goods and services such as computers, network access, cloud storage, open-source software, data analytics and other ICT goods and services will continue to grow. Furthermore, the COVID-19 pandemic highlighted the importance of having adequate ICT infrastructure and equipment. These resources enabled individuals, firms, and governments to adapt swiftly and continue their activities seamlessly through technology-enabled tools during this episode. The pandemic has accelerated the

MAP O.1

Potential Areas for ICT Development in Yucatán



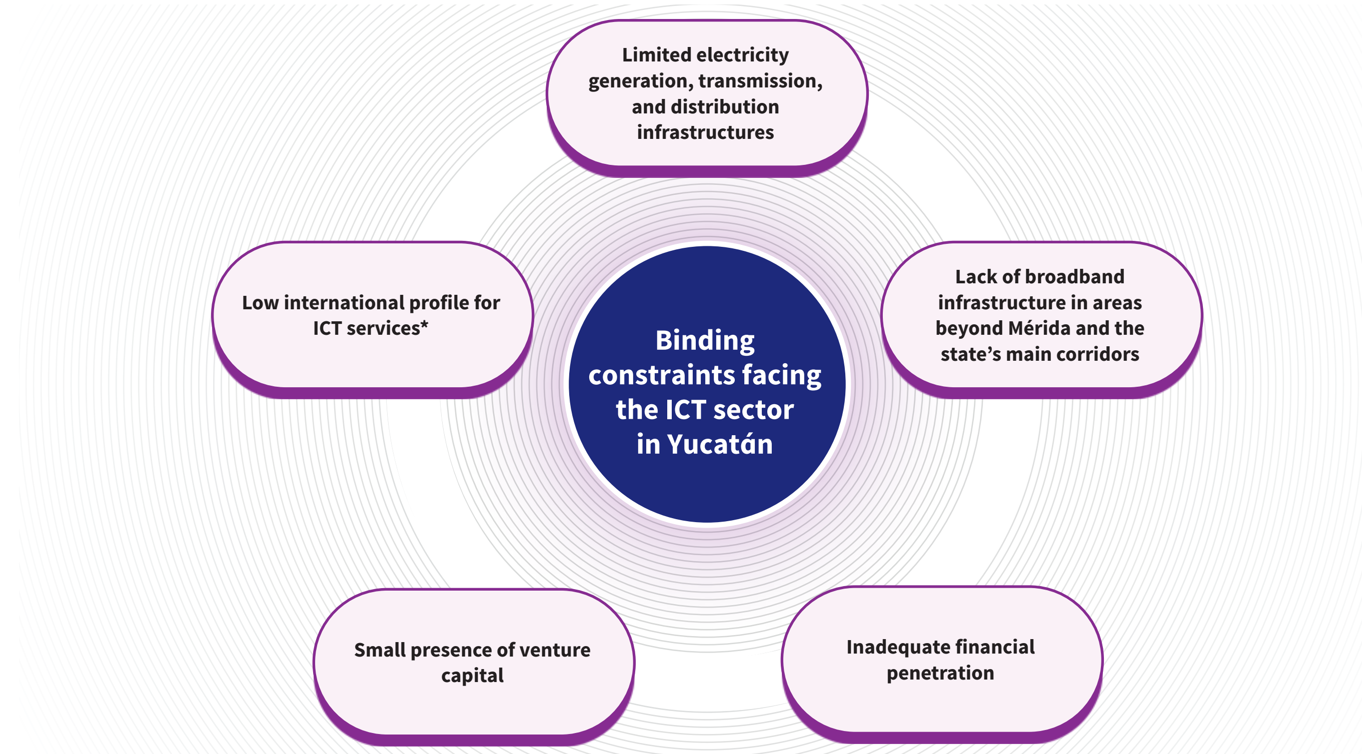
Source: Base map for primary roads, railways, ports and transmission lines was elaborated using ArgGIS with shapefiles from the INEGI's *Biblioteca digital de Mapas* 2019 edition and optical fiber location was according to Bestel n.d.
Note: 4G = fourth generation; ICT = information and communication technology; SIIDETEY = *Sistema de Investigación, Innovación y Desarrollo Tecnológico del Estado de Yucatán*. The industrial innovation centers in Progreso have approximate locations because of limited specific information. The symbols used are for representation purposes only. A qualitative estimate was made for potential ICT locations, but additional studies are required to determine definitive areas with potential. For the corresponding SIIDETEY institutions, institutions with ICT-related programs, and industrial innovation centers, see table F.1 in appendix F.

pace of digital adoption by several years in several sectors, further emphasizing the need to invest in and embrace ICTs to ensure long-term resilience and growth.

ICT firms are generally larger and more capital-intensive than the average firm at both the national and state levels. Nationally, within the ICT sector, telecommunications firms have the largest capital-to-firm ratio, while, in Yucatán, computer and electronics manufacturers hold this distinction. Telecommunications firms also have the highest ratio of capital per worker at the national and state levels. Almost all major ICT-related activities could potentially contribute to job creation in Yucatán. The most labor-intensive ICT subsector appears to be computer and electronics manufacturing, with the highest workers-to-firm ratios both nationally (431.6) and in Yucatán (128.3). Hourly wages for formal providers of ICT-related services, including internet access, web search, information processing, and other telecommunications, exceed the state average.

FIGURE O.3

High-Level Overview of Binding Constraints Facing the ICT Sector in Yucatán



Note: ICT = information and communication technology.
*Affects firms at the national and state levels.

BINDING CONSTRAINTS FACED BY THE SECTOR

The ICT sector in Yucatán is still in its early stages. According to the latest available state-level detailed export data from 2014, Yucatán accounted for just 0.002 percent of national ICT exports and 0.02 percent of ICT exporters.[3] Almost all of Mexico's ICT exports (95 percent) and ICT exporters (80 percent) were concentrated in the states of Baja California, Chihuahua, Jalisco, Nuevo León, and Tamaulipas. In 2018, the ICT sector in Yucatán composed only 0.5 percent of all firms and employed 0.4 percent of all workers in the state. Between 2003 and 2021, the state's ICT sector received 0.5 percent of Mexico's total FDI inflows in the ICT sector.

Human capital does not seem to pose a binding constraint to the ICT sector, but the continuous capacity building of the labor force will be crucial to maintain competitiveness internationally. The rapid pace of technological change demands consistent worker upskilling and retraining. Continued investment in ICT capabilities of the workforce in Yucatán will be vital to ensure they are prepared to perform new tasks in a constantly evolving industry and market.

Insufficient electricity generation, transmission and distribution, and limited communications infrastructure are significant barriers to the growth of the ICT sector, particularly in areas outside Mérida. Yucatán has limited energy generation capacity. The state only has one major high-tension transmission line and few low-tension transmission lines. This inadequate power supply deters energy-intensive firms, including ICT companies, from setting up. Although the state has good access to telephone and mobile internet services, the availability of fixed broadband internet is relatively low. Fiber-optic infrastructure in Yucatán, crucial for ICT firms, is limited and controlled by a small number of operators and extends only through the main corridors of the state (Mérida-Valladolid, Mérida-Progreso, Calkiní in Campeche-Mérida, and Mérida-Tizimín). This lack of broadband infrastructure deters the establishment of ICT companies and constrains the growth of the sector by limiting service usage and demand. However, recent projects such as the *Red Compartida* and Gignet's subsea cable system, as well as other private sector–driven initiatives in Yucatán, are enhancing the state's connectivity.

A strong legal and institutional framework, along with consistent state government support and improvements of the business climate, suggests that policy failures are not hindering ICT development. Around the world, governments have been instrumental in cultivating successful ICT sectors. Between 2007 and 2012, Yucatán saw a withdrawal of state government support that led to an existing ICT cluster being dismantled. This caused a sharp contraction in sectoral output and weakened trust in the state government's commitment to ICT.[4] However, since 2012, the state has implemented significant legal and institutional reforms designed to promote the development of the industry.

Inadequate access to finance is a binding constraint on the development of the ICT sector, especially ICT manufacturing activities and local firms. The low levels of financial penetration in Yucatán pose a challenge as 27 out of the state's 106 municipalities lack financial access points. Nationwide, interest rates for ICT-related firms are at the upper end of the spectrum both for commercial and development banks, which could reflect a higher risk or risk-aversion towards the sector. Some components of the ICT sector, particularly services, have an intangible nature, which further complicates access to finance by preventing assets from being used as collateral. In addition, venture capital, which has been critical to the industry's development in other countries, has low activity in the state. Early-stage funding, such as preseed and seed capital, may be required during the initial stages of promising projects.

Other challenges are deterring the expansion of the ICT industry, especially the services segment. These challenges include (a) weak ICT readiness at the national and state levels that reduces the domestic demand, (b) higher barriers for Mexican firms entering international markets because of the absence of a strong international reputation, and (c) growing concerns around consumer and firm data security and protection.

OPPORTUNITIES FOR GROWTH: WHAT WOULD IT TAKE TO DEVELOP THE SECTOR?

To keep the telecommunications and broadcasting sectors open to competition, promote innovation, and encourage the entry of new suppliers, active government oversight will be needed. Robust competition will hinge on the efficient allocation and management of spectrum frequencies, as well as maintaining a regulatory framework that provides certainty to investors and promotes infra-

structure-sharing. Authorities must also ensure that the deployment of the *Red Compartida* project continues, lay fiber-optic cables alongside feasible segments of the Mayan Train, and promote the development of a certified data center to host ICT firms that utilize data storage and cybersecurity services. In addition, promoting the development of 5G-enabling projects in the state and in the region could significantly boost Yucatán's competitiveness in ICT.

Regular collaboration between the private sector, the government, and academia will be key to identifying and developing the workforce skills necessary for the development of the ICT industry and consolidation of Yucatán's two industrial innovation centers. This collaboration could also increase the state's access to federal government financing, helping to level the playing field across states. Establishing a public-private agency responsible for identifying and attracting ICT projects, consolidating existing industry clusters, and coordinating the creation of a one-stop shop for regulations and permits could accelerate the development of the ICT sector. Efforts to simplify regulatory compliance could be complemented by offering "smart incentives" to attract anchor firms and promote technology transfer to small and medium enterprises (SMEs).

Developing a network of incubators and accelerators could encourage the growth of new ventures in Yucatán's ICT sector. Under the guidance of the public-private agency for the ICT sector, this network could nurture early-stage ventures and provide them with necessary administrative, legal, and technical support. The network could also connect projects with potential investors, and train teams in delivering an effective financing pitch. These incubators and accelerators could also provide valuable real-world experience for local students in ICT-related fields such as engineering, computer science, and mathematics, enabling them to gain exposure to the various stages of project development.

Enhancing ICT uptake and usage to increase the demand for ICT services and generate enough revenues and returns for ICT investments. To initiate this, pilot programs could be launched to promote digitalization and support the use of connected devices, artificial intelligence, machine learning, and virtual reality services in key economic sectors such as transportation, agriculture, manufacturing, health care, education, energy, and urban services. Incentivizing ICT demand can also be achieved by offering subsidized computer equipment, public internet access, and training courses for students and SMEs. Launching periodic hackathons can also address challenges faced by the public and private sectors using ICTs. Furthermore, efforts to transform Mérida as southern Mexico's first "smart city" could accelerate the adoption of 5G technology.

Facilitating access to finance through sector-specific programs that reflect the unique requirements of the ICT industry can promote competition and enable the growth of efficient firms. Prosoft (currently unfunded)[5] could be revived, enhanced and linked to financial programs offered by development banks. The government could facilitate access to this and similar programs by improving the information and guidance provided to companies. To address information asymmetries and lower search costs, a special advisory and support window, linked to the proposed one-stop shop for regulatory compliance, could be established specifically for Yucatán and other southern states with potential for ICT development. Finally, complementing public financial instruments with measures to attract venture capital to Yucatán will be crucial to the development of the ICT sector.

Table O.1 summarizes the policy recommendations for developing the ICT sector in Yucatán.

TABLE O.1

Policy Recommendations Matrix

	Infrastructure
	➔ Expand the broadband coverage in Mexico and in Yucatán by ensuring that the "*Red Compartida*" project remains uninterrupted and financially viable. ➔ Consider laying fiber-optic cables alongside feasible segments of the Mayan Train, to take advantage of this infrastructure to connect more regions in Yucatán. ➔ Consolidate maritime routes to coastal cities in the Gulf of Mexico (both Mexico and U.S. ports) and Latin America to ensure access to raw materials and other intermediate goods for ICT products. ➔ Promote public-private infrastructure investments to enable 5G connectivity. These investments should not only focus on dedicated 5G networks but also include the necessary complementary ICT infrastructure that can be shared with them.
	Sector-specific support
	➔ Establish a public-private agency tasked with identifying and attracting potential ICT projects (manufacturing and services) from different regions of the country and abroad. The agency would focus on consolidating ongoing and new projects in Yucatán, supporting investment promotion, and facilitating links between those projects and support programs in the state. ➔ Promote the development of a certified data center in Yucatán. This initiative aligns with Yucatán's internet exchange point, making it a natural progression, and would position the state as an ICT industry leader not only in southern Mexico but also in Central America. ➔ Collaborate with key stakeholders, such as technological parks, research and academic institutions, and local government authorities, to develop a network of incubators and accelerators aimed at encouraging new ventures in the ICT sector in Yucatán. ➔ Continue strengthening the collaboration between industry, government, and academia (triple helix model) to redesign the academic curricula and create education programs that provide students and professionals with the skills and readiness for the ICT sector. ➔ Support digitalization pilot programs and initiatives aimed at accelerating and deepening the adoption of Internet-of-Things devices, artificial intelligence, machine-type services, and augmented or virtual-reality services in key sectors of the economy.
	Investment climate, competition, and government interventions
	➔ Foster open competition, actively promoting innovation and the participation of new providers in the telecommunications and broadcasting sectors. ➔ Create a single window or one-stop shop dedicated to the ICT Industry, in coordination with all levels of government to integrate, minimize, and facilitate regulatory compliance for new investments or the expansion of existing firms. ➔ Promote digital inclusion by providing subsidized computer equipment and establishing public internet access points to students and SMEs. Consider complementing this initiative with training courses for students tailored to different levels of education, and SMEs in utilizing relevant business software. ➔ Consider providing land grants for major private investment projects, contingent upon the development of last-mile infrastructure or fulfillment of investment and job generation goals. Complement the establishment of ICT clusters by designing nondistortionary incentives to attract anchor firms and promote technology transfer to SMEs.
	➔ Consider increasing government funding for innovation and technology research institutions in the state, particularly those linked to ICT clusters.

(Table continues next page)

TABLE O.1

Policy Recommendations Matrix *(continued)*

	Access to finance
	➔ Engage and coordinate with development banks to establish sector-specific programs for ICT ventures, considering the unique needs of the ICT industry and the intangible nature of the ICT services sector. A joint effort from Bancomext and Nafin is strongly recommended. ➔ Promote the growth of venture capital in the state's ecosystem, which is key for the industry's development. ➔ Engage in partnerships with multilateral institutions to establish a platform that provides financial support and "business know-how" to ICT entrepreneurs and early-stage companies. This could encourage disruptive technologies or initiatives to address the digital gap.

Note: 5G = fifth generation; Bancomext = *Banco Nacional de Comercio Exterior*; ICT = information and communication technology, Nafin = *Nacional Financiera*; SMEs = small and medium enterprises.

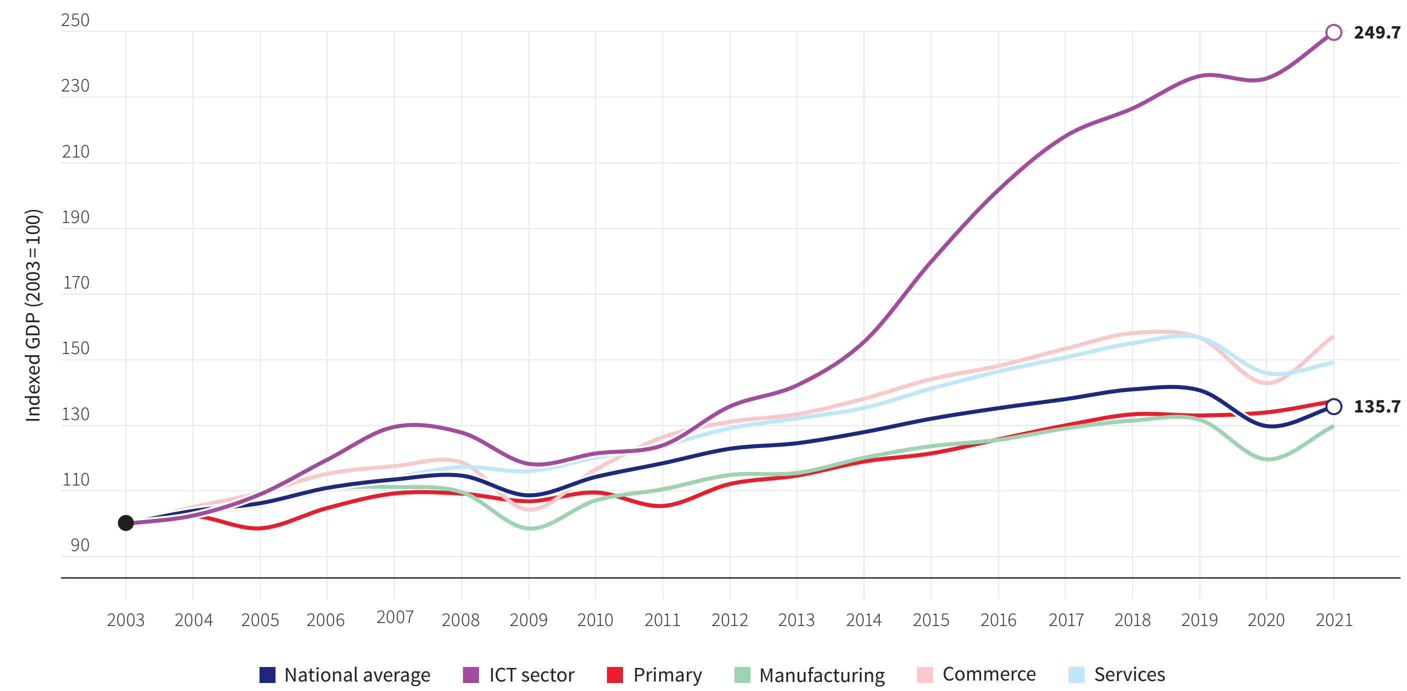
1

The ICT Sector in Mexico

The information and communication technology (ICT) sector in Mexico has experienced rapid growth in recent decades, expanding its share in the nation's economy. Between 2003 and 2021, value added by the sector in Mexico rose by 150 percent (figure 1.1), and its share of the country's gross domestic product (GDP) grew from 2.7 to 4.9 percent. Driving this growth is the telecommunications industry, expanding by approximately 537 percent over the period and contributing approximately 91 percent of the overall growth of the ICT sector (figure 1.2). In 2019, the ICT sector employed 2.5 percent of workers and included 0.4 percent of all firms in the country. The average firm size in the ICT sector was 32 workers—significantly higher than the average for the overall economy of 5.6 workers per firm. Furthermore, the value of the Mexican information technology (IT) market was estimated at US$10.4 billion in 2020 and was projected to rise to US$13.5 billion in 2021.[6]

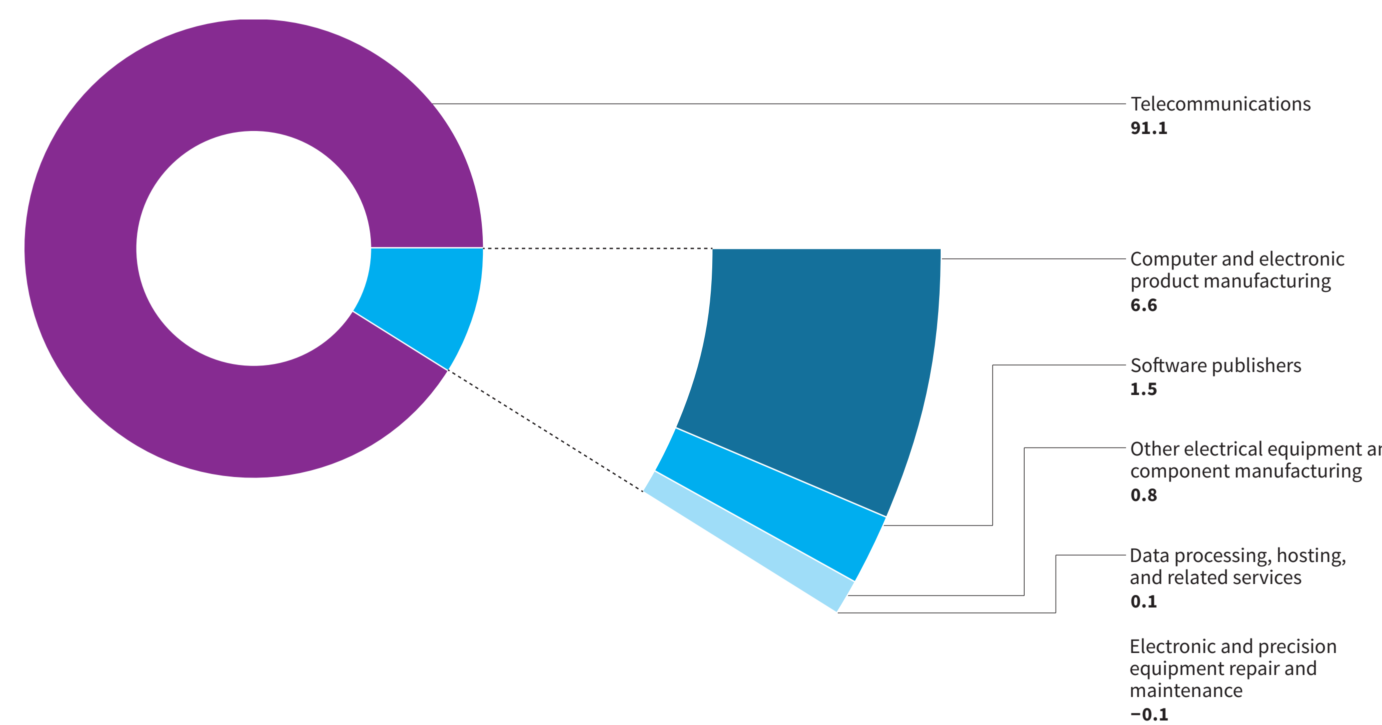
The ICT sector consists of two major components: ICT manufacturing (including hardware) and ICT services (including software). ICT manufacturing encompasses computer and peripheral equipment manufacturing (North American Industry Classification System [NAICS] four-digit code 3341); communications equipment manufacturing (3342); audio and video equipment manufacturing (3343); electronic component manufacturing (3344); navigational measuring, medical, and control instruments manufacturing (3345); manufacturing and reproducing magnetic and optical media (3346); communication and energy wire and cable manufacturing (NAICS six-digit code 335920); reproducing magnetic and optical media (3346); communication and energy wire and cable manufacturing (NAICS six-digit code 335920); and carbon and graphite product manufacturing (335991). ICT services encompasses software publishing (5112); wired and wireless telecommunications (5173); satellite telecommunications (5174); other telecommunications (5179); data processing, hosting, and related services (5182); and repairing and maintaining electronic and precision equipment (811219). The NAICS breakdown in INEGI's national accounts data does not go beyond four digits, so economic activities with NAICS six-digit codes like communication and energy wire and cable manufacturing (335920), carbon and graphite product manufacturing (335991), and other electronic and precision equipment repair and maintenance (811219) are included in their respective NAICS four-digit code aggregates.

FIGURE 1.1
Growth of the Mexican ICT Sector



Source: Based on data from INEGI's National Accounts (various years).
Note: GDP = gross domestic product; ICT = information and communication technology. Data for 2021 are preliminary.

FIGURE 1.2
Decomposition of the Mexican ICT Sector's Growth, 2003–21 (percent)



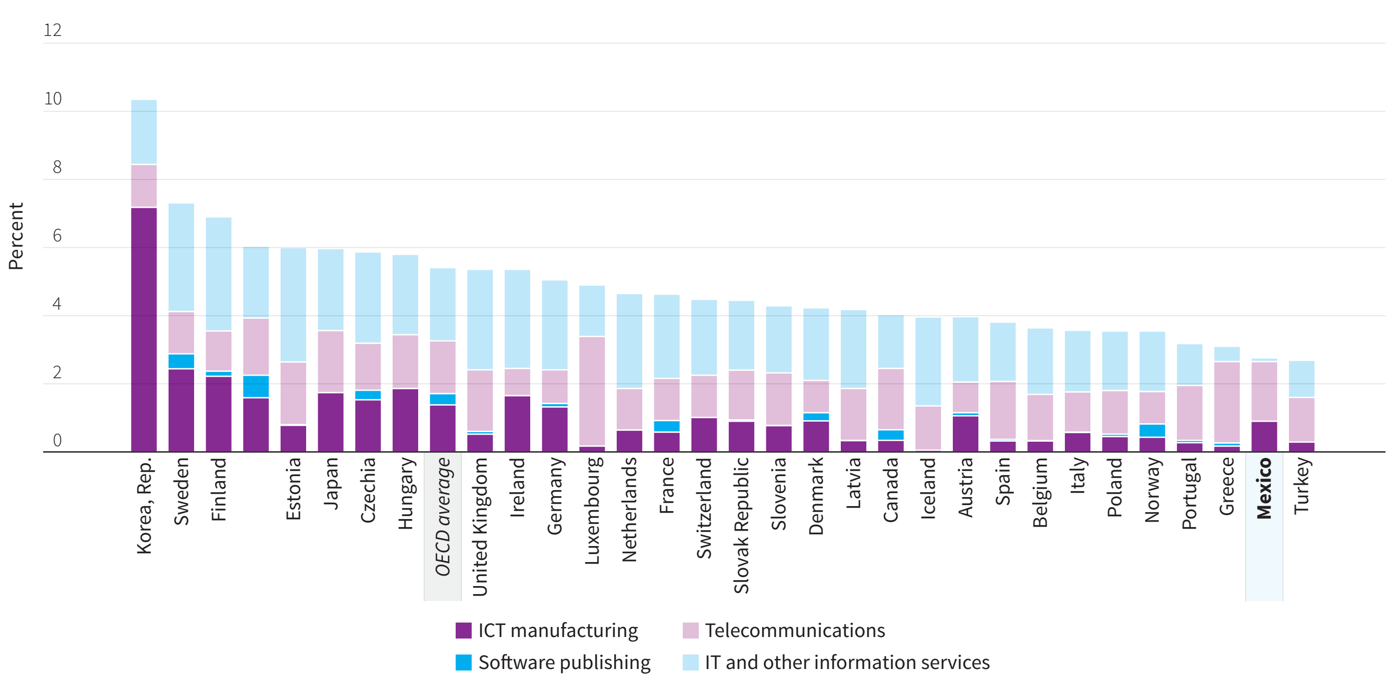
Source: INEGI's National Accounts (various years).
Note: ICT = information and communication technology.

However, the Mexican ICT sector is less mature compared to those in other Organisation for Economic Co-operation and Development (OECD) countries. In Mexico, the value added by the ICT sector represents about 2.75 percent of total value addition, which is the second lowest level among its OECD peers. This is mainly because of the dominance of the telecommunications industry and the limited contribution of software publishing, IT, and other information services. The ICT manufacturing subsector in Mexico contributes 0.9 percent to total added value, which is significantly lower than the OECD average of 1.4 percent. By contrast, the telecommunications sector contributes 1.75 percent to total added value, slightly above the OECD average of 1.6 percent (figure 1.3).

Investment trends suggest that the Mexican ICT sector is profitable. Mexico's ICT sector received 8.1 percent of total foreign direct investment (FDI) between 2003 and 2021. The majority of that foreign inflows into the ICT sector were directed towards computer and electronic product manufacturing (45.6 percent) and telecommunications (39.5 percent).[7] Additionally, ICT investments as a percentage of Mexico's gross capital formation rose from 7.1 percent in 2004 to 19 percent in 2018, with ICT services accounting for 96.5 percent of gross capital formation in the ICT sector.

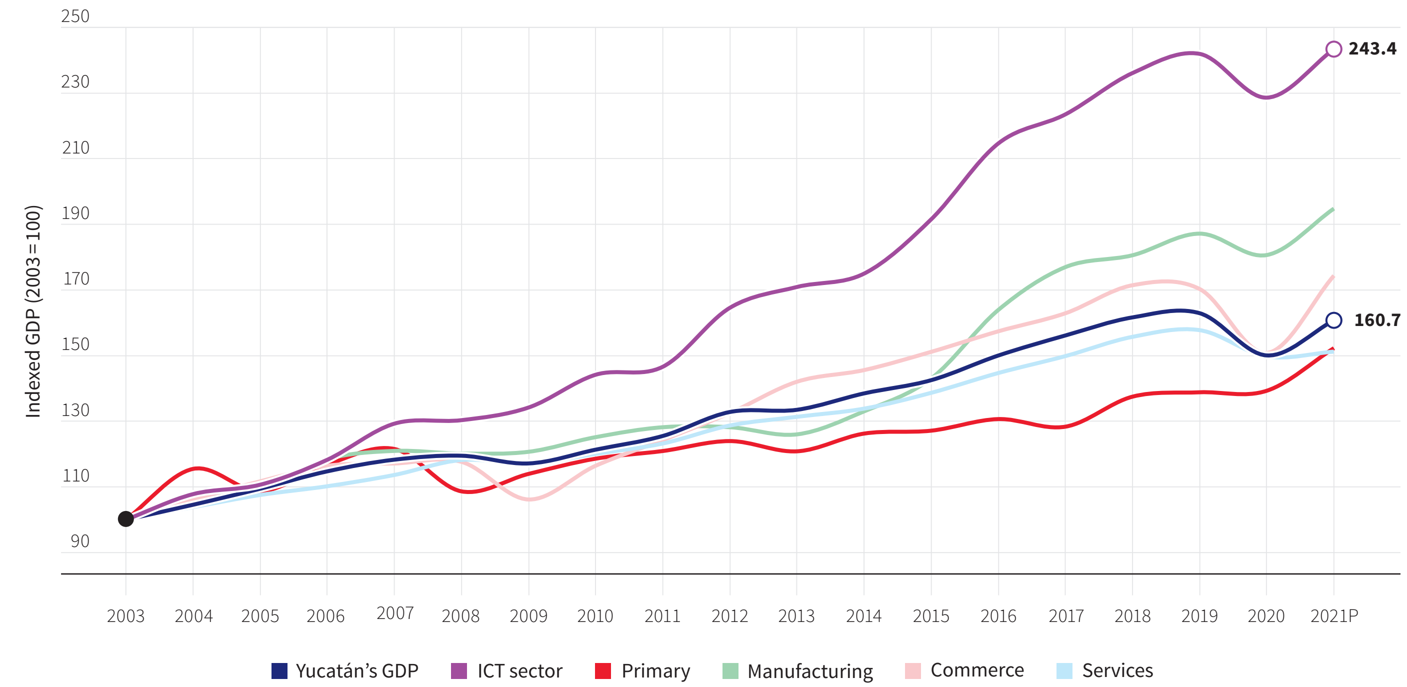
This sector assessment is specifically focused on Yucatán as the state has the greatest potential for developing the ICT sector among the four selected states (Chiapas, Guerrero, Oaxaca, and Yucatán) from southern Mexico.[8] Between 2003 and 2021, the value added generated by ICT activities[9] in Yucatán grew by 143.4 percent (figure 1.4). The majority of this value added correspond to

FIGURE 1.3
Value Added by the ICT Sector as a Share of Total Value Added, OECD Countries, 2015



Source: Based on OECD Data's key ICT indicators.
Note: IT = information technology; ICT = information and communication technology; OECD = Organisation for Economic Co-operation and Development. The ICT sector is defined according to International Standard Industrial Classification Rev. 4: computer, electronic, and optical products ("ICT manufacturing"; Division 26); software publishing (582); telecommunications (61); and IT and other information services (62–63).

FIGURE 1.4
Growth of the Value Added by the ICT Sector and Others in Yucatán



Source: Based on data from INEGI's National Accounts (various years).
Note: GDP = gross domestic product; ICT = information and communication technology; P = preliminary.

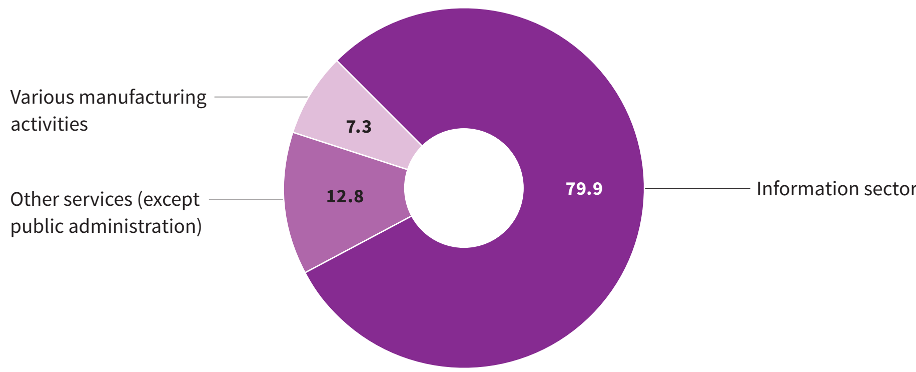
ICT services (figure 1.5). However, despite the growth of the sector in the state, Yucatán's ICT sector contributed only an average of 2.3 percent to the national-level value added in the sector. This suggests that while Yucatán has shown promising growth, its overall contribution to the national ICT sector in terms of value added remains relatively modest.

Although the ICT sector in Yucatán is still relatively small, it is already attracting foreign investment. Table 1.1 shows that the ICT sector in the state accounted for 0.4 percent of total employment and 0.5 percent of all firms in 2018. Most of the ICT firms in the state are small, with an average of 4.4 workers. Between 2003 and 2021, Yucatán received only about 0.5 percent of Mexico's total FDI inflows, and the ICT sector received 7.5 percent of the state's FDI inflows (equivalent to 0.5 percent of the total FDI in the ICT sector in Mexico).[10] Telecommunications received the majority of the FDI in Yucatán's ICT sector, representing 92.8 percent, while computer and electronic product manufacturing received 7.2 percent. Moreover, the total investment in the ICT sector in the state also grew sharply. The sector's share of the state's gross capital formation rose from 0.2 percent in 2003 to 1.0 percent in 2018. This increase was primarily driven by ICT services, which represented 63.1 percent of gross capital formation in Yucatán's ICT sector.

The development of the ICT sector has wide-ranging and positive effects, as it can lead to productivity gains in various sectors. Globally, there is compelling evidence indicating a strong correlation between ICT readiness and economic competitiveness.[11] In emerging markets, a 10 percent increase in broadband pen-

FIGURE 1.5

Decomposition of the ICT Sector's Growth in Yucatán, 2003–21 (percent)



Source: INEGI National Accounts (various years).
Note: ICT = information and communication technology. The corresponding North American Industry Classification System (NAICS) codes for the ICT subsectors are as follows: various manufacturing activities is the sum of machinery manufacturing NAICS (333), computer and electronic product manufacturing (NAICS 334), electrical equipment, appliance, and component manufacturing (NAICS 335), and transportation equipment manufacturing (NAICS 336); information (NAICS 51); and other services (excluding public administration; NAICS 81).

TABLE 1.1

ICT Sector Firms and Workers in Yucatán, 2018

NAICS code	Description	Number of firms	Number of workers
3344	Semiconductor and other electronic component manufacturing	3	385
5112	Software publishers	2	…
5173	Wired and wireless telecommunications carriers	10	321
5179	Other telecommunications	85	529
5182	Data processing, hosting, and related services	7	180
811219	Other electronic and precision equipment repair and maintenance	414	899
	Total ICT sector in Yucatán	521	2,314
Total for all sectors in Yucatán		112,503	516,924
Share of ICT sector in total (%)		0.5	0.4

Source: INEGI 2019.
Note: ICT = information and communication technology; NAICS = North American Industry Classification System. Missing values reflect data that was not reported.

etration is associated with a 1.4 percentage-point increase in the GDP growth rate.[12] Similarly, a 20 percent increase in ICT investment is associated with a 1 percentage-point increase in the GDP growth rate.[13] Moreover, in Latin America and the Caribbean, an average 10 percent increase in broadband penetration could lead to a regional productivity increase of around 2.6 percent, resulting in a 3.2 percent increase in GDP.[14]

Industries across various sectors are increasingly using ICT-related inputs in their operations. The ongoing growth of the ICT sector is expected to have several positive effects on the Mexican economy. This will accelerate economic diversification, strengthen links to global value chains (GVCs), and generate productivity gains in several economic activities related to innovation, knowledge transfer, business collaboration, efficiency gains, workforce transformation, and access to new markets. The ICT sector has the potential to serve as a catalyst for job creation, nationally and specifically in Yucatán. Among subsectors within the ICT sector, computer and electronic product manufacturing appears to be the most labor-intensive. It has the highest worker-to-firm ratio both at the national level with 431.6 and state level with 128.3. This ratio is significantly higher than the national and state averages of 5.7 and 4.6, respectively. In Yucatán, the employment-to-output ratio in the ICT sector is 7.1, far above the national average of 2.7. Moreover, the ICT sector not only serves as an important direct source of high-quality employment for skilled workers (requiring a well-prepared labor force), but it is also changing the overall labor market dynamics. It produces innovative, flexible, inclusive, and globalized ICT-enabled employment modalities that could contribute to reduce barriers and expand job opportunities. However, it is important to address the digital gap in most regions to fully realize these positive benefits.

Activities in the ICT sector exhibit strong backward and forward linkages with other sectors. The total value of inputs purchased by the ICT sector is slightly lower than the value of its sales to other sectors, suggesting that ICT activities have stronger forward linkages. Purchases by the ICT sector represent 8.6 percent of economywide purchases, while its sales represent 9.2 percent of total sales.[15] Furthermore, consolidating the ICT sector in Yucatán has the potential to diversify the state's exports and simultaneously expand Mexico's global market share.

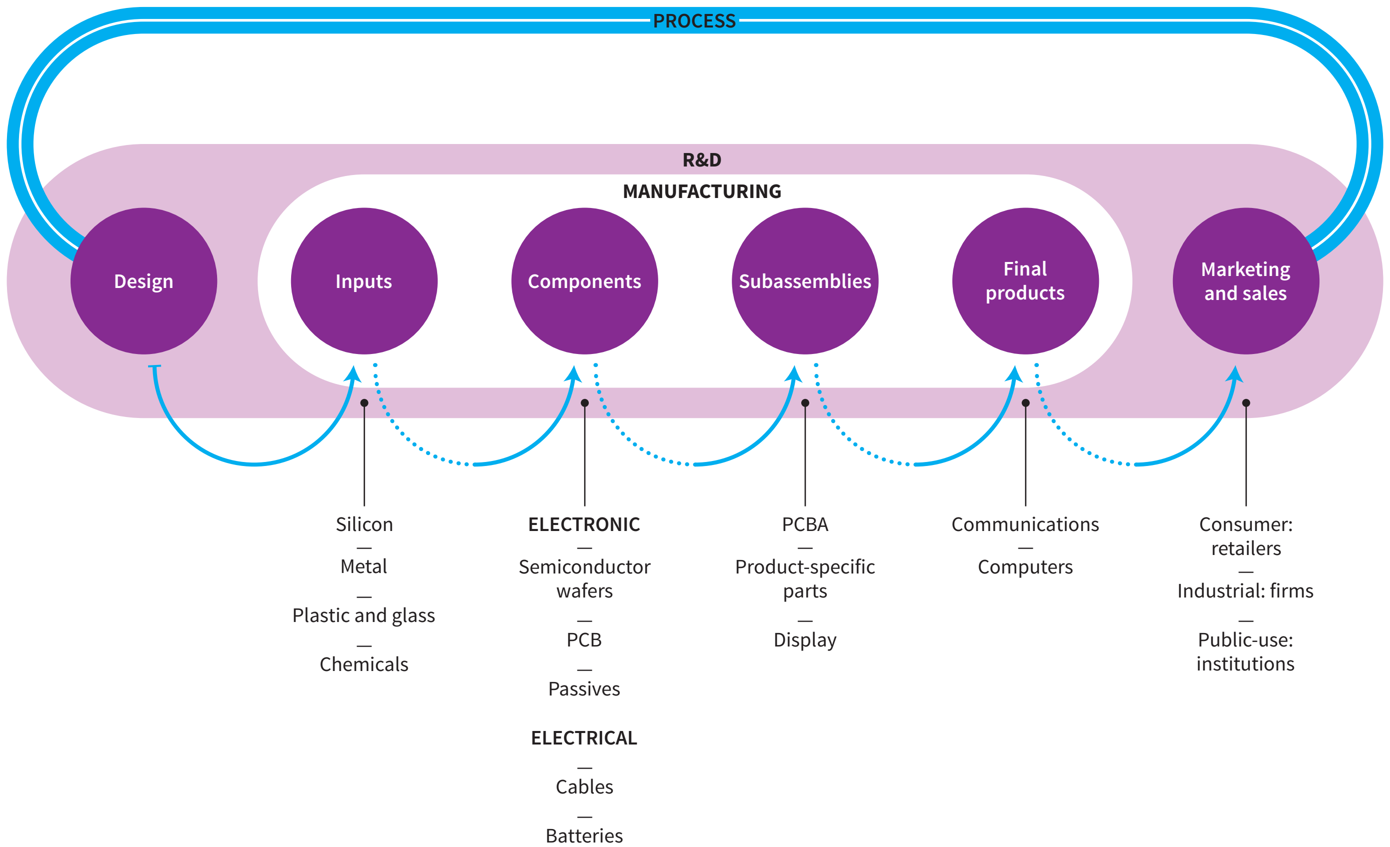
VALUE-CHAIN ANALYSIS

The ICT manufacturing value chain is characterized by a high modularity of its products and the fragmentation of the production process across various stages and firms. This modularity, combined with the low delivery cost of intermediate and final ICT products —which tend to have high value-to-weight ratios— has enabled the extensive globalization of the ICT manufacturing value chain. Figure 1.6 describes the structure of the ICT value chain.

Within the manufacturing value chain, there are two main players: lead firms and contract manufacturers. Lead firms, located mainly in more advanced economies, hold significant market power over suppliers. They develop brands, sell products to final consumers, focus on higher-value segments, and maintain quality and innovation across the value chain. Contract manufacturers, including those in emerging economies like Mexico, participate in the sector's GVC by assembling products for lead firms at different stages, ranging from production services (original equipment manufacturers) to design activities (original design manufacturers).[16]

The ICT services industry comprises general and industry-specific services. Figure 1.7 shows three main types of general ICT services: IT outsourcing (ITO), business process outsourcing (BPO), and knowledge process outsourcing (KPO). ITO focuses on software production and use, including IT consulting and services. BPO involves managing enterprise and human resources, as well as cus-

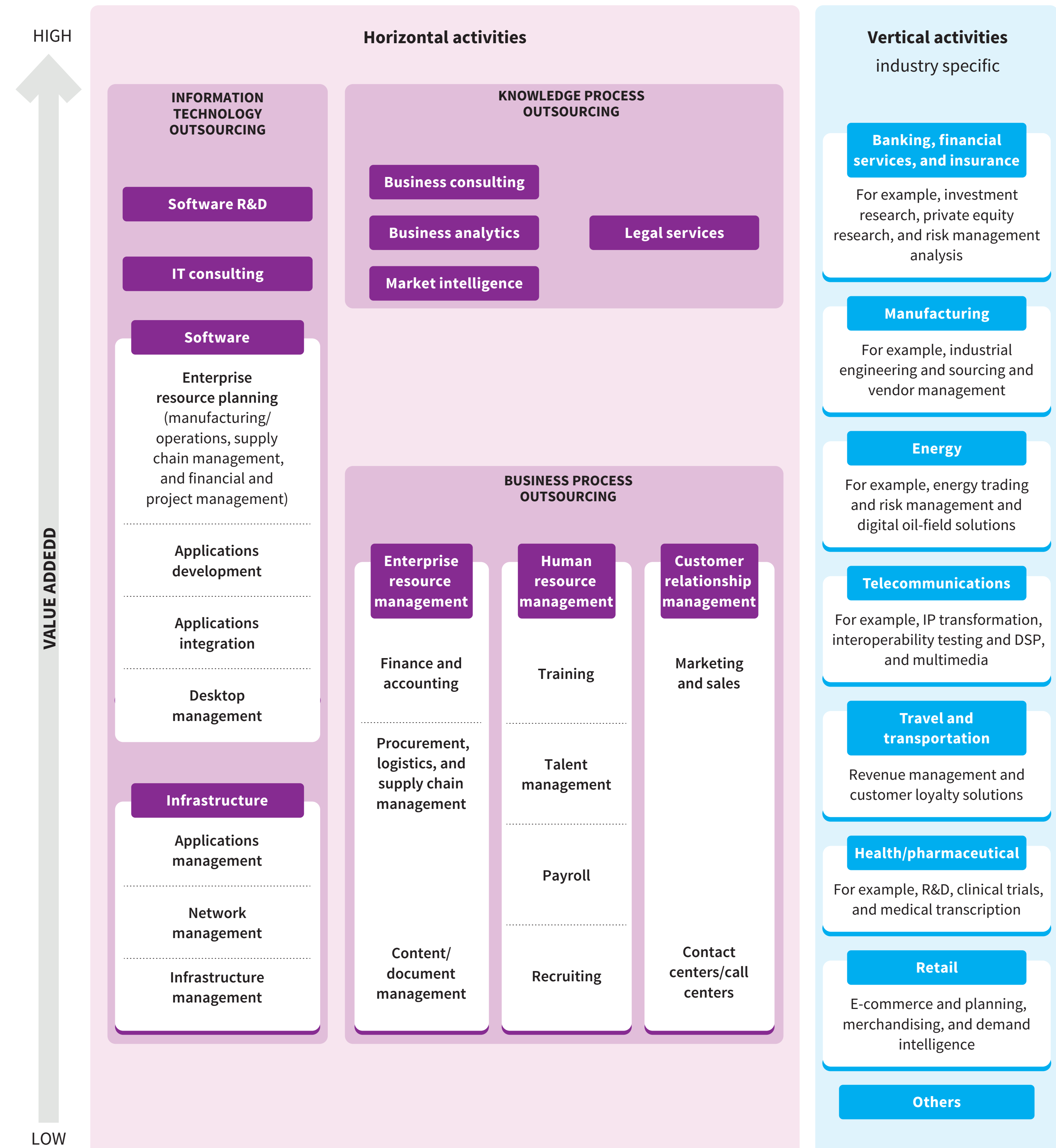
FIGURE 1.6
ICT Manufacturing Value Chain



Source: Adapted from Frederick and Lee 2017; SHCP 2016; and Dominguez, Carrera, and Brown 2018.
Note: ICT = information and communication technology; PCB = printed circuit board; PCBA = printed circuit board assembly; R&D = research and development.

tomer relationships. KPO represents the high value-added segment of the chain and often require licensing and more specialized knowledge that can be applied across various industries such as legal, market intelligence, and data analytics. On the other hand, industry-specific services require specialized knowledge but have limited applicability across specific industries. Numerous Mexican states, including Yucatán, actively participate in the global ICT services value chains.[17]

FIGURE 1.7
ICT Services Value Chain



Source: Adapted from Gereffi and Fernandez-Stark 2011.
Note: DSP = digital signal processing; IP = internet provider; IT = information technology; R&D = research and development. The figure illustrates the industries that have the greatest demand for offshore services. For vertical activities specific to various industries, each industry has a unique value chain. Certain associated services within these chains can be offshored. This graphical representation does not indicate value levels within the vertical activities. Within each industry, activities may include information technology outsourcing, business process outsourcing, and other advanced activities.

THE LEGAL FRAMEWORK FOR THE ICT SECTOR AND GOVERNMENT PROGRAMS

1 **The 2013 telecommunications reform.** In 2013, a series of reforms were established to grant Mexicans the right to participate in the ICT sector and knowledge economy by ensuring access to IT, broadcasting, and telecommunications services. The reforms mandated that these services must be provided competitively, adhering to high quality and coverage standards. The executive branch of the government is responsible for designing and implementing a digital inclusion policy. The reforms also established a series of pro-competition measures designed to level the playing field between new entrants and incumbent operators. Additionally, the institutional framework was strengthened by establishing the autonomous *Instituto Federal de Telecomunicaciones* (Federal Telecommunications Institute), restructuring the *Comisión Federal de Competencia Económica* (Federal Commission for Economic Competition), and creating specialized courts for broadcasting, telecommunications, and the enforcement of competition law. For a description of a project under the 2013 telecommunications reforms, see box 1.1.

2 **Law for the promotion of scientific and technological development and innovation in Yucatán.** This law strengthened the institutional framework for promoting science, technology, and innovation in the state. It ratified the establishment of the *Consejo de Ciencia, Innovación y Tecnología del Estado de Yucatán* (Yucatán Science, Innovation, and Technology Council), established an information system for science and technology, and defined the criteria for promoting science and technology, including financing mechanisms and human capital development.

BOX 1.1

The Red Compartida

A cornerstone of the 2013 telecommunications reforms is the implementation of the *Red Compartida* (Shared Network) project. In 2017, the Altán Consortium[a] was granted the project to develop a wholesale shared mobile network using spectrum from the digital switchover. The project aimed to offer wireless connectivity to 92.2 percent of the Mexican population, including those in remote areas where cell coverage is not economically viable. The International Finance Corporation and the China-Mexico Fund were shareholders of the project. The *Red Compartida* employs 4.5G/LTE (four-point-fifth generation, long-term evolution) technology to boost the performance of the allocated 700-megahertz spectrum. This leads to increasing coverage and capacity, while also lowering prices by up to 60 percent compared to the average offered by its direct competitors. By the end of 2019, the *Red Compartida* had reached 1,053 localities in Yucatán, including Mérida,[b] as well as 57 villages classified with "high" and "very high" marginalization, where previously there was little or no connectivity. As of October 2022, it has successfully connected more than 80 million people nationwide, extending "social coverage" to 108,934 locations, including over 96,600 locations with fewer than 250 inhabitants.[c]

a. The concession is a PPP contract lasting 20 years, with a potential 20-year extension.
b. Mérida is the third major city in southern Mexico covered by Red Compartida, after Villahermosa (Tabasco) and Tuxtla Gutiérrez (Chiapas).
c. In July 2021, Altán filed for commercial bankruptcy to reorganize its financial commitments. Altán had previously expressed intentions to extend coverage goals until 2028 for financial viability, given the large investments and low returns associated with reaching small locations, as well as challenges derived from the pandemic. In June 2022, the Mexican government announced a bailout for Altán and became the majority stakeholder through a signed agreement. Altán emerged from the bankruptcy with a restructuring agreement approved by 94 percent of its creditors.

3 **Yucatán's digital strategy (2015–20).** This strategy sought to coordinate government efforts with those of society, industry, and academia to increase the adoption of ICT in areas such as health, education, and public safety. It also established a roadmap for e-governance at the state level.

4 **The 2016 state innovation agenda.** Developed under the oversight of the state's Economic Development Ministry, the agenda aimed to position the state as a national leader in innovation, scientific, and technological development by 2025. It identifies the following niches for Yucatán: new technology-based businesses, high value-added ICT services, digital citizenship, and smart cities.

5 **Yucatán's state development plan (2018–24).** This plan represents a cross-cutting innovation, knowledge, and technology strategy involving the increased use of ICT in economic activities, education, health, culture, and public safety. With the aim to promote ICT development, the plan includes two main objectives: (a) increasing the applicability of scientific and technological knowledge; and (b) improving the conditions for innovation, science, and technology. To achieve these objectives, the plan calls for the creation of an ICT innovation and development cluster in the state. The Law for the Promotion of Economic Development and Employment in Yucatán serves as the foundation for this state development plan and includes specific incentives for technology and innovation.

6 **Sector-specific programs.** The Mexican government has various programs supporting ICT sector development. Most of these programs are offered by development banks or by the *Secretaría de Economía* (Secretariat of Economy).[18] The state of Yucatán also offers three programs focused on funding entrepreneurial activities and ongoing projects related to innovation and technology via the state's *Secretaría de Investigación, Innovación y Educación Superior* (Secretariat of Research, Innovation and Higher Education). The research, innovation and technological development system in Yucatán encompasses 13 higher education institutes and research centers, which support projects related to the development of ICT solutions and education. For a list of financial programs and products available at the federal and state levels, see table 1.2.

PRODUCTIVITY, LABOR AND CAPITAL INTENSIVENESS, AND WAGES

At the national level, trends in total factor productivity (TFP) have shown varied patterns across the main ICT subsectors. Between 1990 and 2019, the productivity of computer and electronic product manufacturing has risen at an annual average rate of 0.20 percent. In contrast, the productivity of electrical equipment, appliance, and component manufacturing dropped at an annual rate of –1.05 percent. Meanwhile, the productivity of ICT services rose even more sharply, increasing at an annual rate of 4.93 percent (figure 1.8).[19] Within the computer and electronic product manufacturing subsector, the productivity of computer and peripheral equipment manufacturing experienced the greatest increase, rising at an annual rate of 2.05 percent (figure 1.9).

Although firms in the ICT sector are generally larger than average, both in Yucatán and nationwide, labor productivity of all but one ICT subsector in Yu-

TABLE 1.2

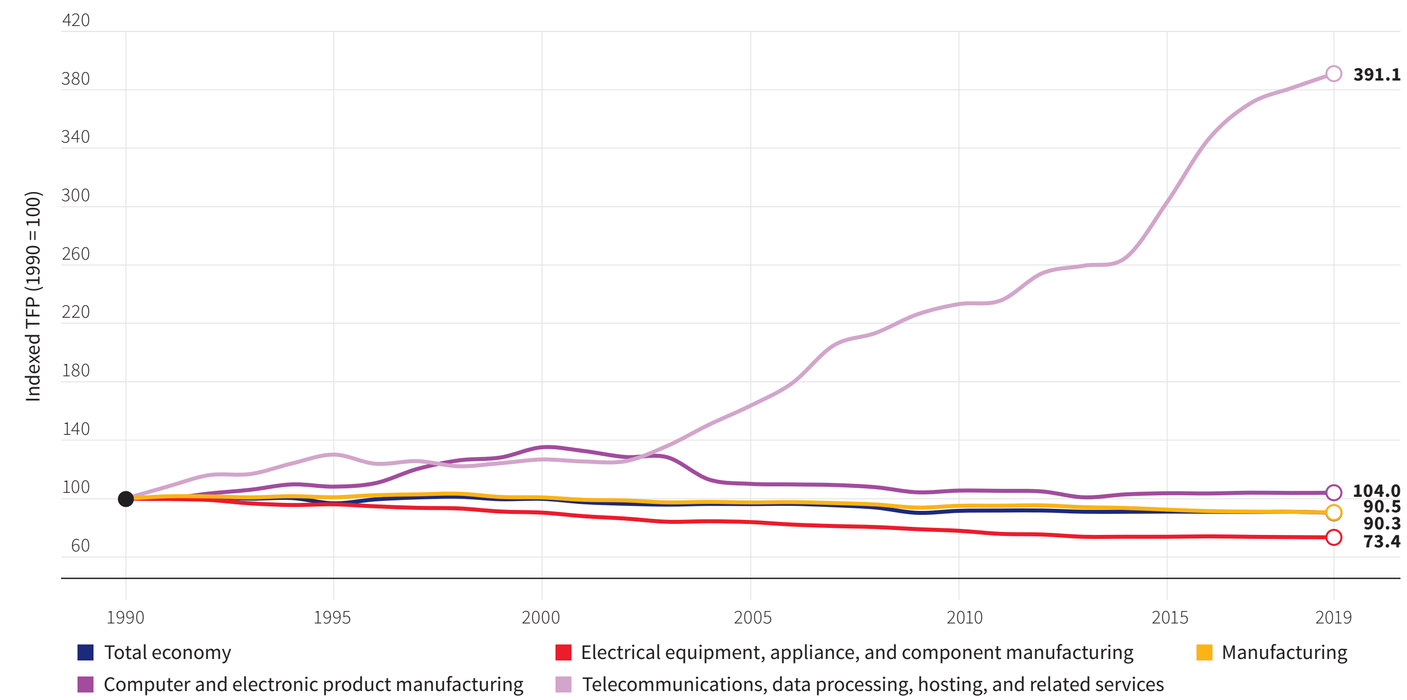
Financial Programs and Products Offered At the Federal and State Levels

Institution	Program	Description
Federal level		
Nafin	*Programa Cadenas Productivas*	Provides financing for customers and suppliers supported by accounts receivable. It also offers working capital and equipment credits, along with technical support. Includes factoring-in-advance, at maturity, and distributed.
	Fianzas para Pymes	Supports MSMEs engaged in providing services to the federal or state public administration. It offers loans of up to Mex$30 million and guarantees to fulfill requirements with other financial institutions.
	Garantía Selectiva	Provides financing for SMEs and large-sized firms through guarantees of up to 50 percent, credits for up to Mex$20 million for working capital, fixed asset purchases (except lands), creation of infrastructure, technical support, environmental improvements, supply chain, and liabilities restructuring. The resources are awarded through a financial intermediary.
	Jóvenes Empresarios	Offers loans designed for MSMEs or individual entrepreneurs who have been operating their businesses for at least one year. The loan has an interest rate of 13.5 percent and a repayment period ranging from 36 to 60 months. It aims mainly to provide financing for working capital and investment in fixed assets.
	Inclusión Financiera: Mujeres Empresarias	Caters to the financing needs of women-owned MSMEs. It offers loans of up to Mex$5 million with an interest rate of 13.5 percent and a repayment period ranging from 36 to 60 months.
	Financiamiento Empresarial	Offers MSMEs a guarantee to secure a loan of up to MEX$20 million from commercial banking institutions. The repayment period extends up to five years. The credit obtained must be used in working capital and fixed assets.
Bancomext	*Sectores Estratégicos: Telecomunicaciones*	Supports firms in the ICT sector supply chain. It targets technology and digital content developers, infrastructure providers, and firms in the productive chain of the sector. The initiative offers credits of at least US$3 million for working capital, equipment purchases, or investment projects.
Secretaría de Economía (Secretariat of Economy)	Prosoft	In 2016, this program underwent a merger with the Finnova Fund. The merged program aimed to support the development of software and innovation, with subsidies of up to Mex$45 million per project. It focuses on medium and large companies, as well as entrepreneurial associations looking to establish "industrial innovation centers." After averaging an annual budget of around Mex$1 billion from 2008–15, the program's budget declined to Mex$175 million in 2020. Since 2021, the program has not been funded.
State level		
SIIES	*Incubador de empresas de las Telecomunicaciones y Tecnologías de Información y Comunicaciones*	Facilitates the establishment of SMEs in the ICT sector by providing support to aspiring entrepreneurs enrolled in higher education who wish to start a company in Yucatán. The program includes technical training and a grant of Mex$70,000 intended to be invest in working capital.
	Fondo Yucatán a la Innovación	Offers a valuable resource in form of "seed capital" to entrepreneurs who are in the initial stages of their startup projects. The financial support provides a grant of up to Mex$200,000.
	Fondo para Emprendedores del Estado de Yucatán	Provides economic support to entrepreneurial projects that have previously received benefits from the Yucatán Innovation Fund and have shown promising results, justifying the need for continued funding in later stages. The grant of up to Mex$500,000 is provided in two phases.

Sources: Based on information from https://www.nafin.com; Bancomext 2021; SE 2016; SHCP n.d.; Gobierno del Estado de Yucatán n.d.
Note: Bancomext = *Banco Nacional de Comercio Exterior* (National Exterior Commerce Bank); Finnova = *Innovación Financiera* (Financial Innovation); ICT = information and communication technology; MSMEs = micro, small, and medium enterprises; Nafin = Nacional Financiera; Prosoft = *Programa para el Desarrollo de la Industria de Software y la Innovación*; SIIES = *Secretaría de Investigación, Innovación y Educación Superior del Estado de Yucatán* (Secretariat of Research, Innovation and Higher Education of the State of Yucatán); SMEs = small and medium enterprises.

FIGURE 1.8

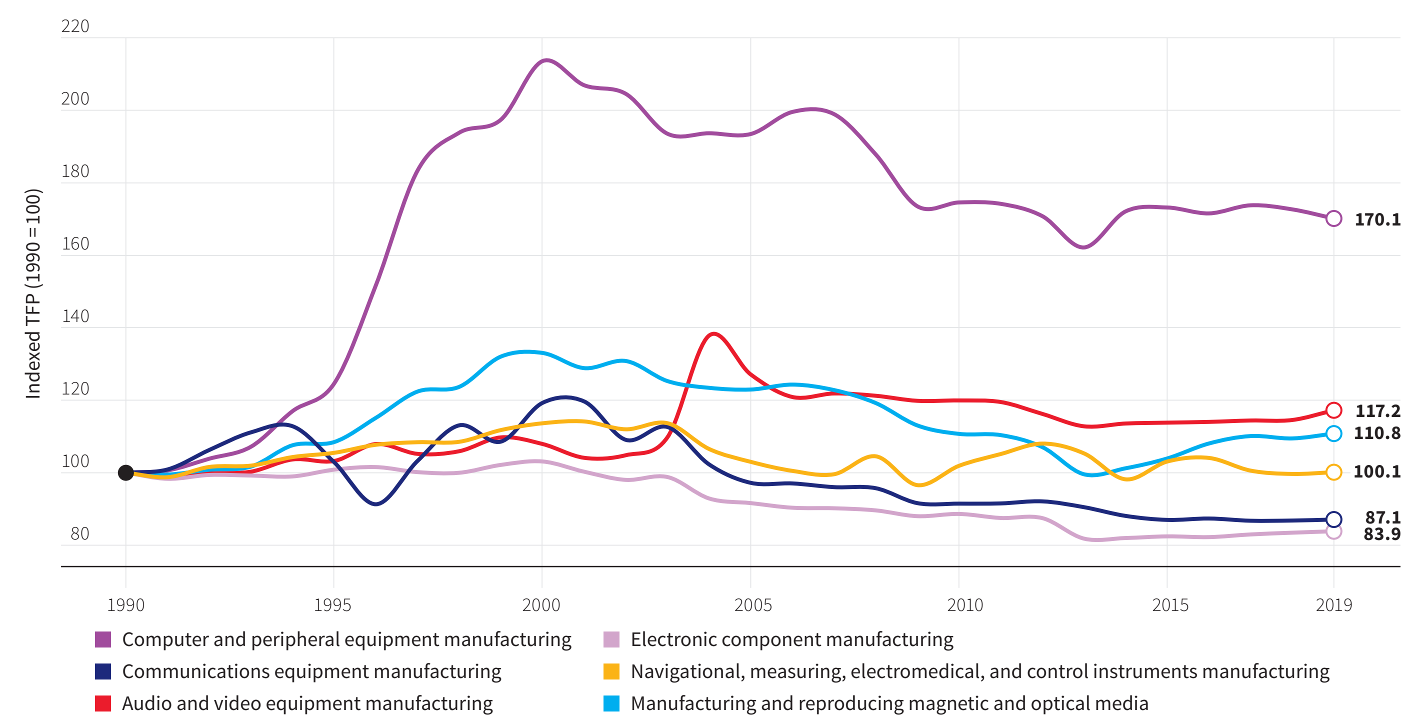
TFP in Selected ICT Subsectors



Source: INEGI.
Note: ICT = information and communication technology; TFP = total factor productivity.

FIGURE 1.9

TFP in the Computer and Electronic Product Manufacturing Subsector

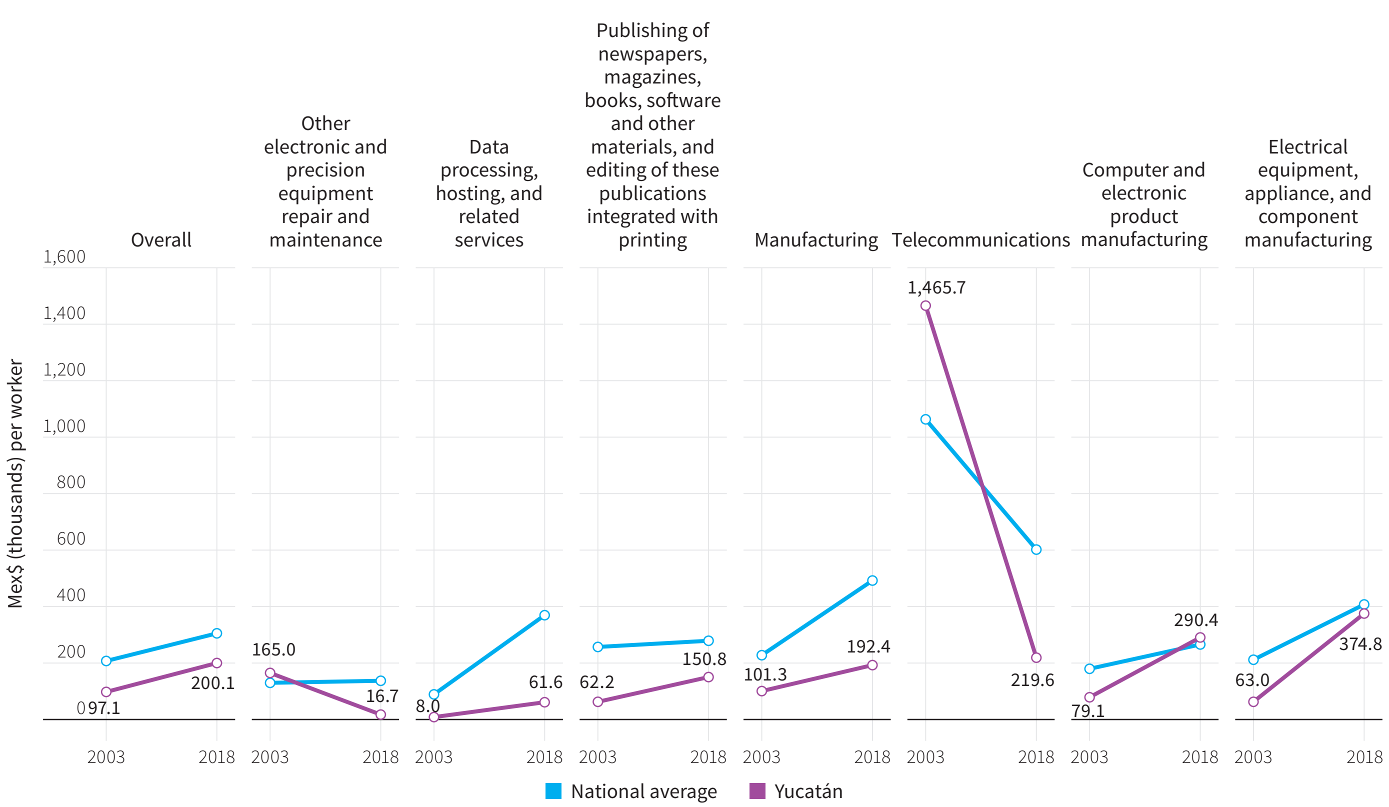


Source: INEGI.
Note: ICT = information and communication technology; TFP = total factor productivity.

catán is below the national average. At the national level, telecommunications is the subsector with the highest capital-to-firm ratio (Mex$227.3 million), whereas in Yucatán it is computer and electronic product manufacturing (Mex$13.4 million). In both cases, telecommunications has the highest capital-to-worker ratio (Mex$4.3 million and Mex$208,600, respectively) (table 1.3). Computer and electronic product manufacturing has the highest worker-to-firm ratio, both at the national level (431.6) and in Yucatán (128.3), followed by electrical equipment, appliance, and component manufacturing (201.9 and 54.7, respectively). Although the labor productivity[20] of the manufacturing sector in Yucatán falls below the national average, the labor productivity in the computer and electronic product manufacturing subsector is higher than the national average and ranks as the ninth highest among the 32 states, even exceeding the average for the five states that represent 75 percent of total value added in the subsector.[21] At the national level and in Yucatán, hourly wages in the ICT manufacturing subsectors tend to be lower than the average, while wages in the ICT services subsectors tend to be higher. Moreover, according to figure 1.10, between 2003 and 2018, output per worker growth rates in most ICT-related subsectors were higher than the observed in the rest of the country: for computer and electronic product manufacturing (267.2 percent) was 5.5 times the national average (48.2 percent), in the case of electrical equipment, appliance, and component manufacturing was 5.3 times (494.7 percent versus 92.8 percent),

FIGURE 1.10

Labor Productivity of ICT Related Subsectors



Source: INEGI 2003; 2018.
Note: ICT = information and communication technology.

for data processing, hosting, and related services was 2.1 times (673.0 percent versus 313.4 percent) and for publishing and editing of newspapers, magazines, books, software and other materials was 16.2 times (142.6 percent versus 8.8 percent). However, there was a significant reduction in the productivity of the telecommunications subsector in Yucatán during the same period (85 percent), which is partly because the fixed assets in the subsector declined by 88.7 percent (from Mex$1,564.3 million to Mex$177.3 million).

TYPICAL COST STRUCTURE AND PROFITABILITY

A comparative study of Mexico and nine high-income countries conducted in 2016, revealed that Mexico has a cost advantage in labor and facilities of 14.8 percent for ICT manufacturing and 34.4 percent for ICT services.[22] In Mexico's ICT manufacturing sector, raw materials, transportation, and other equipment-related expenses represent 81.1 percent of total production costs. Labor represents 12.5 percent of production costs, followed by electricity (5.7 percent), fuel (0.5 percent), and water (0.2 percent). The cost structure for ICT services varies widely by subsector, but the share of labor is relatively higher compared to manufacturing. The share of labor cost represents 23.5 percent for the repair and maintenance of other electronic equipment and precision equipment (North American Industry Classification System [NAICS] code 811219), 27.8 percent for other telecommunications (NAICS 5179), 43.9 percent for satellite telecommunications (NAICS 5174) and 40.8 percent for software publishers (NAICS 5112). Data processing, hosting, and related services (NAICS 5182) have the largest share of labor costs at 46 percent, whereas wired and wireless telecommunications carriers (NAICS 5173) have the lowest relative labor costs at 17.9 percent.[23] In terms of remuneration, wages in the ICT goods manufacturing sector at the national level are lower than the average in the formal sector, whereas the wages in ICT-related services are higher. This trend is similar in Yucatán as well (table 1.4).

Across the ICT sector, profitability depends on the value chain segment in which a firm operates. In 2019, ICT manufacturing firms registered annual earnings before interest, taxes, depreciation, and amortization (EBITDA) margins ranging from 16.9 to 17.6 percent and annual net margins between 14.2 and 15.4 percent. Regarding ICT services, the profitability ranges according to the nature of services. Internet services registered an annual EBITDA margin between 22.7 and 24.6 percent and an annual net margin between 20.6 and 24.3 percent. For communication services, the annual EBITDA margin was between 10.3 and 14.1 percent and the annual net margin was between 3.8 and 6.2 percent. Software development registered an annual EBITDA margin between 20.3 and 20.9 percent and an annual net margin between 19.9 and 20.7 percent.[24]

TABLE 1.3

ICT Related Subsectors Use of Capital and Labor, 2018

	National average	Yucatán
	Capital per firm (Mex$, thousands)	
Total manufacturing	5,116.1	860.5
Computer and electronic product manufacturing	65,419.7	13,449.0
Electrical equipment, appliance, and component manufacturing	63,381.1	6,976.5
Publishing of newspapers, magazines, books, software and other materials, and editing of these publications integrated with printing	2,546.9	2,299.4
Telecommunications	227,345.2	1,866.1
Data processing, hosting, and related services	8,013.5	489.0
Other electronic and precision equipment repair and maintenance	219.8	124.6
Overall	2,413.3	884.8
	Capital per worker (Mex$, thousands)	
Total manufacturing	456.9	207.5
Computer and electronic product manufacturing	151.6	104.8
Electrical equipment, appliance, and component manufacturing	314.0	127.5
Publishing of newspapers, magazines, books, software and other materials, and editing of these publications integrated with printing	79.9	54.2
Telecommunications	4,274.0	208.6
Data processing, hosting, and related services	95.0	19.0
Other electronic and precision equipment repair and maintenance	76.7	57.4
Overall	426.9	192.6
	No. of workers per firm	
Total manufacturing	11.2	4.1
Computer and electronic product manufacturing	431.6	128.3
Electrical equipment, appliance, and component manufacturing	201.9	54.7
Publishing of newspapers, magazines, books, software and other materials, and editing of these publications integrated with printing	31.9	42.5
Telecommunications	53.2	8.9
Data processing, hosting, and related services	84.4	25.7
Other electronic and precision equipment repair and maintenance	2.9	2.2
Overall	5.7	4.6

Source: Calculations based on data from INEGI 2019.
Note: ICT = information and communication technology.

TABLE 1.4

Salaries and Education in the ICT Industry (Formal and Informal Sector), 2019 Averages

	National average		Yucatán	
	Formal	Informal	Formal	Informal
	Overall			
Average income per hour worked (Mex$)	47.3	33.4	47.9	31.3
Average years of education	12.0	8.5	12.1	8.1
	Computer and electronic product manufacturing			
Average income per hour worked (Mex$)	40.5	40.8	35.5	n.a.
Average years of education	11.5	13.6	11.0	n.a.
	Electrical equipment, appliance, and component manufacturing			
Average income per hour worked (Mex$)	39.5	36.0	30.8	11.6
Average years of education	10.9	12.6	10.9	12.0
	Publications and software edition, except through the internet			
Average income per hour worked (Mex$)	58.4	40.4	38.8	35.6
Average years of education	13.1	12.1	12.8	12.5
	Internet, web search, and information processing service providers			
Average income per hour worked (Mex$)	68.0	76.3	n.a.	n.a.
Average years of education	14.5	16.0	n.a.	n.a.
	Other telecommunications			
Average income per hour worked (Mex$)	55.5	39.9	51.1	37.8
Average years of education	13.6	11.8	13.6	12.3

Source: Based on data from INEGI's ENOE database.
Note: ICT = information and communication technology; n.a. = not available.

INDUSTRY LEADERS

Out of the top 500 firms in Mexico, 28 operate within the ICT sector.[25] In 2021, nine ICT manufacturing firms had a combined sales of US$20.6 billion. Among these manufacturing firms, the three largest in terms of total sales were Jabil Circuit de México, Samsung México, and Flextronics Manufacturing México. Seven ICT services firms had a combined sales of almost US$4.3 billion in the same year, led by Amazon México, Mercado Libre de México, Softtek, and SAP México. Furthermore, firms in the telecommunications subsector had over US$54 billion in sales, including América Móvil, AT&T México, and Grupo Televisa.[26]

In addition, there are 15 ICT companies in Mexico that have significant potential for exponential growth.[27] Notably, the international firm KIO Networks had an estimated value of over US$1 billion, earning it the status of a "unicorn" company. Other notable companies include 3D Robotics, Aspel, Bestday, Intelisis, Lanix, Linio, Price Travel, and Yellow Pepper with estimated values ranging from US$100 million to US$500 million. There are also companies such as Contpaq, Empleo Listo, Konfio, Kubo Financiero, Kueski, and Payclip, which have estimated values between US$50 million to US$100 million.

2
Market Potential

EXPORTS[28]

As of 2021, the total value of global ICT goods exports amounted to US$2.32 trillion, representing 13.1 percent of global merchandise trade, while global ICT services exports amounted to US$848.4 billion, representing 14 percent of total trade in services. The share of ICT goods in global merchandise trade has declined since 2000 (16 percent), whereas the share of ICT services in global trade in services increased since 2005 (6.2 percent). Close to 90 percent of ICT goods exports in 2021 were concentrated in nine countries: China (37.0 percent); Hong Kong SAR, China (17.7 percent); Taiwan, China (9.9 percent); the United States (6.9 percent); Malaysia (4.2 percent); Germany (3.5 percent); Mexico (3.1 percent); the Netherlands (3 percent); and Japan (2.8 percent).[29] Between 2000 and 2021, the annual growth rate of global ICT goods exports was 4.1 percent, increasing from US$1 trillion to US$2.32 trillion. In Mexico, the annual growth in ICT goods exports was 3.5 percent during the same period, rising from US$34.8 billion to US$71.0 billion. Mexico's share in global exports within this sector has decreased compared to 2000 (3.5 percent), with the highest percentage reached in 2001 at 4 percent.

In the ICT services sector, 70 percent of global exports was concentrated in 10 countries in 2021. The leading countries in terms of ICT services exports were Ireland (23.3 percent), India (9.6 percent), China (9.1 percent), the United States (6.2 percent), Germany (4.4 percent), the United Kingdom (4.0 percent), the Netherlands (3.3 percent), Israel (2.9 percent), France (2.5 percent), and Singapore (2.1 percent). During 2005–21, the annual growth rate for ICT services exports averaged 10.7 percent, increasing from US$166.7 billion to US$848.4 billion. In contrast to the ICT goods subsector, Mexico's market share in global ICT services is extremely modest, accounting for only 0.01 percent. The value of Mexico's ICT service exports saw a significant decline from US$547.9 million in 2005 to US$75.3 million in 2021. ICT services now represent just 0.3 percent of Mexico's total trade in services.

Globally, the main exports in ICT goods consist of electronic components (40.1 percent), computers and peripheral equipment (25.2 percent), and communication equipment (22 percent). In Mexico, ICT goods exports are mainly concentrated in computers and peripheral equipment (49.9 percent), consumer electronic equipment (25.9 percent), and communication equipment (17 percent) (table 2.1). Exports of computers and peripheral equipment has experienced a higher-than-average growth rate in Mexico, reaching 5.5 percent. In addition, the country also enjoys a larger-than-average global market share in this category, amounting to 6.1 percent. However, although the global market share of Mexico in computers and peripheral equipment has nearly doubled from 3.2 percent in 2000 to 6.1 percent in 2021, the country saw a decline in market share for all other ICT goods exports, except for consumer electronic equipment, which saw an increase from 8.6 to 9.2 percent.

The contribution of Yucatán to the ICT manufacturing exports of Mexico remains negligible. Based on estimations from the Atlas of Economic Complexity of Mexico, Yucatán accounted for just 0.002 percent of these exports in 2014, which is the latest year available before the database was discontinued.[30] Moreover, the state lacked a comparative advantage in any ICT export good during

TABLE 2.1
Global Share and Annual Growth Rate of Mexico's ICT Exports

Subsectors	Global exports			Mexico's exports		
	Total product value, 2021 (US$, billion)	Share in total global ICT exports, 2021 (%)	CAGR, 2000–21 (%)	Total product value, 2021 (US$, billions)	Share in total global product exports, 2021 (%)	CAGR, 2000–21 (%)
Computers and peripheral equipment	583.8	25.2	2.2	35.4	6.1	5.5
Communication equipment	508.9	22.0	5.8	12.1	2.4	1.6
Consumer electronic equipment	199.2	8.6	3.1	18.4	9.2	3.4
Electronic components	928.3	40.1	5.2	4.3	0.5	1.2
Miscellaneous	96.0	4.1	3.1	0.8	0.8	−4.7
Total	2,316.2	100.0	4.1	71.0	3.1	3.5

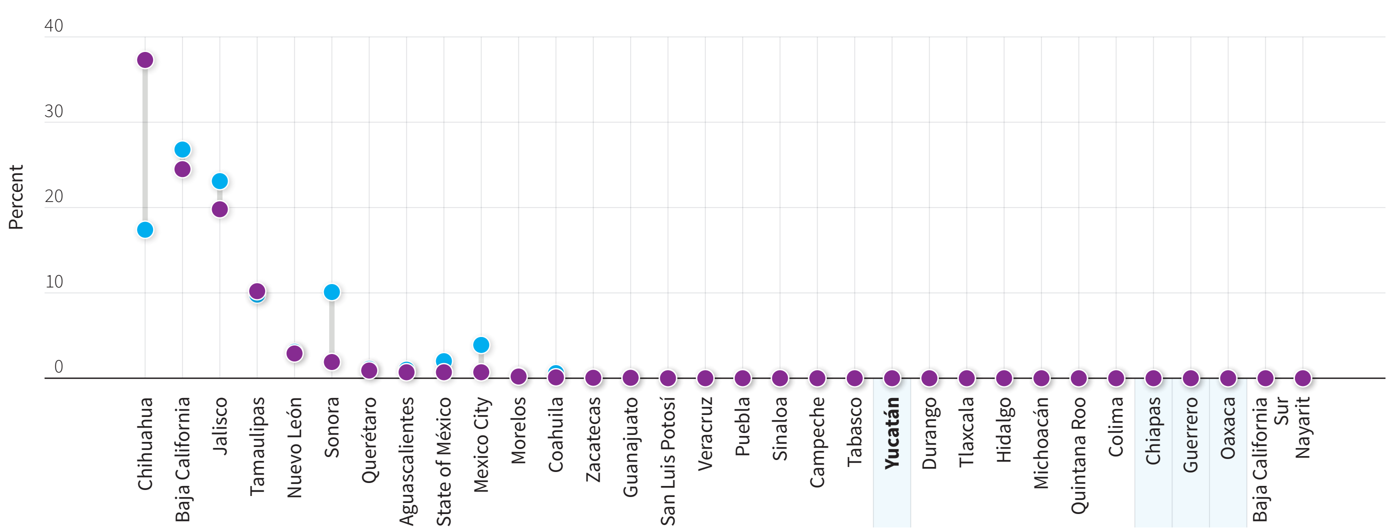
Source: Based on data from UNCTADSTAT database.
Note: CAGR = compound annual growth rate; ICT = information and communication technology.

that period.[31] Approximately 95 percent of the sector's exports were concentrated in five central and northern states: Chihuahua (37.3 percent), Baja California (24.5 percent), Jalisco (19.8 percent), Tamaulipas (10.2 percent), and Nuevo León (2.9 percent) (figure 2.1).

IMPORT-SUBSTITUTION ANALYSIS[32]

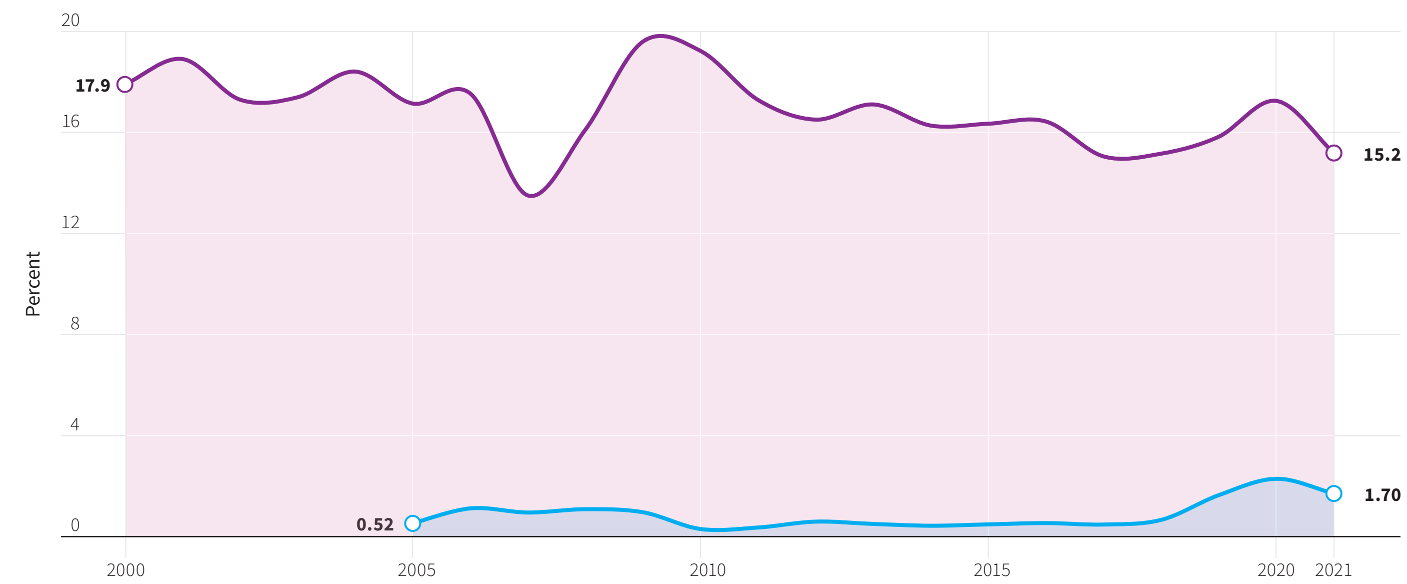
In 2021, Mexico's imports of ICT goods represented 2.9 percent of global ICT goods imports, amounting to US$76.9 billion, while its imports of ICT services represented 0.16 percent of estimated global ICT services imports, amounting to US$658.1 million. Figure 2.2 shows that ICT goods made up 15.2 percent of Mexico's total goods imported, while ICT services accounted for 1.7 percent of its total services imports. The majority of Mexico's ICT goods imports come from China (42.5 percent); Malaysia (13.2 percent); Republic of Korea (8.6 percent); Taiwan, China (8.4 percent); the United States (8 percent); and Vietnam (4.9 percent).

FIGURE 2.1
Contribution to ICT Goods Exports and Exporting Firms, by State, 2014



Source: Calculations based on data from Mexico Atlas of Economic Complexity.
Note: ICT = information and communication technology.

FIGURE 2.2
ICT Goods and Services as a Share of Mexico's Total Goods and Services Imports



Source: Based on data from UNCTADSTAT database.
Note: ICT = information and communication technology. Data on the trade of ICT goods is available starting from 2000, while data on the trade of ICT services is available starting from 2005.

In Mexico, three ICT goods stand out for their import value and growth in recent decades. Electronic components make up 36.7 percent of Mexico's total ICT goods imports, followed by computers and peripheral equipment (29.5 percent), and communications equipment (17.8 percent). Among these goods, computers and peripheral equipment experienced the fastest annual growth rate between 2000 and 2021, at 15.3 percent. In contrast, consumer electronic equipment experienced the slowest growth rate at 3.5 percent.[33]

The ICT imports of the leading ICT states highlight the potential for strengthening Mexico's domestic ICT sector production. Jalisco, Mexico City, Nuevo León, the State of México, and Quintana Roo together generate 50 percent of the jobs in the ICT sector. Additionally, Aguascalientes, Guanajuato, Puebla, San Luis Potosí, and Querétaro are also significant players in the sector, given the synergies that exist between the transportation equipment manufacturing and the use of ICT inputs. In 2014, these states concentrated 40.6 percent of the total ICT goods imported into the country. Based on this analysis, there are goods that have greatest potential for import substitution. These ICT goods include telephone sets and other apparatus for the transmission or reception of data (Harmonized System [HS] code 8517), data-processing machines, magnetic or optical readers, and machines for transcribing or processing data (HS 8471), and transmission apparatus for radiobroadcasting or television, and cameras (HS 8525).[34]

3
Main ICT Goods and Services and Potential Locations

MANUFACTURING ACTIVITIES

Three primary types of products account for a combined 80 percent of information and communication technology (ICT) goods imports: electronic components (36.7 percent), computers and peripheral equipment (29.5 percent), and communications equipment (17.8 percent). The total value of Mexico's imports in these categories amounts to US$64.6 billion, with the top 10 products representing over 88 percent.[35] Based on table 3.1, the ICT goods with the highest import values are electronic integrated circuits (22.9 percent), parts and accessories of machines (16.8 percent), machines for voice, images or other data (10.1 percent), and other electronic integrated circuits (8.5 percent). Upon converting Harmonized System codes of the identified products to their corresponding North American Industry Classification System code (NAICS), five ICT manufactured goods stand out for their significant near-term development potential based on economic complexity indicators.[36] These goods include all other electrical equipment and component manufacturing (NAICS 33599), radio and television broadcasting and wireless communications equipment (33422), communications and energy wire and cable manufacturing (33592), electronic component manufacturing (33441), and computer and peripheral equipment manufacturing (33411).

The manufacturing of ICT goods relies heavily on raw materials and adopting a circular economy approach for procuring them could offer a viable path towards sustainable development. Many of the raw materials used in electronics are metals such as iron, steel, aluminum and copper, as well as rare-earth elements,[37] plastics, and carbon-based products (graphite). Under the status quo, Yucatán would need to source these materials from other parts of the country or import them from abroad. Although improving transportation and logistics infrastructure to ensure access to these inputs is important, adopting a circular economy approach to minimize electronic and electrical waste should be a priority (box 3.1).

SERVICES

Building a skilled workforce for ICT services requires expertise in various fields such as mathematics, logic, problem solving, programming, and engineering. Developing these skills in Yucatán and other southern states will require years of investment and appropriate incentives. Recognizing the importance of fostering human capital necessary to support the growth of the ICT sector, the Yucatán government has taken initiatives such as the 2015–20 *Estrategia Digital Yucatán* (Yucatán Digital Strategy). The state government has prioritized the knowledge economy and invested in research infrastructure to anchor the development of ICT clusters.[38] Twelve public academic and research institutions are part of the *Sistema de Investigación, Innovación y Desarrollo Tecnológico del Estado de Yucatán* (Yucatán State Research Innovation, and Technological Development System; SIIDETEY).[39] Furthermore, the state also hosts two industrial innovation centers and two ICT-oriented industrial parks, as well as 25 higher education institutions that offer engineering and technology-related programs. The presence of these research institutions, innovation centers, and academic facilities not only fosters the cultivation of a skilled labor force, but

TABLE 3.1
Strategic ICT Manufactured Goods to Develop in the Near Term

HS code	Description	Import value, 2021 (US$, billions)	Share of three category imports (%)	Category	Mexican NAICS code equivalence
854231	Electronic integrated circuits; processors and controllers, whether or not combined with memories, converters, logic circuits, amplifiers, clock and timing circuits, or other circuits	14.77	22.9	Electronic components	334410
847330	Parts and accessories of the machines of heading 84.71	10.82	16.8	Computers and peripheral equipment	334410
851762	Machines for the reception, conversion and transmission or regeneration of voice, images or other data, including switching and routing apparatus	6.55	10.1	Communication equipment	334220
854239	Other electronic integrated circuits, other than amplifiers, memories, processors, and controllers	5.46	8.5	Electronic components	334410
847170	Storage units	5.16	8.0	Computers and peripheral equipment	334410
851712	Telephones for cellular networks or for other wireless networks	5.09	7.9	Communication equipment	334210, 334410
853400	Electronic printed circuits	2.95	4.6	Electronic components	334410
847130	Automatic data processing machines; portable, weighing not more than 10 kg, consisting of at least a central processing unit, a keyboard and a display	2.80	4.3	Computers and peripheral equipment	334110
851770	Parts of telephone sets, including telephones for cellular networks or for other wireless networks; other apparatus for the transmission or reception of voice, images or other data, including apparatus for communication in a wired or wireless network (such as a local or wide area network), other than transmission or reception apparatus of heading 8443, 8525, 8527, or 8528	1.83	2.8	Communication equipment	334210, 334410
854140	Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels	1.44	2.2	Electronic components	334410, 335999*
	Others	7.68	11.9		
	Total for three categories considered	64.55			

Sources: Based on data from UN Comtrade database, USITC Dataweb Commodity Translation Tool, and Macalester College.
Note: HS = Harmonized System; ICT = information and communication technology; kg = kilogram; NAICS = North American Industry Classification System; USITC = United States International Trade Commission. To determine Mexico's NAICS six-digit code equivalence, USITC's Dataweb Commodity Translation Tool was used, which provides equivalences for HS 10-digit codes, U.S. NAICS 6-digit codes, Standard International Trade Classification five-digit codes, and Standard Industrial Classification (SIC) four-digit codes. Because there were no equivalences between HS and U.S. NAICS in some cases, a chart that maps SIC four-digit codes to U.S. NAICS six-digit codes, available at Macalester College, was used. Finally, a simple comparison between the codes was made to arrive at the Mexican NAICS, which is considerably more limited than the U.S. version.
*Because of its broad nature, all other miscellaneous electrical equipment and component manufacturing (NAICS 335999) was excluded in the sector assessment as a manufacturing component of the ICT sector, even at the six-digit level.

BOX 3.1
E-Waste: A Risk That Could Be Turned Into an Opportunity

The manufacturing of information and communication technology (ICT) goods heavily relies on raw materials. In Yucatán, these raw materials often need to be sourced from other regions of the country or imported, making the improvement of logistics and infrastructure, such as roads, railroads, and ports, particularly important for the state. On the other hand, adopting a circular economy approach could offer additional business opportunities, either by obtaining secondary raw materials through recycling or exploring the restoration and resale of computers, cellphones, and other ICT equipment as a revenue stream. Both approaches align with initiatives to address the rising concerns surrounding electronic and electrical waste (e-waste). The latter approach, in particular, is even better in terms of environmental impact and potential for reaching "low budget" market segments that have been overlooked but with high potential for scaling up. Yucatán could leverage the substantial presence of tech-savvy firms, of which close to 80 percent specialize in repairing and maintaining electronic and precision equipment.

By 2021, it is estimated that e-waste exceeded more than 52 million annual tons, equivalent to more than 6 kilograms per capita. If this trend continues, this figure could reach 120 million by 2050. Half of the e-waste is produced in Europe and the United States, with personal devices such as computers, screens, smartphones, tablets, and television sets accounting for the majority. Although the global e-waste is valued at more than US$62.5 billion annually—with most of it being reusable and containing valuable raw materials such as precious metals and rare-earth elements—only one-fifth of waste is appropriately collected and recycled. Even in advanced countries like the United States, recycling rates reached only around 35 percent.

To increase the recycling rate of e-waste, several measures can be implemented from the supply and demand sides. From the supply side, it is important to: (1) enhance the efficiency of collection and management systems, as well as improve the recycling infrastructure; (2) increase the quality and quantity of recycled output to meet the demands of supply chains in a stable and reliable way; and (3) promote the development of new production processes to design and manufacture products with greater repairability, recyclability, and reusability. From the demand side, it is important for consumers to: (1) raise their awareness about the environmental impact of e-waste—by understanding the issue, they may be willing to pay a premium for environmentally friendly and sustainable products, and (2) learn on how to properly manage e-waste.[a]

a. WEF (2019).

also signals the long-term commitment of the government to the development of the ICT sector.

Yucatán performs relatively well in metrics related to research and development. In 2021, the state had 348 researchers per million inhabitants, the fifth highest ratio nationwide.[40] In addition, Yucatán recorded 27.6 inventions registered and seven patents were filed per million inhabitants, the seventh and 12th highest ratios in the country, respectively.[41] Yucatán has more researchers and inventions per capita than any other Mexican southern state, while it ranks second in terms of patents, just behind Puebla.[42]

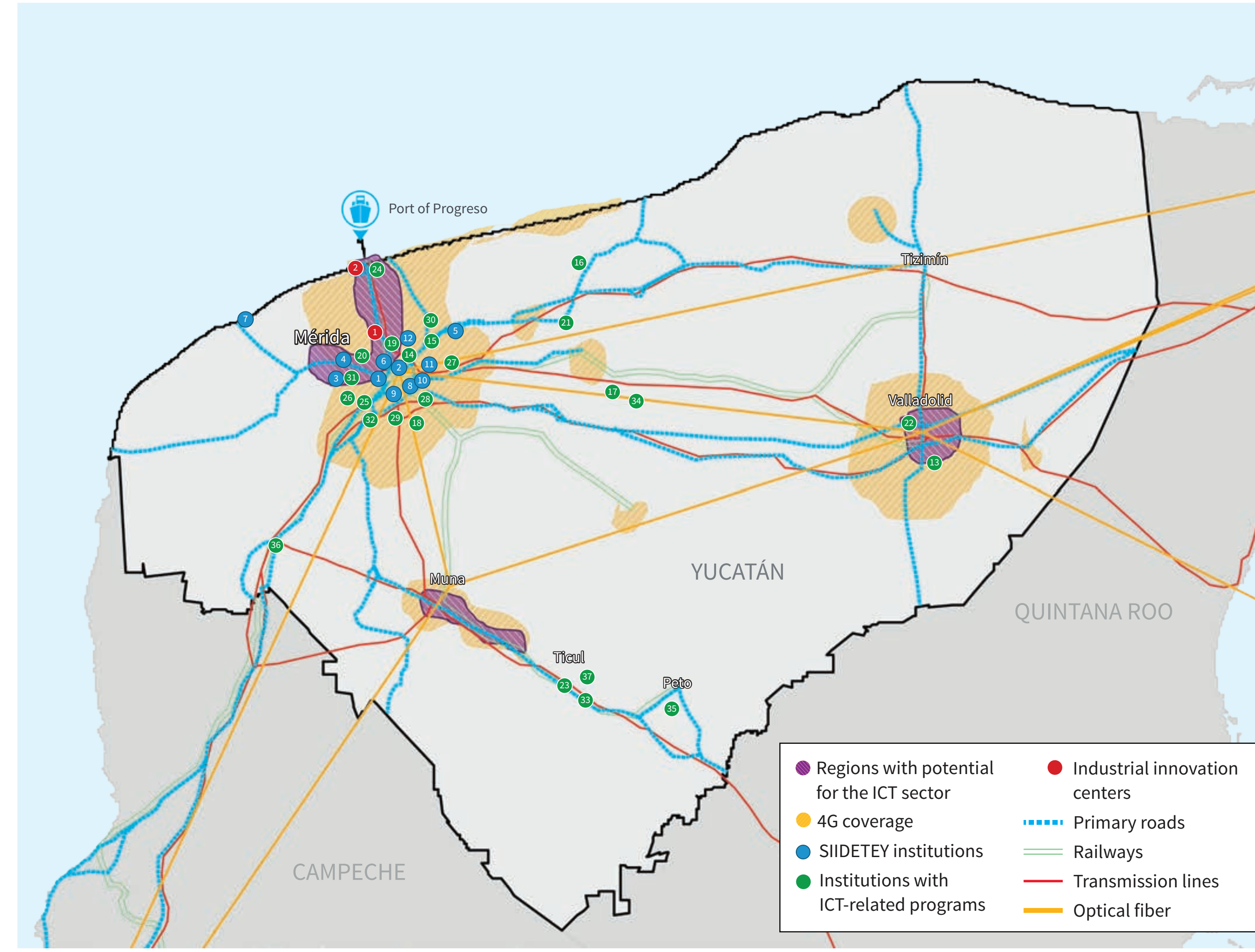
Yucatán's enabling ecosystem provides opportunities for developing ICT services in several target markets. Telecommunications accounts for 18 percent of Yucatán's ICT services firms. Although data processing, hosting, and related services (NAICS 5182) and software publishing (NAICS 5112) account for just 1.3 and 0.4 percent of ICT firms, respectively, they exhibit the greatest potential for growth. The use of digital services could increase productivity in almost all industries.[43] Small and medium enterprises can adopt ICT services to improve financial planning, management, operations, accounting, and tax practices. These services also facilitate commercial collaboration, innovation, knowledge transfer, and access to new markets. Large firms can utilize ICT services to strengthen payroll and human resources management to ensure compliance with new regulations on subcontracted workers, whose compensation must now be included on firms' balance sheets. The public administration can also drive demand for ICT services as e-government software can help expand online public services, improve planning and resource management, strengthen accountability, enhance transparency, and improve tax collection effectiveness.

POTENTIAL LOCATIONS

The city of Mérida and its surrounding area appears to be the most viable location for a growing ICT sector. Map 3.1 shows that this area has a large potential workforce and hosts most of the state's SIIDETEY facilities and higher education institutions. The corridor between Mérida and Progreso, including the road connecting Progreso to Hunucmá , also has considerable potential for ICT manufacturing development. It offers rapid access to the city of Mérida and the international container-shipping port in Progreso. The areas around Valladolid to the east and the corridor between Muna and Ticul to the south demonstrate medium-term growth potential. These regions possess a large potential workforce, several ICT-related institutions, and are connected to Mérida and Progreso through the Federal Highways 180D and 261.

MAP 3.1

Potential Areas for ICT Development in Yucatán



Source: Base map for primary roads, railways, ports and transmission lines was elaborated using ArgGIS with shapefiles from the INEGI's *Biblioteca digital de Mapas* 2019 edition and optical fiber location was according to Bestel n.d.

Note: 4G = fourth generation; ICT = information and communication technology; SIIDETEY = *Sistema de Investigación, Innovación y Desarrollo Tecnológico del Estado de Yucatán*. The industrial innovation centers in Progreso have approximate locations because of limited specific information. The symbols used are for representation purposes only. A qualitative estimate was made for potential ICT locations, but additional studies are required to determine definitive areas with potential. For the corresponding SIIDETEY institutions, institutions with ICT-related programs, and industrial innovation centers, see table F.1 in appendix F.

4

Key Challenges and Sector-Specific Binding Constraints

To identify the main constraints for the consolidation of the information and communication technology (ICT) sector in Yucatán, this section adapts the growth diagnostics decision tree developed by Hausmann, Klinger, and Wagner (2008) at the sectoral level.[44] Applying this framework to Yucatán, the main constraints in the state include: (1) deficient electricity and communication infrastructure, especially in areas outside Mérida and (2) insufficient access to finance, particularly for the ICT manufacturing industry.

HUMAN CAPITAL[45]

The assessment on whether human capital is a binding constraint on ICT development in Yucatán yielded inconclusive results. In terms of the deviation between workforce skills and industry requirements for ICT goods manufacturing, Yucatán performs relatively close to the median. The relative salary in Yucatán is in the middle of the distribution among the 32 states, for total and formal workers, indicating that there is no apparent wage premium being offered to attract more skilled workers to the state. In the ICT services sector, Yucatán falls within the lower half of the distribution in terms of skills gaps, and only the salary of other telecommunications is relatively high, especially in the formal sector (figure 4.1). Although there is no convincing evidence indicating a lack of human capital as a binding constraint for the development of the ICT industry in Yucatán, it is vital to continue building the capabilities of the local workforce. As the industry grows, a greater number of skilled workers will be required, and ICT firms will demand constant upskilling to keep up with rapidly evolving technologies.

INFRASTRUCTURE AND FACTOR INTENSITY[46 and 47]

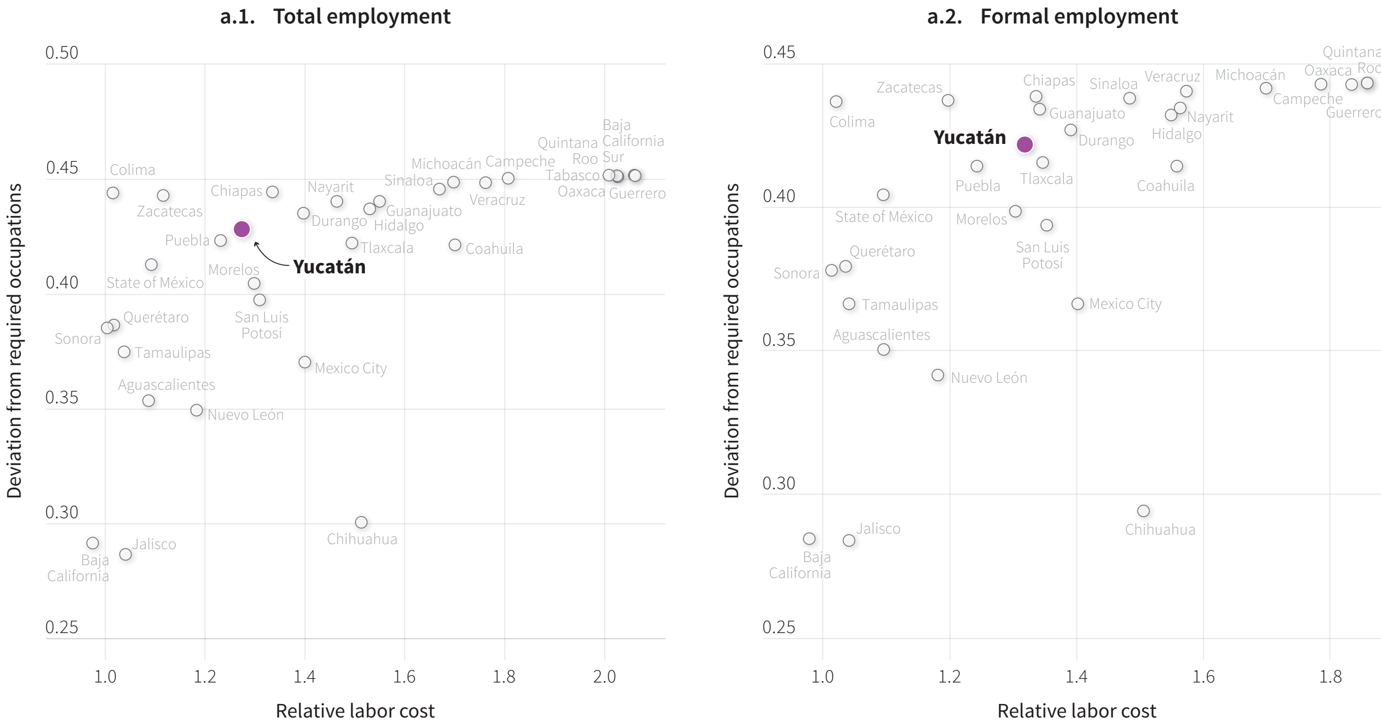
Energy infrastructure shortcomings could be a constraint to develop the most energy-intensive operations. Figure 4.2 shows that all ICT manufacturing activities are relatively energy intensive. Manufacturing navigational, measuring, electromedical and control instruments (North American Industry Classification System [NAICS] four-digit code 3345), magnetic and optical media (3346), and wires for electric conduction (NAICS six-digit code 335920) are all moderately energy intensive, while manufacturing of computer and peripheral equipment (3341), communications equipment (3342), audio and video equipment (3343), and electronic components (3344) are more energy intensive, and manufacturing of electric products of coal and graphite (335991) is highly energy intensive. Yucatán's limited energy generation and distribution capacity may limit the potential for establishing energy-intensive operations. Energy intensity is also a key constraint for some ICT services subsectors, especially data processing, hosting, and related services (518), which consumes far more energy than most forms of ICT manufacturing.[48]

Water infrastructure in Yucatán is sufficient even for the most water-intensive ICT production. Some ICT manufacturing activities are highly water intensive, including manufacturing of electronic components (3344), navigational, measuring, electromedical and control instruments (3345), magnetic and optical media (3346) and electric products of coal and graphite (335991). However, the abundant water supply in Yucatán ensures that water intensity is not a constraint on the development of ICT manufacturing, despite some improvements in the service might be required. Similarly, the abundant water supply in Yucatán meets the needs of ICT services, which require less water, mainly for facility operations.[49]

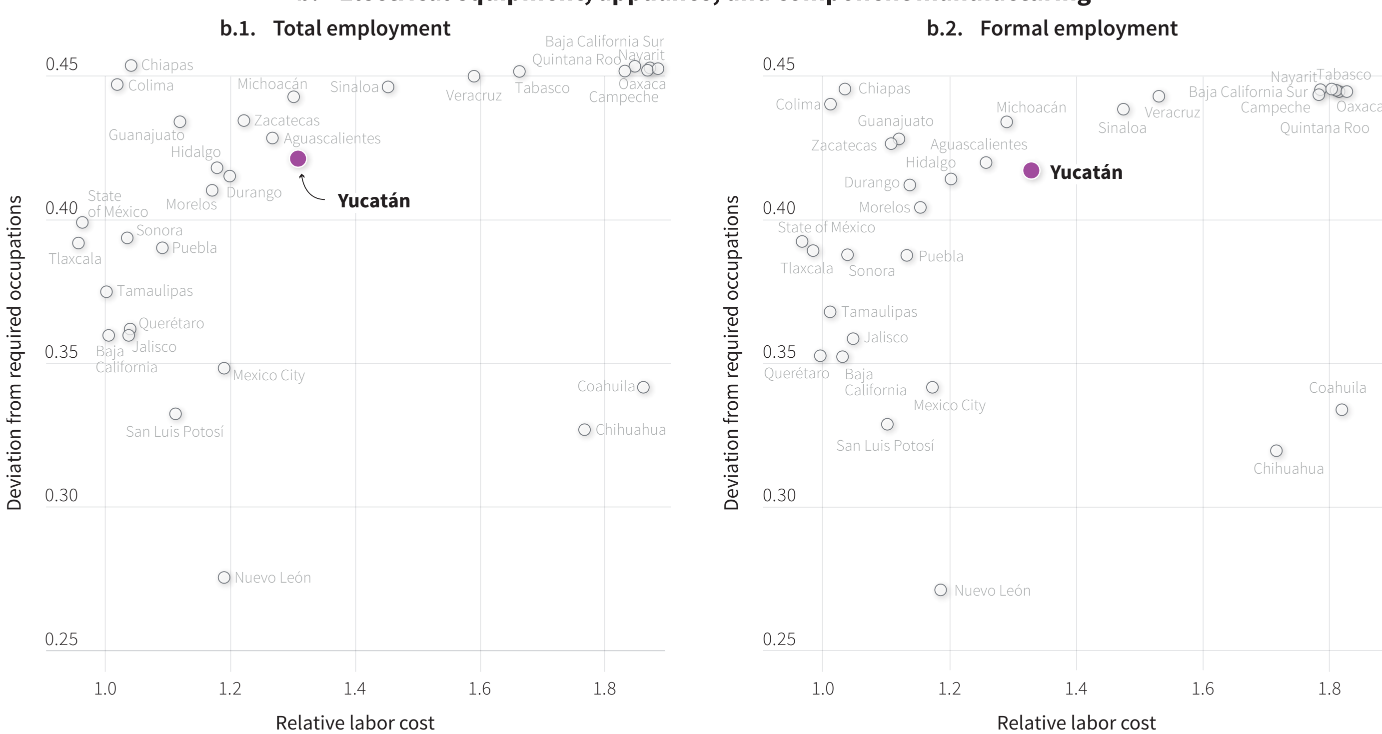
Fuel availability is not considered a constraint for most ICT subsectors given their low fuel intensity. Out of all these subsectors, only communications equipment manufac turing (3342) is considered as mid-highly fuel intensive. Despite this, fuel availability is not a binding constraint on ICT manufacturing. Similarly, fuel supply is not a constraint for ICT services, which require even less fuel in their production process.[50]

FIGURE 4.1
Skills Deviations and Labor Costs in the Primary ICT Subsectors

a. Computer and electronic product manufacturing



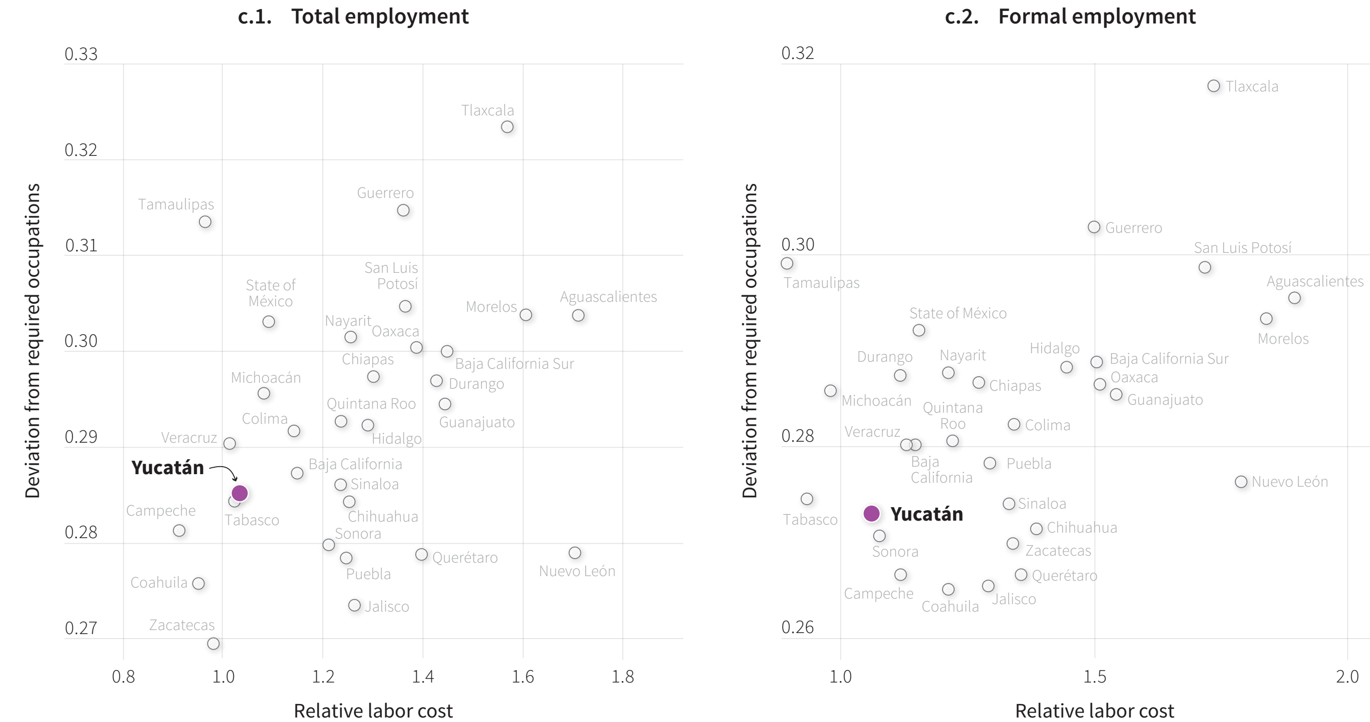
b. Electrical equipment, appliance, and component manufacturing



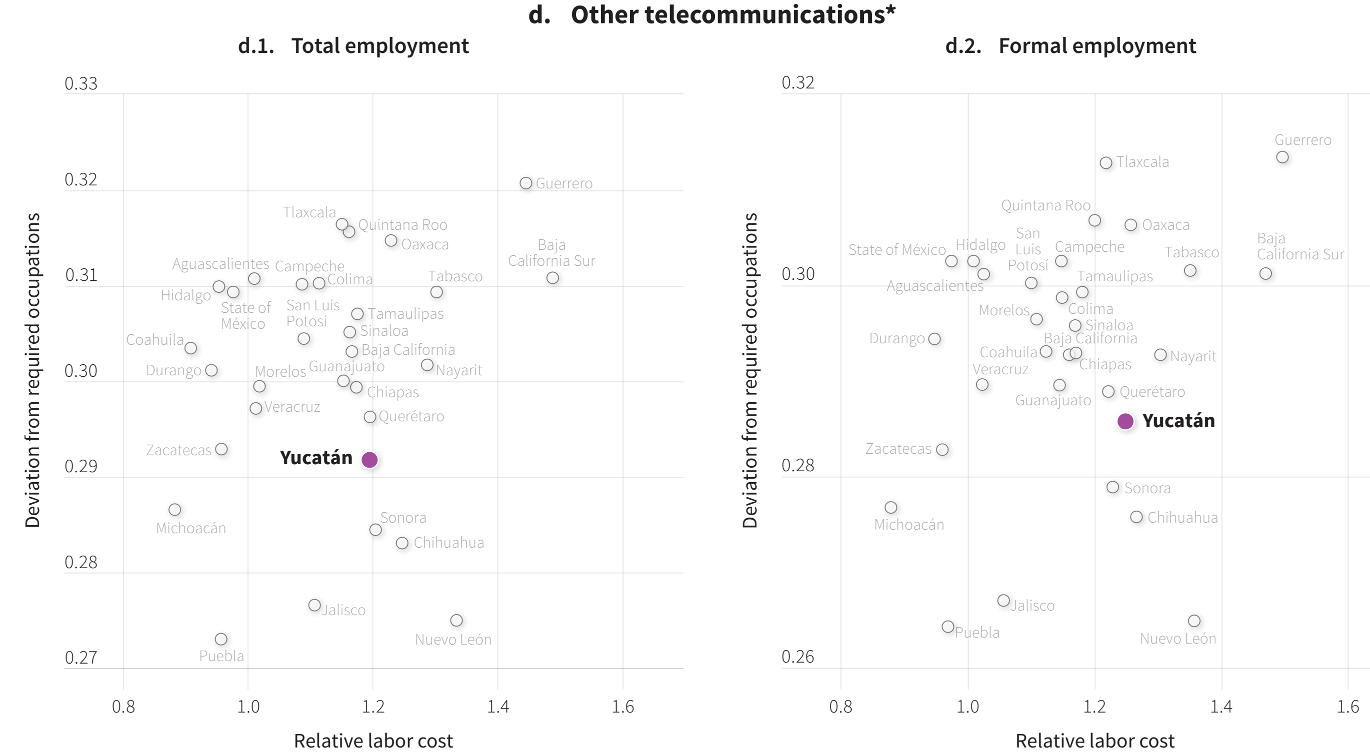
(Figure continues next page)

FIGURE 4.1
Skills Deviations and Labor Costs in the Primary ICT Subsectors *(continued)*

c. Publishing and editing of newspapers, magazines, books, software, and other materials*



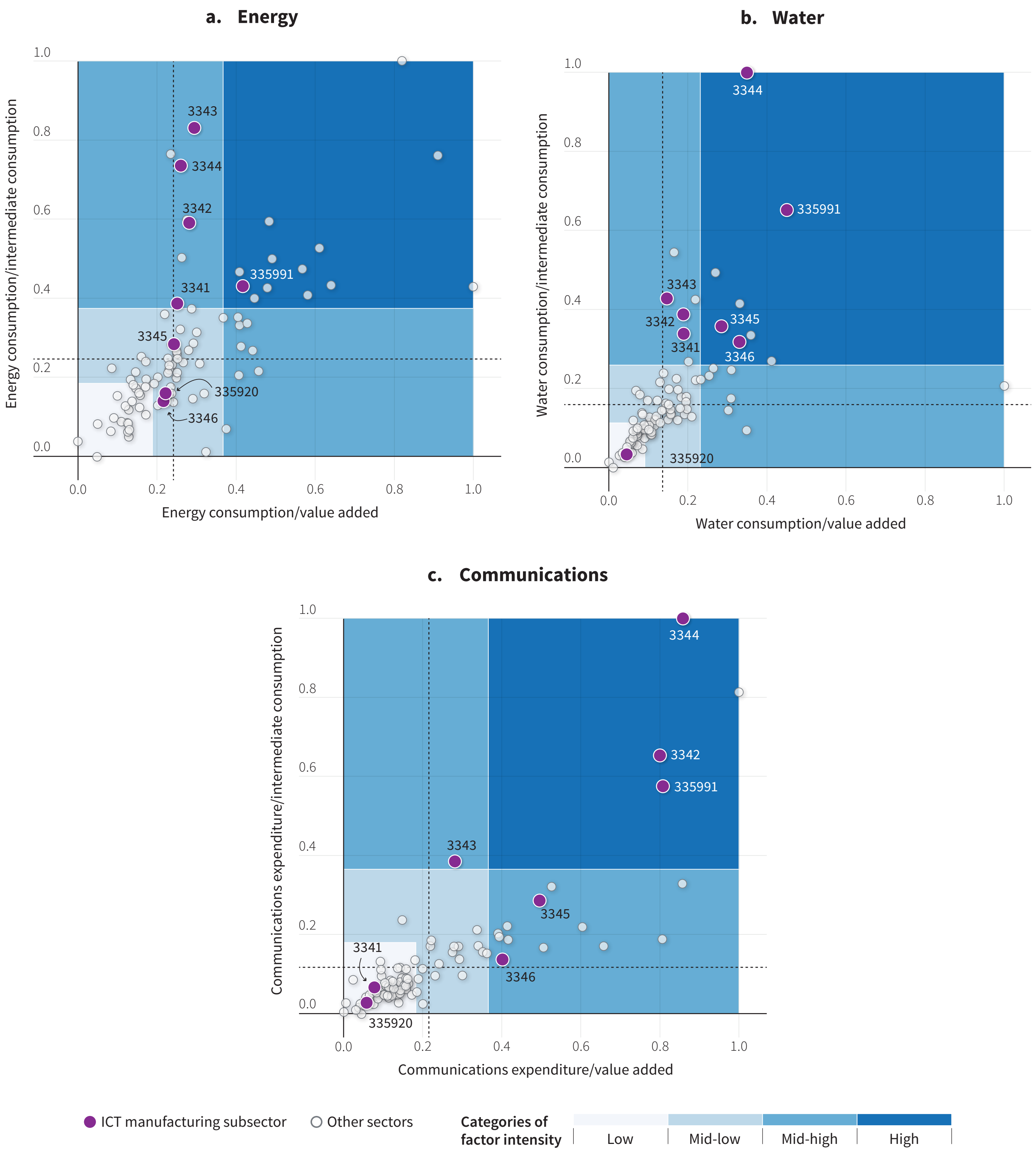
d. Other telecommunications*



Source: Calculations based on the methodology implemented by Barrios and others (2018a; 2018b) using data from INEGI's ENOE database.
Note: For all panels, the x-axis is the ratio of the average hourly wage ratios at national and state levels, and y-axis is the deviation in occupation shares between national and state levels (using the symmetric mean absolute percentage error), in the first quarter of 2019. In cases where a state has no workers engaged in a particular occupation, the highest salary among all states for that occupation was assigned to reflect the scarcity of workers in that field, necessitating a premium to attract qualified workers.
*Mexico City is excluded from the analysis because its value is less than three standard deviations below the average. Therefore, it is considered an outlier.

FIGURE 4.2

Use Intensity of Selected Factors by Sector, 2014 and 2019 Averages



Source: Calculations based on data from INEGI 2014; 2019.
Note: ICT = information and communication technology. Sectors are classified using the North American Industry Classification System (NAICS). Dashed lines represent the average normalized value of the sectors with a revealed comparative advantage greater than one for Yucatán and those are NAICS sectors 3111, 3112, 3116, 3117, 3118, 3121, 3131, 3141, 3149, 3151, 3152, 3159, 3169, 3219, 3261, 3273, 3279, 3323, 3332, 3333, 3353, 3366, 3371, and 3399. Purple points represent group industries of the information and communication technology manufacturing sector in NAICS.

The freight intensity of ICT manufacturing varies across subsectors, but Yucatán has a relatively adequate transport and logistics infrastructure, especially in the most densely populated regions. Navigational, measuring, electromedical and control instruments manufacturing (3345) is the least freight intensive. Computer and peripheral equipment manufacturing (3341), communications equipment manufacturing (3342), manufacturing and reproducing magnetic and optical media (3346) and manufacturing wires for electronic conduction (335920) are moderately freight intensive. Audio and video equipment manufacturing (3343) and electronic component manufacturing (3344) are more freight intensive, while manufacturing of electric products of coal and graphite (335991) is the most freight intensive. Nevertheless, Yucatán has an adequate road network, with one of the highest levels of firm satisfaction for toll-free roads among 32 states. The Chiapas-Mayab Railway Line passes through the state, linking Valladolid with the rest of Mexico's railway system at Veracruz. The government's flagship Mayan Train project[51] is expected to increase freight capacity.[52] Furthermore, Yucatán has 12 seaports, including the international port of Progreso,[53] which has untapped growth potential.[54] Given these abundant freight-transport options, the transportation infrastructure should not constrain the development of ICT manufacturing activities in Yucatán in the short term. Similarly, transportation is not a constraint on ICT services, which require little to no freight capacity.

The high intensity of communications use across ICT activities could present a constraint to the development of the sector in certain areas of Yucatán. The least communications-intensive ICT manufacturing subsectors are the manufacturing of wires for electronic conduction (335920) and computers and peripheral equipment (3341). Audio and video equipment manufacturing (3343) and manufacturing and reproducing magnetic and optical media (3346) are moderately communications intensive. All other ICT manufacturing activities are highly communications intensive, particularly electronic components manufacturing (3344). ICT services firms use up to twice the volume of communication services as compared to ICT manufacturers.[55] Yucatán has good access to telephony and mobile internet services, but supply of fixed-broadband internet is limited in several municipalities. The fiber-optic infrastructure, owned by a few operators, is largely concentrated in the corridors between Mérida and Valladolid, Mérida and Progreso, Calkiní (in Campeche) and Mérida, and Mérida and Tizimín. The lack of telecommunications infrastructure outside these areas could act as a binding constraint on the development of the ICT industry. Yucatán ranked mid-low on the ICT index for 2015 and 2017,[56] however, the implementation of the *Red Compartida* may have improved its connectivity in recent years. Another improvement is the recent installation of the country's second internet exchange point node in Yucatán, which increases the efficiency of data centers.

GOVERNANCE AND PUBLIC POLICY

The public sector often plays a key role in the development of ICT clusters at the international, national, and state levels. In Mexico, states like Jalisco and Nuevo León have developed comprehensive ICT industrial policies, propelling them into leadership positions within the sector (for a description of the development of the ICT cluster in Jalisco, see box 4.1). In 2000, the federal government included the

BOX 4.1

Jalisco's ICT Cluster

During the last six decades, Jalisco has experienced a significant development in information and communication technology (ICT), giving rise to a vibrant ICT cluster. This cluster primarily focuses on the manufacturing of computer hardware and, more recently, it has expanded to include design, software development, logistics, and digital animation. In Mexico, this cluster represents the largest ICT hub, encompassing original equipment manufacturers (OEMs), contract manufacturers (CMs), electronic manufacturing services, design centers, specialized suppliers, and over 150 software firms. Its origin can be traced back to the 1960s when two industry leaders, Motorola and Burroughs, established subsidiaries in Guadalajara. These companies aimed to serve the growing yet closed Mexican market at the time. Subsequently, IBM and Hewlett Packard arrived during the 1970s and early 1980s. The North American Free Trade Agreement in the 1990s, which has now been replaced by the United States-Mexico-Canada Agreement, triggered the establishment of new subsidiaries and fostered the emergence of spin-offs and startups in the state. Several factors contributed to Guadalajara's attractiveness for the high-volume, low-mix segment of the electronics industry. The city enjoyed a relatively educated and low-cost labor force, as well as favorable connectivity with the United States further boosted its appeal.

However, the rise of China had a significant effect on Guadalajara's cost-based competitiveness, which led to an economic crisis in the state in 2001. As a result, it became imperative for Jalisco to upgrade from an electronics maquila state to a generator of technology and knowledge. This shift prompted the state to transition towards smaller-scale production of higher-value goods. Notably, the development of original design manufacturing has positioned the state as Latin America's most important semiconductor design center. The shift also has also facilitated the growth of software development, multimedia, and advanced-technology services.

The success of Jalisco in this transition can be attributed to the implementation of a public-private strategy. The state has established a collaborative approach involving a highly institutionalized and nonpartisan private sector supporting continuity across government administrations.

The development of the ICT industry has been supported by a strong public-private planning approach that dates back to the 1995–2001 State Development Plan. This plan focused on attracting OEM subsidiaries and contract manufacturers while developing local procurement. Following the economic crisis in 2001, the public and private sectors conducted an industry diagnostic, laying the foundations for the state's science and technology program in 2003, which served as a roadmap to upgrade Jalisco from electronics assembly to design, knowledge, and technology generation.

To execute the strategy, Jalisco pioneered the establishment of key institutions and the consolidation of public-private partnerships. In 1998, the state government and electronic firms created the *Cadena Productiva de la Electrónica* to promote the development of local suppliers for the electronics industry. In 2002, the *Instituto Jalisciense de Tecnologías de la Información* (IJALTI) was established to support the state's upgrading strategy. Its board include members of the state government, the *Cámara Nacional de la Industria Electrónica, de Telecomunicaciones y Tecnologías de la Información Sede Occidente* (also known as CANIETI Occidente, is the regional branch of a national chamber of commerce representing the electronics, telecommunications, and information technology [IT] industries), and the University of Guadalajara. IJALTI played a key role in implementing the *Política Jalisciense de Tecnologías de Información, Microelectrónica y Multimedia* (Jalisco Policy on IT, Microelectronics, and Multimedia; TIMEMU) and the development of the ICT industry. In addition, in 2013, Jalisco became the first state in the country to establish a science and innovation ministry, which coordinates the state's technical education institutions.

The academic sector has played a key role in the ICT cluster's development, given its ability to respond to the human capital needs of the industry. Jalisco has 13 technical education institutions and three technical universities. Additionally, the private education system has 12 universities and over 60 graduate programs, business schools, training facilities, and technical institutions. These academic institutions collaborate closely with the state government and the private sector to offer standardized and updated programs that develop the skills required by the industry.

Jalisco has also implemented an aggressive FDI attraction strategy, offering support with permits, temporary tax breaks, training programs, collaboration in research and development projects, and infrastructure facilities, including business incubators and accelerators. Furthermore, the state aligns with ICT-related national programs, such as Prosoft (*Programa para el Desarrollo de la Industria del Software*), which was influenced by Jalisco's TIMEMU policy. Jointly selected projects by the state and CANIETI Occidente led to the creation of a software center in 2006, funded by Prosoft (70 percent), the state (25 percent), and the private sector (5 percent), administered by IJALTI.[a]

a. Palacios (2008); Ferraro and Rojo (2018); Schatan and Enríquez (2015); Jaén and León (2005).

ICT industry in the 2000–06 National Development Plan, prompting Yucatán to follow suit in its 2002 State Development Plan. In September 2002, Yucatán established the country's first ICT cluster, the *Consejo de la Industria de la Tecnología para la Información Yucatán*. This cluster included 11 firms, the local chapter of the *Cámara Nacional de la Industria Electrónica, de Telecomunicaciones y Tecnologías de la Información* (Chamber of Electronics, Telecommunications, and Information Technologies), the *Instituto Tecnológico de Mérida* (Technology Institute of Mérida), and the Anahuac Mayab University. By 2010, the cluster had grown to encompass 21 firms, two chambers of commerce, and representatives of the state government. However, from 2007 to 2012, government support for the development of the ICT clusters in Yucatán was more limited, because of a change in government and subsequent shift in policy priorities. Although the state government continued to provide infrastructure to the cluster, it allowed the lease on the main building to expire in 2011. This resulted in the dismantling of the cluster and engendered a distrust of the state government among the ICT business community.[57] Furthermore, the state government failed to support local firms in fully taking advantage of the support grants offered by the federal government's Prosoft program (*Programa para el Desarrollo de la Industria de Software*). Consequently, firms in Yucatán forfeited a critical edge to their counterparts in other states such as Jalisco and Nuevo León.[58]

Nevertheless, a subsequent change in government in 2012 brought renewed support for the ICT industry in Yucatán. The 2012–18 State Development Plan reestablished the sector's strategic importance. In 2013, Yucatán ranked 12th in the national index of science, technology, and innovation indicators.[59] The worst-performing indicators for the state were academic and research infrastructure (21st), ICT development (19th), and the institutional framework (19th). However, the state had since embarked on significant legal and institutional reforms. These included establishing a new innovation and ICT development center (CIDTI), enacting a Law for the Promotion of Scientific and Technological Development and Innovation in Yucatán, creating a *Secretaría de Investigación, Innovación y Educación Superior* (Secretariat for Research, Innovation and Higher Education), and founding a Scientific and Technological Park, among others. The role of the state has moved beyond the provision of infrastructure to the creation of partnerships and networks for innovation with the involvement of key stakeholders.

The government of Yucatán is committed to developing a competitive ICT industry in the state. In the 2022 State Competitiveness Index, Yucatán ranked 17th in economic innovation and third in government ICT usage. Although Yucatán's 2018 Scientific and Innovation Capabilities Index score was below the national average, it had shown improvement since 2014, moving from 20th to 17th nationwide. The inclusion of the ICT sector in the state's 2018–24 Development Plan, suggests that industry support now transcends administrations and has become a state priority. Although Yucatán still has significant room for improvement—particularly when compared to states like Jalisco, Mexico City, and Nuevo León—its robust legal and institutional framework, greater policy continuity, and continuous progress in key indicators suggest that government support is no longer a constraint on the development of the ICT industry in Yucatán.

ACCESS TO FINANCE

Access to international financing is not a constraint on the ICT sector in Yucatán. Between 2003 and 2021, the sector received 7.5 percent of the state's total FDI inflows. Moreover, Mexico has attracted global ICT firms that have full access to global capital markets. The ICT sector in the country also benefit from the involvement of multilateral institutions such as the *Corporacion Andina de Fomento* (Development Bank of Latin America), the Inter-American Development Bank, and the World Bank Group. These institutions actively invest in the ICT sector or facilitate investments, contributing to its expansion and development.

Access to domestic financing by local firms in Yucatán, however, has significant room for improvement. Out of the 106 municipalities in Yucatán, 27 lack financial access points,[60] representing the third-lowest coverage among municipalities in the country. Although Yucatán's ratio of 13.1 financial access points per 10,000 inhabitants is slightly higher than the national median, it ranks 18th among all 32 states in terms of personal deposits accounts per capita nationwide.[61] This limited financial penetration may constrain the development of the state's ICT sector. States with high levels of ICT development tend to have larger portfolio balances relative to GDP, but Yucatán's ratio is below that of ICT leaders such as Jalisco, Mexico City, Nuevo León, and Quintana Roo.[62]

Interest rates charged to firms in ICT-related activities are among the highest nationwide. Although specific data for all ICT activities are not available, interest rates charged to communications and telecommunications firms at the national level are at the upper end of the range. This could reflect either a scarcity of financial resources or heightened risk aversion in these activities. Smaller firms in the communications and telecommunications sector face the highest interest rates, while large firms face the lowest. The combination of uneven access to finance, lower levels of bank penetration in Yucatán, and high interest rates charged to the sector could undermine competition and constrain the development of the ICT industry in the state.

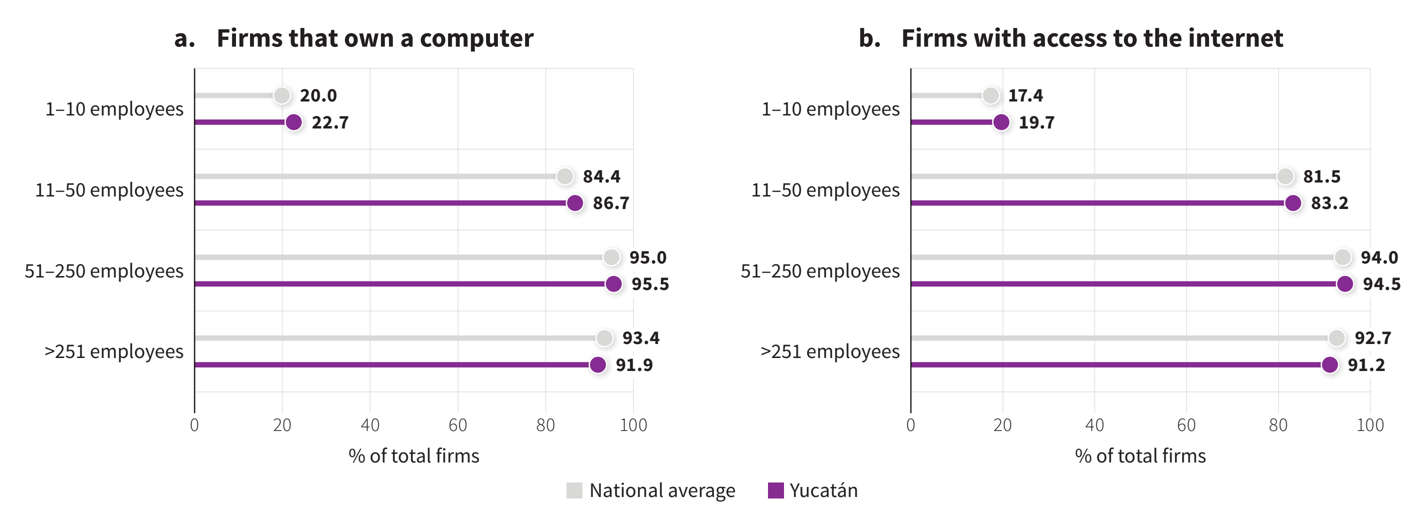
In Yucatán, ICT manufacturing firms practically have no access to finance, while ICT services firms are more likely to receive external financing.[63 and 64] Across all economic activities, Yucatán has among the smallest shares of firms that report having access to external financing. This pattern holds for ICT manufacturing firms, though they represent a small portion of the state's ICT sector. Only one ICT manufacturing firm reported having access to external sources of finance, while ICT services firms have a more balanced access to external sources of finance. Over 8 percent of ICT services firms reported having access to external sources of finance, exceeding the shares in Mexico City, Nuevo León, and State of México. In addition, 4.2 percent of ICT services firms reported having access to bank financing, higher than in Jalisco, Mexico City, and State of México.

Overall, access to finance appears to be a binding constraint on the development of the ICT sector in Yucatán. The low penetration of financial services and the high interest rates charged to ICT firms by commercial and development banks, are likely to reduce investment and slow growth in the sector. Credit constraints may particularly be binding in the ICT manufacturing subsector, where firms do not seem to be seeking financing at all. Although ICT services firms appear to have relatively better access to finance, the state's low financial penetration indicators and high interest rates could inhibit the development of this component within the sector, particularly considering their intangible nature and lower availability of assets to be used as collateral.

OTHER RISKS AND CHALLENGES

- **Weak ICT readiness at the national and state levels.** Out of 139 countries, the World Economic Forum's 2016 Global Information Technology Report (latest available at the moment of the elaboration of this report) ranked Mexico 76th in networked readiness,[65] 84th in infrastructure and digital content, and 88th in international internet bandwidth. Similarly, out of 176 countries, Mexico ranked 87th on the International Telecommunications Union's 2017 ICT Development Index (latest available). At the subnational level, Yucatán performs below the national average on ICT readiness indicators.[66] Mexican firms also exhibit low levels of ICT adoption. Small and medium enterprises account for 99.8 percent of all firms in the country and contributed to around half of GDP, yet rates of technological uptake among these firms are very low (figure 4.3).
- **Unequal access to education and digital skills development.** Despite recent advances, Yucatán must do more to address disparities in access to high-quality general education. Education is vital to enable the use of ICT goods and services and to help build the workforce skills necessary for the development of the sector. As emerging tech nology trends require continuous upskilling to meet the demands of employers, a well-educated workforce becomes a critical driver of comparative advantage.[67]
- **Low international presence in the ICT services sector.** Several Mexican firms aiming to offer software development and other ICT services in international markets have identified a lack of confidence among potential foreign clients. The absence of a strong international reputation for Mexican ICT firms may limit their ability to form strong business relationships, often leading them to merge or partner with foreign firms for access new markets.
- **Security and data protection concerns.** Increasing concerns around consumer and firm security, as well as data protection, combined with rising trade protectionism in some developed economies, could reduce foreign investment and weaken the demand for ICT exports. More rigid regulations might limit the flow of information, a key element of the ICT industry, while also raising compliance cost and infrastructure expenditures associated with the fragmentation of data storage systems and implementation of security measures.[68] Furthermore, protectionism could limit the growth of the sector, especially in Mexico and Yucatán, by hindering expansion into global value chains.

FIGURE 4.3
ICT Adoption by Firm Size in Mexico and Yucatán, 2018



Source: INEGI 2019.

5

Comparative Advantages to Develop

The following analysis is based on the four dimensions outlined in Michael Porter's diamond framework for assessing competitive advantages (figure 5.1).[69]

1 **Factor conditions.** Although the labor productivity of the overall manufacturing sector in Yucatán falls below the national average, the labor productivity is higher in computer and electronic product manufacturing. With the state government's active support, Yucatán has significantly narrowed the productivity gap for most information and communication technology (ICT) subsectors. Moving into more sophisticated ICT activities requires close coordination between educational institutions and the private sector, and Yucatán has taken steps in this direction. There are 12 public academic and research institutions in the state, including the *Universidad Politécnica de Yucatán*, a bilingual university created in 2016 to satisfy the labor demand of the ICT sector by offering programs in data engineering, computational embedded systems engineering, and computational robotics engineering. However, the state's limited energy generation and transmission capacity could constrain the growth of the ICT industry, particularly in energy-intensive services subsectors. Furthermore, the lack of adequate telecommunications infrastructure outside Mérida could also constrain the growth of the sector, despite the broad adequacy of other forms of infrastructure such as transportation.

2 **Demand conditions in the local market.** Mobile phone penetration and internet access are key elements of demand for ICT products and services. While 99.3 percent of adults in Yucatán have a mobile phone, the second highest percentage in the country, about 66 percent of households have an internet connection, and 44.7 percent have a computer.[70] Moreover, uptake rates for some ICT services are very low: for example, the mobile banking subsector has just four customers per 10,000 adults.[71]

3 **Supporting and related industries.** The financial sector in Yucatán falls short in offering adequate support for ICT development. The limited penetration of financial services and the high interest rates charged to firms in the sector could limit the growth of the industry in the state. Similarly, the absence of venture capital, which has been key to ICT development in other countries, is another limitation in the state. Nevertheless, Yucatán has made significant progress toward establishing ICT clusters, including an innovation and ICT development center and scientific and technological park.

4 **Context for Strategy and Rivalry.** Mexico's extensive network of foreign trade agreements offers preferential access to nearly 50 markets. However, 95 percent of Mexico's ICT manufacturing exports originate from four states in the central and northern regions, while Yucatán's contribution remains very limited. Only around 0.02 percent of Mexico's ICT manufacturing exporters are based in Yucatán, indicating that local rivalry is weak. The ICT service sector presents a similar pattern, with few large international players dominating the market and limited competition. However, nearshoring investments could be attracted to accelerate the development of ICT manufacturing and services in Yucatán, leveraging on Mexico's proximity and close trade relationship with the United States, and the enabling environment offered by the state.

FIGURE 5.1

Key Comparative Advantages to Develop in Yucatán

Source: Adapted from Porter 2008.

In Yucatán, three local ICT firms have been identified as significant job creators, as each has over one hundred employees. These firms operate in the manufacturing component of the ICT sector. Their presence in the state demonstrates the viability of this component in Yucatán which could help attract more firms in the sector (table 5.1).

Recent investment announcements in Yucatán reaffirm the attractiveness of the state to host ICT activities. Before the pandemic, in 2019, Elecnor Deimos, a Spanish firm, announced an investment of US$130 million for establishing a technological center in Yucatán that will focus on satellites and space technology. This center, set to be the first of its kind in Mexico, will play a crucial role in supporting the development of a satellite manufacturing plant in Yucatán. The investment is seen as a by-product of Yucatán's advanced technology ecosystem, which has been revolutionized by the *Universidad Politécnica de Yucatán*. The university would provide Elecnor Deimos with aeronautical engineers to support the operations of the center.[72] Furthermore, there are other important projects in the tourism and infrastructure sectors aimed at enhancing ICT components. However, detailed information about these projects is not yet publicly available, as they are still in the early stages of the investment process.[73]

TABLE 5.1

Key Players in Yucatán's ICT Sector

NAICS six-digit code	Sector	Enterprise	Municipality
334410	Semiconductor and other electronic component manufacturing	Falco Electronics México S.A. de C.V.*	Umán
335920	Communication and energy wire and cable manufacturing	Argos Eléctrica S.A. de C.V.	Umán
517311	Wired telecommunications carriers	Telesistemas Peninsulares S.A. de C.V.	Mérida

Source: Based on data from INEGI's DENUE database.
Note: ICT = information and communication technology; NAICS = North American Industry Classification System. The table lists firms with 101 workers or more.
*The firm has at least 251 workers.

6
Policy Recommendations

To accelerate the growth of the information and communication technology (ICT) sector in Yucatán, this chapter offers a summary of policy recommendations aimed at creating or strengthening public goods and correcting market failures through interventions. For a more detailed discussion of the policy recommendations, see appendix A.

PUBLIC GOODS

1. **Maintain the telecommunications and broadcasting sectors open to competition, actively promoting innovation and participation of new providers.** This requires the government's ongoing commitment to efficient allocation and management of the radio electric spectrum frequencies, as well as uphold a regulatory framework that fosters investor confidence and promotes infrastructure sharing when necessary.

2. **Strengthen the state's communications infrastructure:**
   - **Ensure the continuity and financial viability of the "Red Compartida" project.** If necessary, complement the network with the establishment of smaller community networks in underserved rural areas.
   - **Promote the development of certified data centers to host ICT firms that rely on data storage and cybersecurity services.**
   - **Support and facilitate the development of 5G (fifth generation)-enabling projects in the state.**
   - **Consolidate the planned installation of optical fiber parallel to the route of the Mayan Train, at least in the segments feasible to be completed.**

3. **Establish a public-private agency focused on fostering the development of the state ICT sector.** This agency should be tasked with (a) identifying and attracting large-scale ICT projects and consolidating ongoing projects and existing clusters; (b) coordinating the creation of a one-stop shop dedicated to the ICT industry; (c) developing a network of incubators and accelerators to encourage new ventures in the ICT sector, nurture early-stage ventures, and link startups with potential investors and support services; and (d) promoting domestic ICT services firms to increase their exposure and reach overseas markets.

4. **Continue efforts to strengthening links between the government, the private sector, and academic institutions.** Collaboration is vital to identify and develop relevant skills to support the industry's growth and consolidate the state's two industrial innovation centers.

5. **Enhance digital literacy and promote ICT adoption to bolster demand and increase the returns on investments in ICT technologies such as 5G.** Supporting pilot programs and private initiatives would accelerate digitalization in key sectors of the economy such as transportation, agriculture, manufacturing, health care, education, energy, and urban services.[74]

6. **Foster venture capital growth in the state, given its vital role in the early stages of ICT projects.**

MARKET INTERVENTIONS

1. **Consider providing land grants for major private investments with substantial economic and social benefits.** These grants should be conditional upon meeting requirements, such as construction of last-mile infrastructure, and tied to specific investment or job generation goals. The previously secured land for the cancelled special economic zone close to the port in Progreso and the city of Mérida, could serve as a land bank for this purpose.

2. **Complement the ICT clusters consolidation efforts by establishing "smart" fiscal incentives to attract anchor firms and promote technology transfer to local enterprises.**

3. **Level the playing field for federal government financing and subsidies.** Authorities could consider channeling resources back to Prosoft, link it with financial programs offered by development banks, and improve information and guidance provided to companies keen on investing in the state. The establishment of a dedicated advisory and support window for the southern states, linked to the proposed one-stop shop, and even with a quota of the program's resources for this region, could further facilitate equal access to federal resources.

4. **Consider providing subsidized computer equipment, public internet access points, and training courses to students and small and medium enterprises to increase digital inclusion.**

5. **Facilitate access to finance from development banks.** Collaborate with development banks to establish sector-specific programs tailored to the unique financial needs of the ICT industry, particularly considering the intangible nature of the ICT services sector. This could be more effective especially if paired with measures to reduce the administrative costs associated with applying for loans. In addition, forming partnerships with multilateral institutions to create dedicated instruments for capital and business-development training for entrepreneurs could help foster the development of a robust startup ecosystem in Yucatán.[75]

Appendixes

APPENDIX A
Detailed Policy Recommendations

This appendix presents a set of public policy recommendations organized in measures aimed at creating or strengthening public goods and correcting market failures through interventions. The recommendations are not exhaustive and should be complemented, deepened, and adapted to the particularities of the state, target market, products to be developed, and specific investments to attract, retain, or expand. A comprehensive and continuous public-private interaction should be carried out to complement the diagnostic and calibrate the proposals. This coordination should not only be among local actors, but also among lead firms, potential investors, academic institutions, and even other governments that have been successful in similar productive strategies in other regions. The focus should embody more than just improving the competitive environment for sector development. It should also maximize the benefits and spillover effects while minimizing any potential negative externalities.

PUBLIC GOODS

1. Maintain the telecommunications and broadcasting sectors open to competition, actively promoting innovation and the participation of new providers. This requires efficient allocation and management of the radio electric spectrum frequencies, as well as uphold a regulatory framework that ensures investor confidence and promotes infrastructure sharing when necessary.

2. Ensure the continuity and financial viability of the "*Red Compartida*" project, which aims to increase broadband coverage in Mexico, especially in hard-to-reach rural communities, where greater investments are required and returns

are lower. With ongoing public-private initiatives in Yucatán, such as the internet exchange point, Gignet's subsea cable deployment, and new fifth-generation (5G)-related investments, the state has the potential to position itself as an information and communication technology (ICT) hub in the country and Latin America, offering faster internet speeds and more penetration. One step in this direction is the "Roaming Social" Agreement between the federal government, Altán Redes, and major operators like AT&T, Movistar, and Telcel. This agreement allows these relevant players to use the infrastructure of *Red Compartida* through "visitor" or roaming user services and enable them to reach locations with less than 5,000 inhabitants, which would contribute to closing the digital gap and increasing the revenue from users in these low-traffic zones.[76] In addition, if necessary, complement these efforts with the establishment of community networks in underserved rural areas.

3. In those segments of the Mayan Train project feasible to be completed, install fiber-optic cables parallel to its tracks, leveraging this infrastructure to connect more regions in Yucatán.

4. Promote public-private infrastructure investments to enable 5G Connectivity, not only those specifically dedicated to 5G networks, but also complementary ICT infrastructure required to share with the former.

5. Promote the development of at least one certified data center in Yucatán, as this is a natural step once the state has an internet exchange point. The presence of data centers would not only consolidate the state as an ICT industry leader in southern Mexico and Central America,[77] but also boost the growth of ICT firms utilizing data storage and cybersecurity services.

6. Consolidate the maritime routes connecting coastal cities in the Gulf of Mexico (Mexican and U.S. ports) and Latin America, to support the supply chain of primary or secondary (recycled) raw materials that could serve as inputs for ICT manufacturing in Yucatán. Promoting short-sea shipping between Puerto Progreso and major ports in Mexico and neighboring countries can serve as a mechanism to increase maritime transportation in the state, while their infrastructure-related limitations are not completely addressed.[78]

7. Establish a public-private agency tasked with identifying and attracting potential ICT investment projects (manufacturing and services) from different regions of the country and abroad. The agency would focus on consolidating ongoing and new projects in Yucatán, investment promotion and linking ICT projects with support programs in the state. Furthermore, the agency should support in promoting local firms capable of providing ICT services abroad to increase their exposure to international markets and boost ICT services exports.

8. Create a single window or one-stop shop dedicated to the ICT Industry, in coordination with all levels of government. This platform will streamline and simplify regulatory compliance requirements for new investments or the expansion of existing firms. It can also serve as a focal point for accessing support services required by firms in the sector.

9. Continue efforts to strengthen the collaboration between industry, government, and academia (triple helix model), with the objective of redesigning academic curricula and creating education programs that equip students and professionals with the necessary skills and readiness for the ICT sector. These initiatives should focus on topics related to mathematics, data science, deep learning, artificial intelligence, internet of things, big data, innovation, and language proficiency.
   - Facilitating continuous communication between the private sector and academia focused on consolidating the two industrial innovation centers is highly necessary.
   - Building an ecosystem able to support firms in implementing employee training and retraining programs to acquire new technical skills required by the ICT industry is crucial.

10. Collaborate with existing actors, such as technological parks, research and academic institutions, and local government authorities to develop a network of incubators and accelerators aimed at encouraging new ventures in the ICT sector in Yucatán. These incubators and accelerators will provide a nurturing environment for early-stage ventures, offering support in administrative, legal, and technical affairs. For ventures that require significant investments, they will facilitate connections with potential investors, such as venture capitalists and angel investors, while training them to effectively deliver pitches.
    - The network should develop alliances with international incubators and accelerators, particularly those from Israel and the United States. These alliances will facilitate constant knowledge sharing, software exchanges, and support interactions among entrepreneurs.

11. Implement initiatives similar to "*convocatorias*," such as "hackathons," to foster the development of the ICT sector by addressing real-world challenges faced by public and private agents in the state. Through this initiative, the government of Yucatán can identify various issues of public or private interest, including digital government, health care, education, mobility, watchful neighbors, idea marketplace, retail, banking, customer experience and relationship, and security. The *convocatoria* would invite entrepreneurs and their teams to design ICT-driven solutions to address these challenges.
    - The *convocatorias* can be launched periodically, depending on the issue at stake.
    - Entrepreneurs should have the option to use any technological park or research and academic institutions where the state is involved to accomplish their task.

12. Promote the growth of venture capital in Yucatán's ecosystem, currently absent and key for the development of the ICT sector.

13. Support digitalization pilot programs and initiatives aimed at accelerating and deepening the adoption of Internet-of-Things devices, artificial intelligence, and augmented or virtual reality services in key sectors of the economy to generate sufficient demand and revenue, providing enough returns for ICT investments in general, and particularly for the deployment of 5G technology.

- Promote ICT adoption in key sectors of the economy like transportation, agriculture, manufacturing, health care, education, energy, and urban services.
- Conduct feasibility studies to identify the prerequisites for the city of Mérida, and potentially other urban areas in the state, to establish itself as a "smart city."[79] This concept, which is gaining popularity internationally, involves prioritizing sustainable and citizen-focused solutions by leveraging ICTs.

14 Establish electronic recycling facilities close to potential ICT manufacturing clusters. In conjunction with this initiative, it is recommended to implement mandates that outline the responsibilities of governments, companies, and users regarding proper handling and disposal of electronic waste.

MARKET INTERVENTIONS

1 Provide subsidized computer equipment and establish public internet access points for students and small and medium enterprises (SMEs). In addition, offer training courses for students to increase ICT readiness, and provide SMEs with training on effective use of business software, including accounting, inventory management, and e-commerce platforms. These initiatives could improve productivity, promote digitalization, and increase market access for SMEs.

2 Level the playing field by ensuring equitable distribution of federal government financing and subsidies aimed at supporting the development of the sector.

- Reallocate resources back to Prosoft (*Programa para el Desarrollo de la Industria de Software y la Innovación*), link it with financial programs offered by development banks, and improve information and guidance provided to companies interested in Yucatán. Furthermore, consider establishing a dedicated advisory and support window for the southern states, and potentially assign a quota of the program's resources for this region.
- Increase government funding for innovation and technology research institutions linked to ICT clusters in the state. Reinstate or establish a trust similar to the "*Fondo Mixto*" by the *Consejo Nacional de Humanidades, Ciencias y Tecnologías* and the Government of Yucatán to facilitate financial support for innovation and scientific projects that need resources to be launched.[80]

3 Collaborate with development banks to establish financing programs tailored for early-stage ICT ventures. These financing programs should address the unique financing requirements of the ICT industry, particularly during stages when firms usually do not generate revenues until they secure orders and/or meet client requirements. Streamline the process for accessing and monitoring these financing programs, reducing unnecessary requirements. A joint effort from Bancomext and the Nafin is strongly recommended.

4 Engage in partnerships with multilateral institutions to establish a platform that provides financial support and "business know-how" to ICT entrepreneurs and early-stage companies. This platform should foster the development of disruptive technologies or initiatives aimed at addressing the digital gap.[81]

5 For attracting major private investments with great economic and social benefits, consider providing land grants for their establishment. These grants should be conditional upon meeting requirements, for example, development of last-mile infrastructure or fulfillment of investment and job generation goals. The previously secured land for the cancelled special economic zone close to the port of Progreso and the city of Mérida, could serve as a land bank for this purpose.

6 In addition to the ICT clusters consolidation efforts, establish nondistortionary incentives. This would further enhance the attractiveness of Yucatán for anchor firms and enable technology transfer to SMEs.

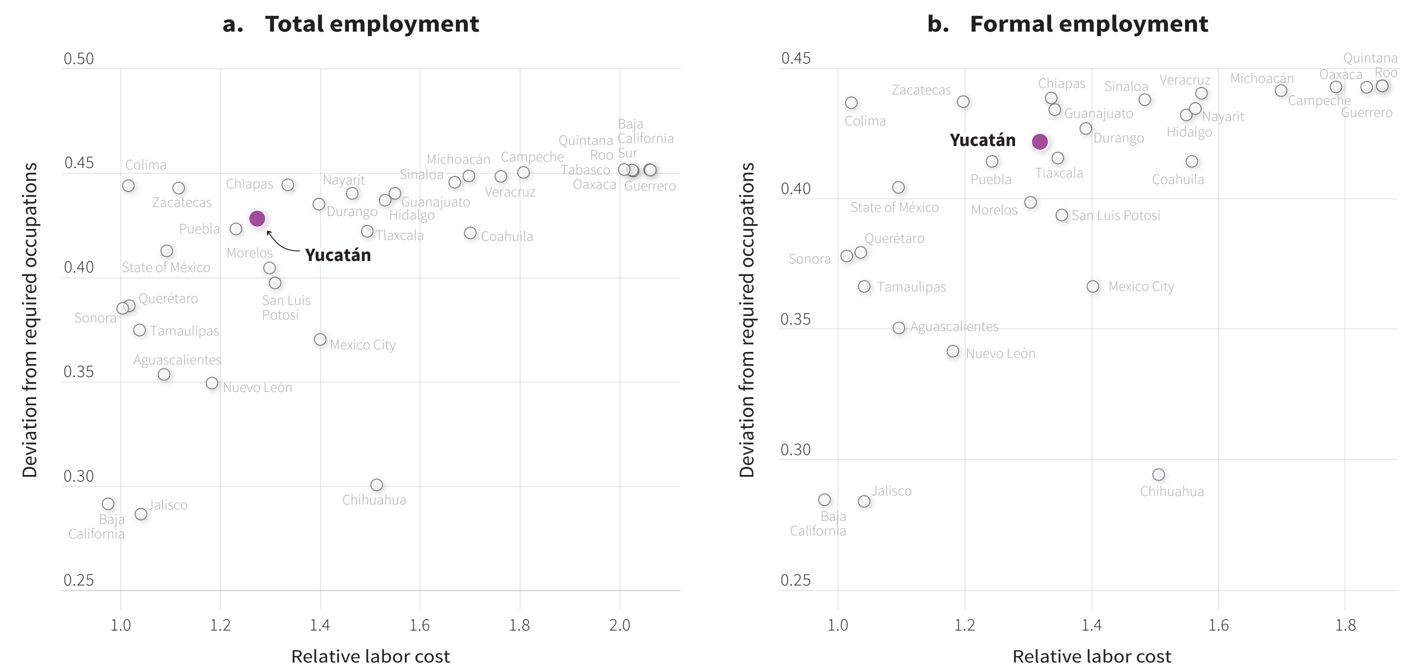
APPENDIX B
Assessment of Human Capital Constraints

To evaluate whether the lack of human capital is a binding constraint for the development of the information communication technology (ICT) sector in Yucatán, an analysis of the availability and cost of labor force is carried out, following a methodology implemented by Barrios and others (2018a; 2018b),[82] using data from the *Encuesta Nacional de Ocupación y Empleo* (National Survey of Occupation and Employment; ENOE) and information from the *Sistema Nacional de Clasificación de Ocupaciones* (National Classification System for Occupations). Because of the limited sectoral disaggregation level of ENOE data, the analysis focuses on four ICT subsectors: computer and electronic product manufacturing; electrical equipment, appliance, and component manufacturing; publishing and editing of newspapers, magazines, books, software, and other materials; and other telecommunications. First, we calculate the deviation between the share of occupations at the national and state levels, using the symmetric mean absolute percentage error to measure the availability of workers performing the occupations required. Second, we compare the relative labor cost in the state to the national level to measure the relative availability or scarcity of qualified human capital.[83] The analysis considers the total employment (formal and informal) and only the formal sector, taking into account the high prevalence of informality and the salary gap between formal and informal jobs.

The results showed that the evidence of human capital as a binding constraint is inconclusive for all ICT-related subsectors. For ICT goods manufacturing, figures B.1 and B.2 show that Yucatán ranks in the middle in deviation of occupations required and relative salaries.

FIGURE B.1

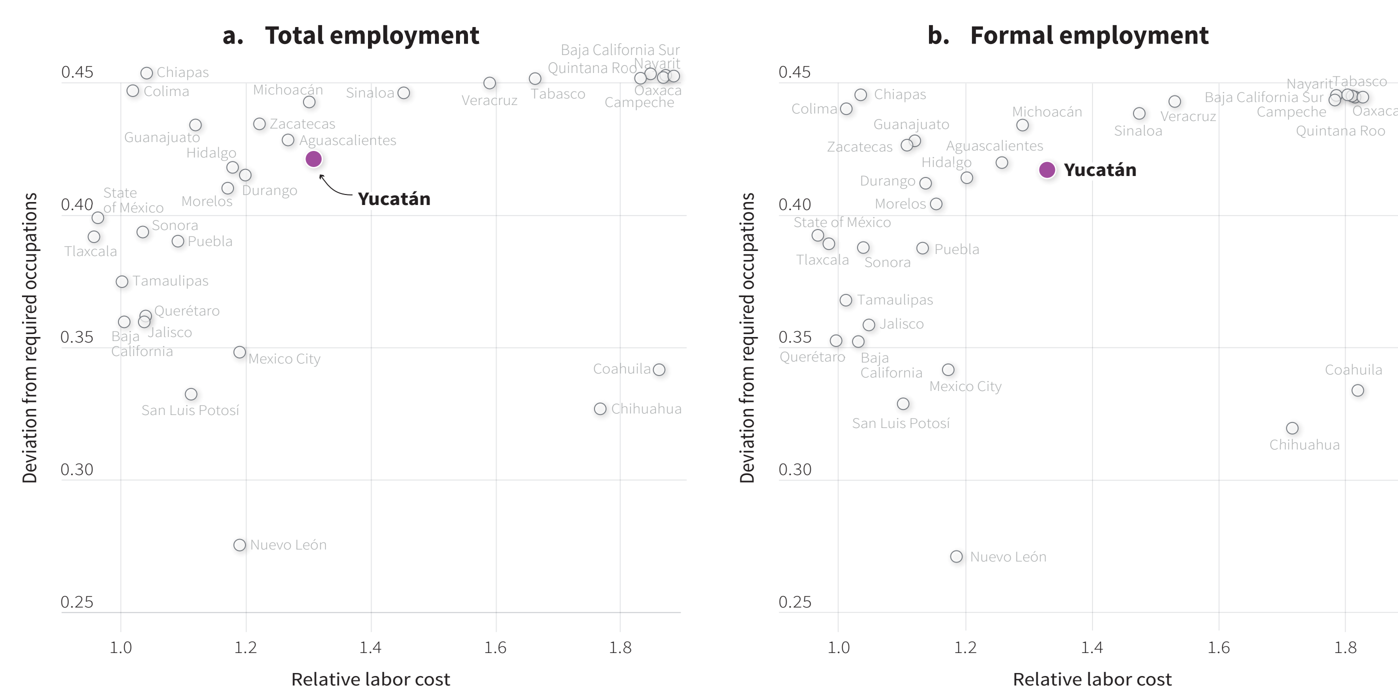
Skills Deviations and Labor Costs in Computer and Electronic Product Manufacturing, 2019



Source: Calculations based on the methodology implemented by Barrios and others (2018a; 2018b) using data from INEGI's ENOE database.
Note: In both panels, the x-axis is the ratio of the average hourly wage ratios at national and state levels, and y-axis is the deviation in occupation shares between national and state levels (using the symmetric mean absolute percentage error), in the first quarter of 2019. In cases where a state has no workers engaged in a particular occupation, the highest salary among all states for that occupation was assigned to reflect the scarcity of workers in that field, necessitating a premium to attract qualified workers.

FIGURE B.2

Skills Deviations and Labor Costs in Electrical Equipment, Appliance, and Component Manufacturing, 2019

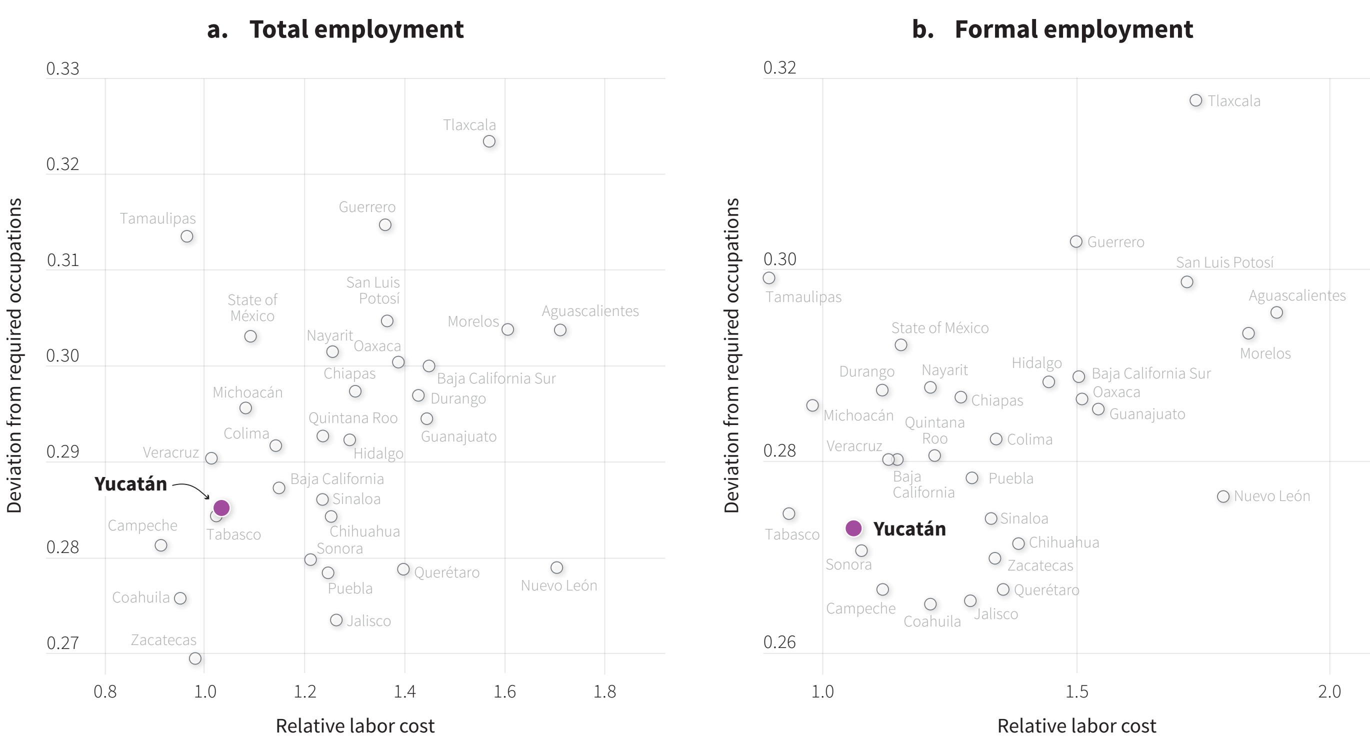


Source: Calculations based on the methodology implemented by Barrios and others (2018a; 2018b) using data from INEGI's ENOE database.
Note: In both panels, the x-axis is the ratio of the average hourly wage ratios at national and state levels, and y-axis is the deviation in occupation shares between national and state levels (using the symmetric mean absolute percentage error), in the first quarter of 2019. In cases where a state has no workers engaged in a particular occupation, the highest salary among all states for that occupation was assigned to reflect the scarcity of workers in that field, necessitating a premium to attract qualified workers.

Regarding ICT services, figure B.3 shows that Yucatán ranks in the lower half among all states in deviation of occupations required for the subsector of publishing and editing of newspapers, magazines, books, software, and other materials. The state has the seventh and fourth lowest relative salary in the subsector among all workers and workers in formal jobs, respectively. Furthermore, for the subsector of other telecommunications, the results in figure B.4 suggest that Yucatán ranks in the lower half in deviations of occupations required. However, in terms of relative salary, the state ranks in the upper half. It has the eighth highest labor cost in the formal sector and tenth highest when considering total employment.

FIGURE B.3

Skills Deviations and Labor Costs in Publishing and Editing of Newspapers, Magazines, Books, Software, and Other Materials*



Source: Calculations based on the methodology implemented by Barrios and others (2018a; 2018b) using data from INEGI's ENOE database.
Note: In both panels, the x-axis is the ratio of the average hourly wage ratios at national and state levels, and y-axis is the deviation in occupation shares between national and state levels (using the symmetric mean absolute percentage error), in the first quarter of 2019. In cases where a state has no workers engaged in a particular occupation, the highest salary among all states for that occupation was assigned to reflect the scarcity of workers in that field, necessitating a premium to attract qualified workers.
*Mexico City is excluded from the analysis because its value is less than three standard deviations below the average. Therefore, it is considered an outlier.

FIGURE B.4

Skills Deviations and Labor Costs in Other Telecommunications*

Source: Calculations based on the methodology implemented by Barrios and others (2018a; 2018b) using data from INEGI's ENOE database.
Note: In both panels, the x-axis is the ratio of the average hourly wage ratios at national and state levels, and y-axis is the deviation in occupation shares between national and state levels (using the symmetric mean absolute percentage error), in the first quarter of 2019. In cases where a state has no workers engaged in a particular occupation, the highest salary among all states for that occupation was assigned to reflect the scarcity of workers in that field, necessitating a premium to attract qualified workers.
*Mexico City is excluded from the analysis because its value is less than three standard deviations below the average. Therefore, it is considered an outlier.

APPENDIX C
Infrastructure Conditions

To identify possible infrastructure-related constraints that could hinder the development of the information and communication technology (ICT) sector in Yucatán, this appendix presents an analysis of key inputs for production processes, namely electricity, water, combustibles, transportation, and telecommunications infrastructures, as well as other sector-specific infrastructure. The findings in this appendix are combined with the use intensity analysis of each input by the ICT subsectors to determine whether potential mismatches between the provision and demand of infrastructure services are limiting the growth of those subsectors (for the use intensity analysis, see appendix D).[84]

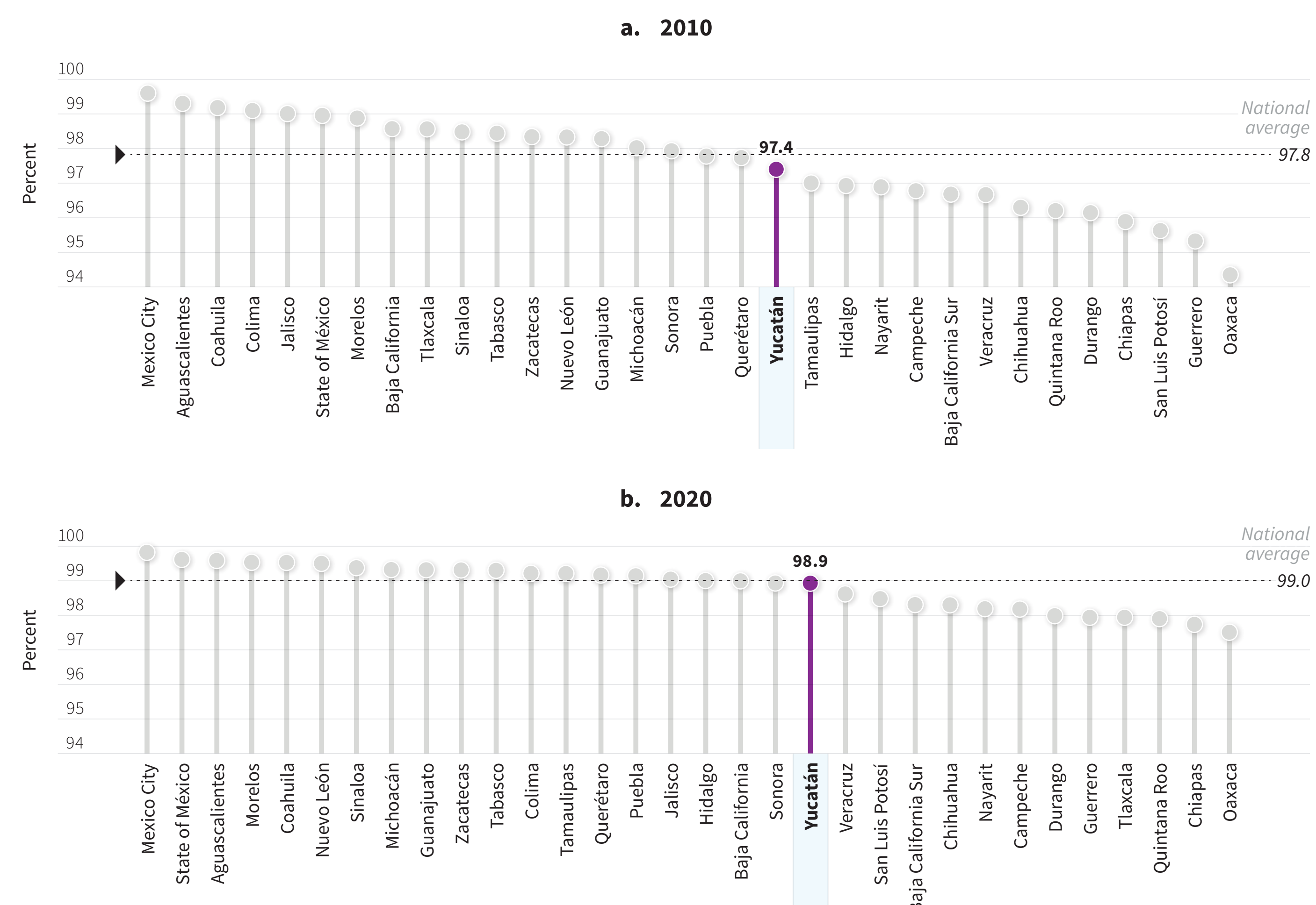
ELECTRICITY

To determine the conditions of electricity infrastructure in Yucatán, comparisons across states for access, generation, consumption and balance, as well as satisfaction levels and distribution capacities are made.

During the last decade, Yucatán reached a level of household electricity access that is close to the national average (figure C.1). In terms of satisfaction with overall electricity services for economic activities, 52 percent of firms in Yucatán expressed satisfaction, a proportion that is higher than the national average (46.2 percent). However, when it comes to continuity of service, 61.6 percent of firms consider it to be continuous, and when it comes to affordability, only 38.4 percent consider it to be affordable. These proportions are lower than the national levels of 67.1 and 41.3 percent, respectively (figure C.2).

Although the difference between generation and consumption of electricity in Yucatán is positive, figure C.3, panel c shows that the state ranks among those with the lowest energy surplus. Moreover, this surplus is mainly because of low average consumption rather than high energy generation capacity. Indeed, the

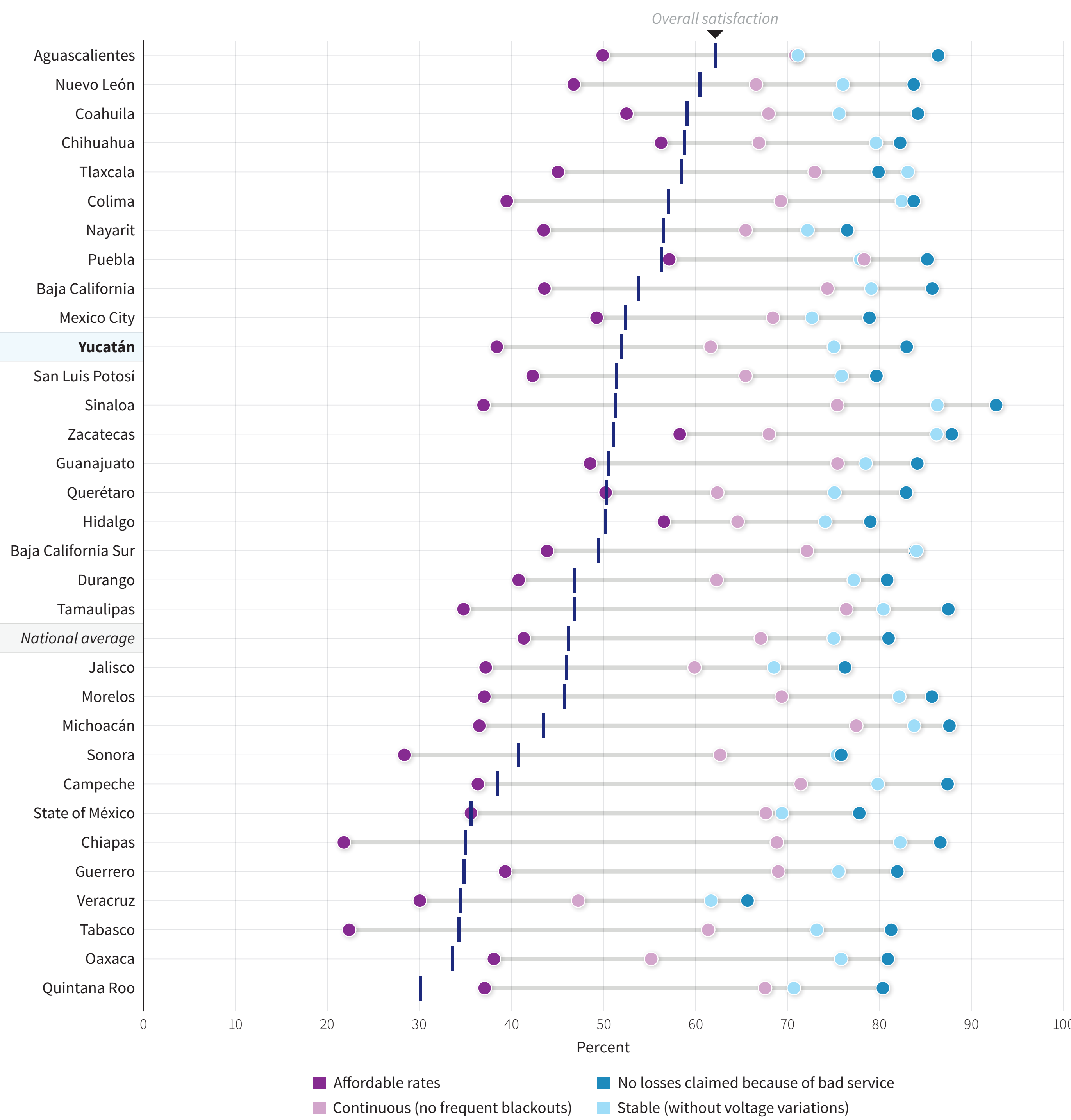
FIGURE C.1
Households with Access to Electricity, State Comparison



Source: Based on data from INEGI 2010; 2020.

FIGURE C.2

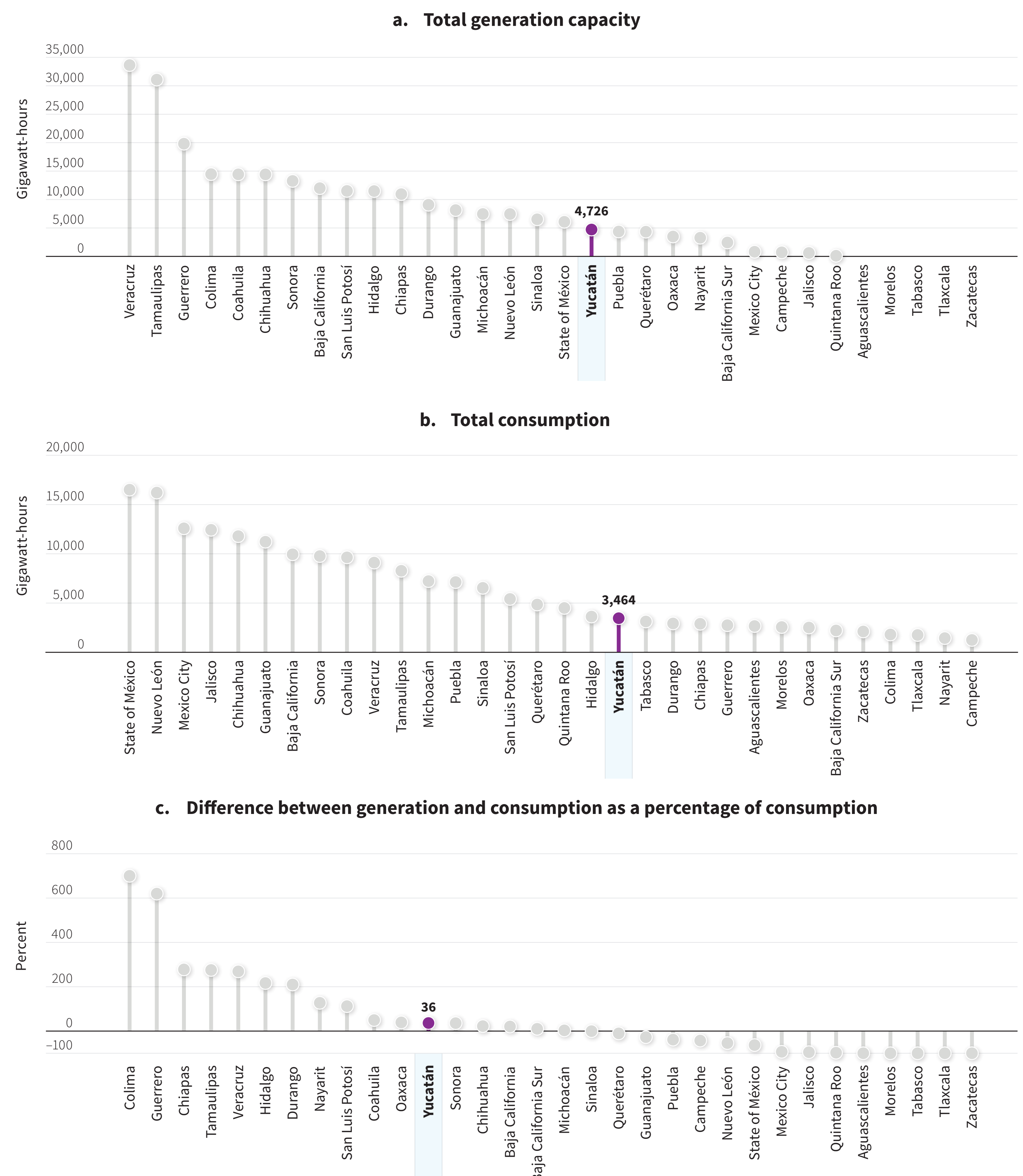
Firms' Satisfaction with Electricity-Related Services, 2016



Source: Based on data from INEGI 2016.
Note: The survey included an assessment of energy services only until 2016.

FIGURE C.3

Electricity Generation and Consumption, State Comparison, 2017



Source: Calculations based on data from SENER's SIE database.
Note: The most recent available electricity generation and consumption data is for 2017.

state has limited generation capacity, including combined-cycle gas turbine plants, wind and thermoelectric power production, which are concentrated around major cities (map C.1). This discrepancy could hinder energy-intensive industries from operating in the state if access to external sources is not made available.

Understanding the potential availability of electricity in Yucatán involves assessing the existing infrastructure of the national electricity system. Map C.1 demonstrates that there are a few transmission lines crossing the state with low tension (between 69 to 115 kilovolts) and only one with high tension (400 kilovolts). This could be limiting Yucatán's ability to procure energy from other states and distribute it with adequate volumes across all its regions, restricting its capacity to meet the energy demand in certain areas.

WATER

To determine whether the provision of water services could pose a challenge to the productive development of Yucatán, a series of indicators on the availability and quality of this input are considered. Maps C.2 and C.3 show the availability of water resources in Mexico and they reveal that the availability of superficial and underground water in Yucatán is sufficient. Therefore, the provision of water does not seem to be a constraint for productive activities requiring this input.

MAP C.1

Mexico's National Electricity System, Southern and Peninsular Regions, 2018

Source: CENACE 2018.
Note: kV = kilovolts.

MAP C.2

Superficial Water Availability in Mexico, 2016

Source: CONAGUA 2017.

MAP C.3

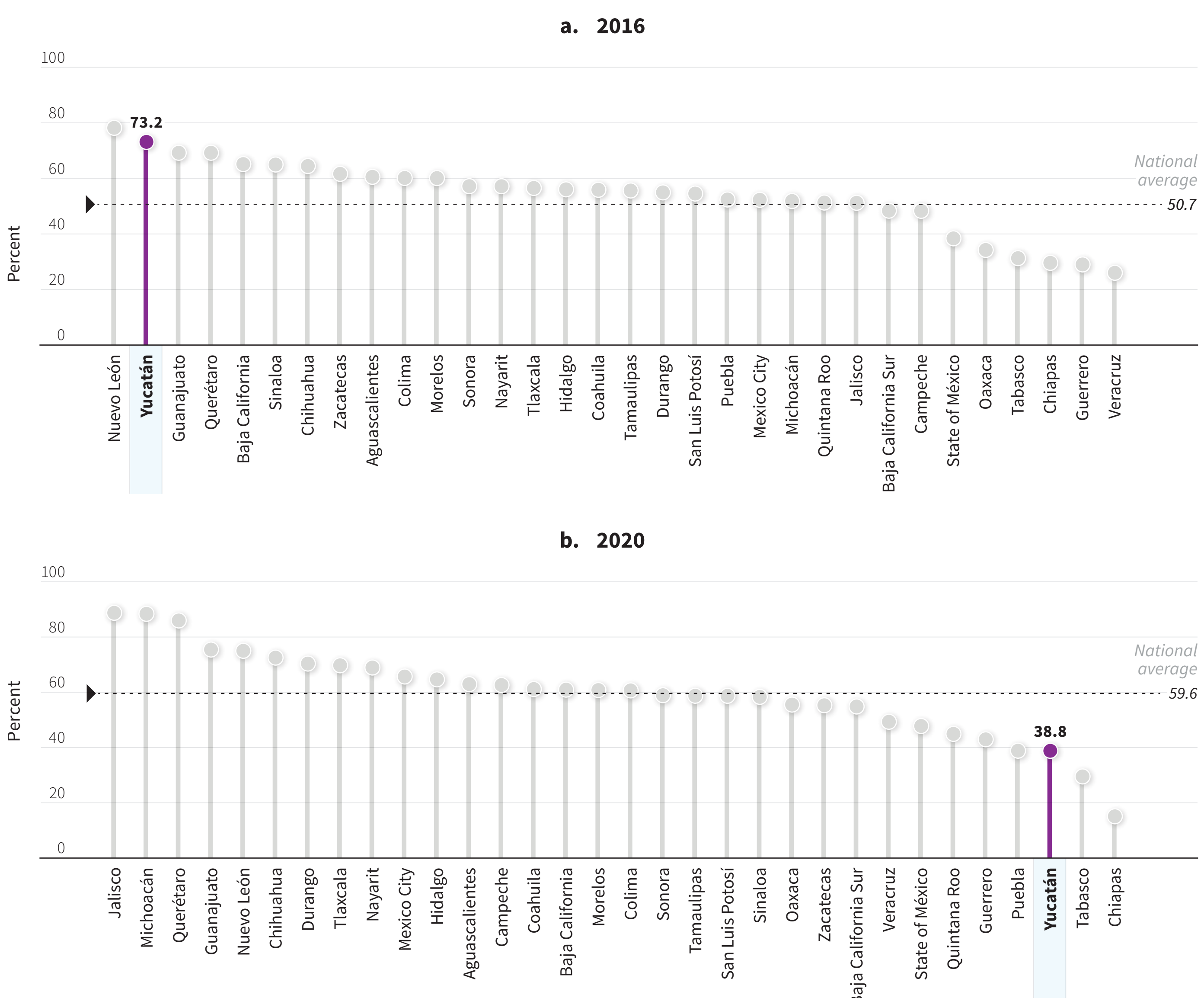
Underground Water Availability in Mexico, 2016

Source: CONAGUA 2017.

Figure C.4 shows the satisfaction level firms have with the provision of water services. In 2016, with 73.2 percent Yucatán was the second state with the highest levels of satisfaction. However, by 2020 the level of firm´s overall satisfaction dramatically fell to 38.8 percent, the third lowest among the 32 states. Figure C.5 shows that the proportion of firms considering that there is a reliable supply, cost is affordable, and there is no waste due to leaks increased to 88.2 percent, 90.3 percent and 83.7 percent, respectively. Yet, the share of firms considering that there is enough water pressure, water is pure and clear, and potability is adequate reduced to 37 percent, 45.4 percent and 42.1 percent, respectively. Even though this could be related to the water stress generated by the pandemic and the suspension of some activities, the quality of water services must be monitored to guarantee an adequate provision for productive use.

FIGURE C.4

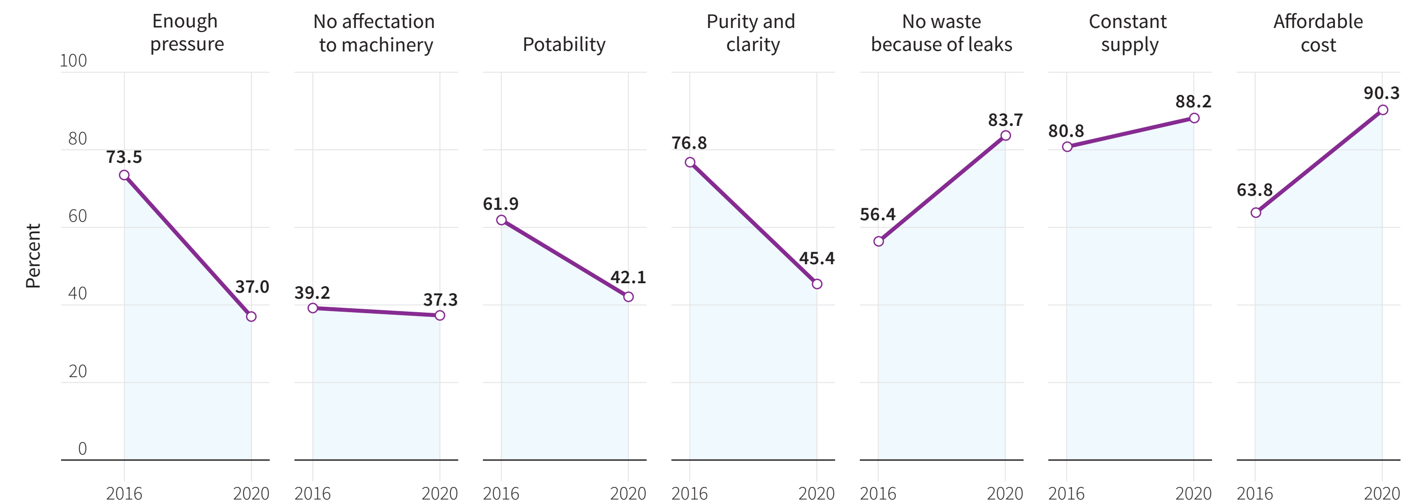
Firms' Satisfaction with Water-Related Services



Source: Based on data from INEGI's ENCRIGE database.

FIGURE C.5

Indicators of Firms' Satisfaction with Water Services in Yucatán



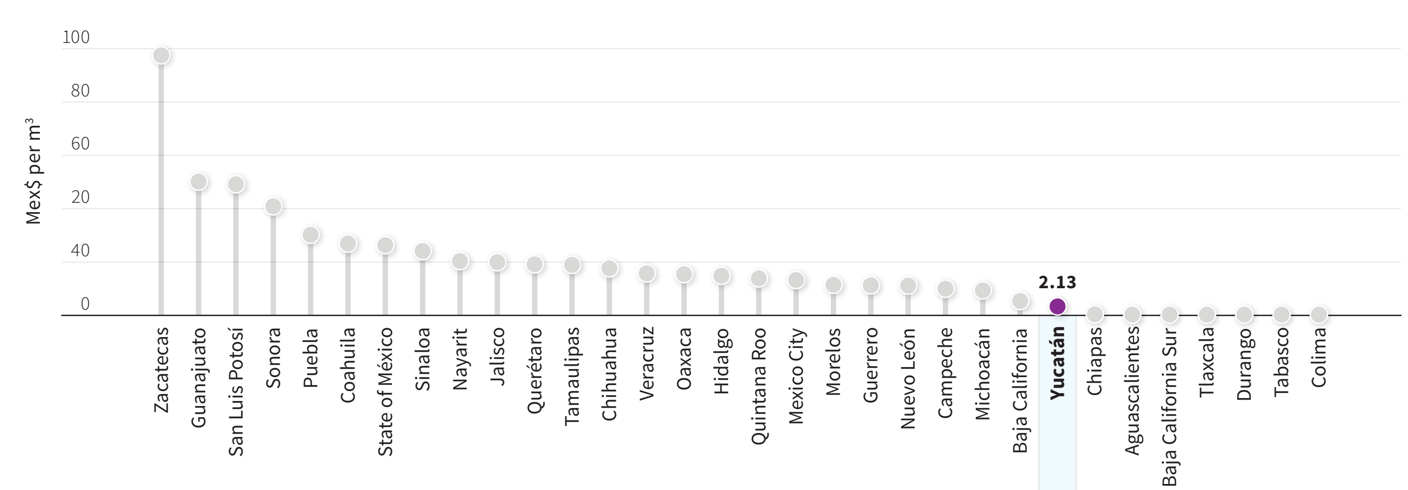
Source: Based on INEGI's ENCRIGE database.

To evaluate whether the quality of water supply is negatively affected by unsuitable pricing and collection systems to ensure the financial sustainability of the provision of water services, Figures C.6, C.7, and C.8 compare costs, fares and the efficiency of local agencies in collecting fares across states. Yucatán has one of the lowest costs per volume produced, at Mex$2.13 per cubic meter. However, its cost-fare ratio is the third lowest (0.003), and the local agency in charge of water supply has the lowest metric of global efficiency. This suggests that the local agency does not have a whole coverage for collecting fares within the state's regions.

In conclusion, if more water intensive industries were installed in the state, quantity does not seem to be a constraint, although the quality of water provision services could be improved.

FIGURE C.6

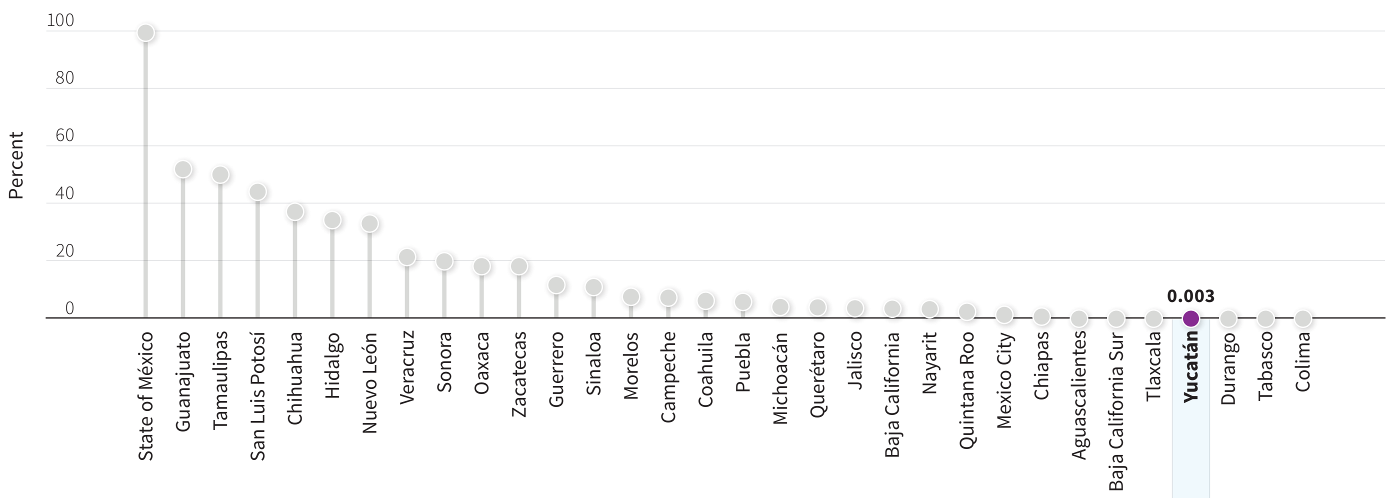
Water Cost per Volume Produced, 2017



Source: Based on data from CONAGUA and IMTA 2017.
Note: m^3 = cubic meter.

FIGURE C.7

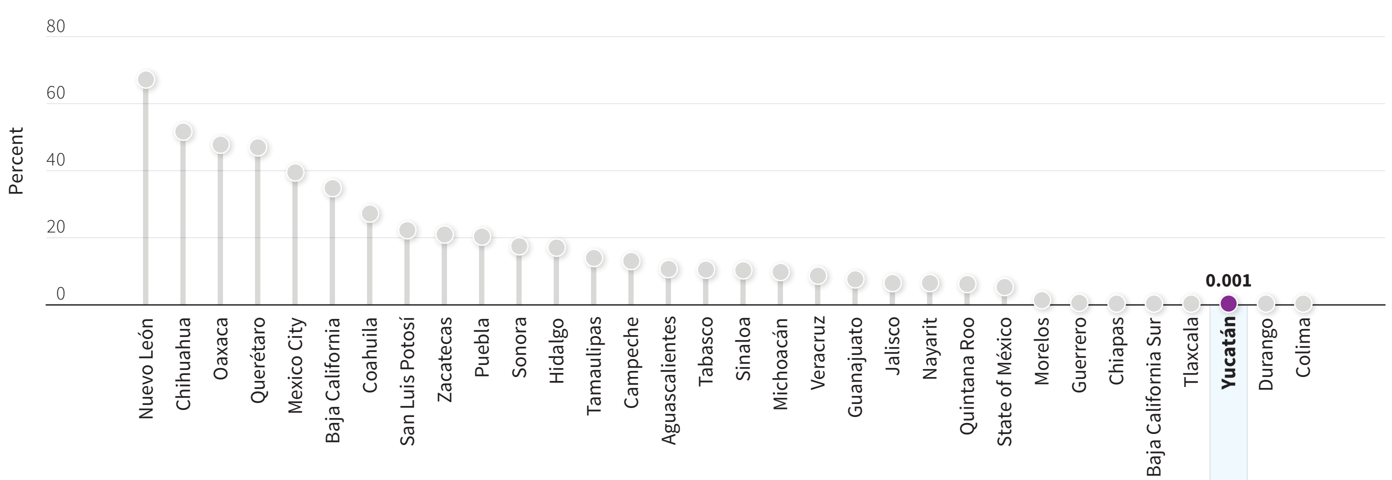
Water Cost-Fare Relation, 2017



Source: Based on data from CONAGUA and IMTA 2017.

FIGURE C.8

Water-Use Global Efficiency (Simple Averages), 2017



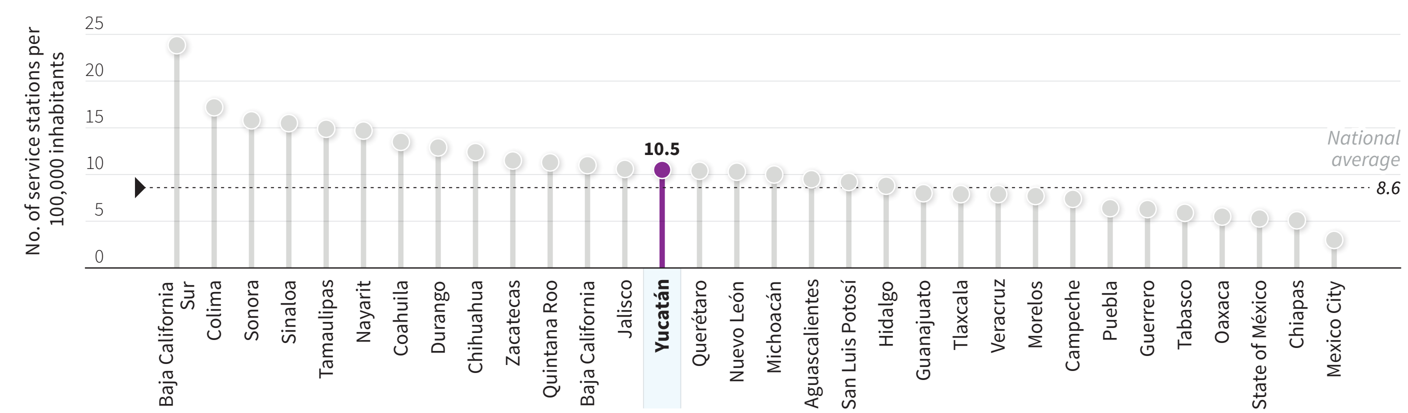
Source: Based on data from CONAGUA and IMTA 2017.
Note: Figure shows the volume of water collected by volume produced.

COMBUSTIBLES

To identify potential constraints in the access to combustibles, we analyze the physical infrastructure, consumption, and satisfaction levels. According to figure C.9, Yucatán exceeds the national average for number of service stations with a rate of 10.5 stations per 100,000 inhabitants. This indicates that the state has a competitive infrastructure for natural gas delivery. However, figure C.10 shows that Yucatán's consumption levels are relatively low compared to more industrialized states, reaching only 104.5 million cubic feet per day in 2019. On a positive note, figure C.11 shows that Yucatán is well positioned in terms of the provision of combustible, with 57 percent of firms being satisfied with its delivery, one of the highest proportions among the 32 states. Moreover, map C.4 shows that Yucatán is one of the southern states that is connected to Sistrangas (*Sistema de Transporte y Almacenamiento Nacional Integrado de Gas Natural*; National Interconnected System of Natural Gas) through the Mayakan pipeline.

FIGURE C.9

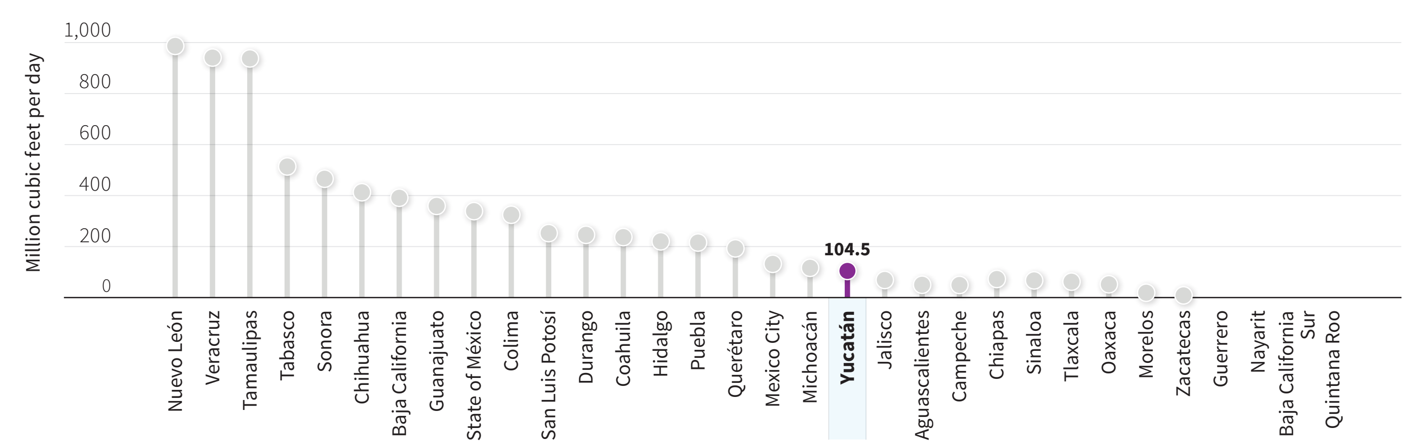
Number of Fuel Service Stations per 100,000 Inhabitants, 2017



Source: Based on Pemex 2019.
Note: Service stations are those that supply gasoline and diesel.

FIGURE C.10

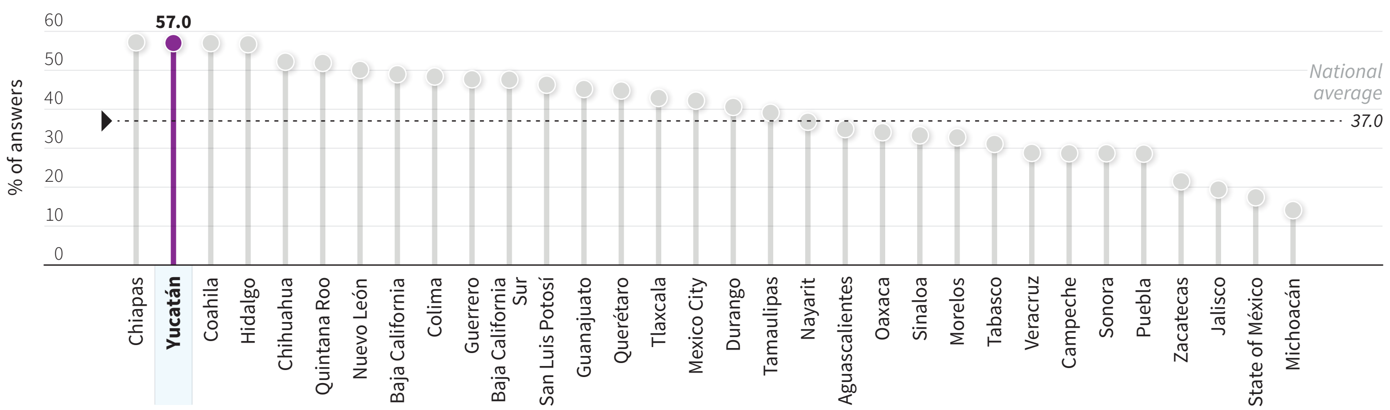
Consumption of Natural Gas per State, 2019



Source: Based on data from SENER's SIE database.

FIGURE C.11

Firms' Satisfaction with Combustible-Related Services, 2016



Source: Based on data from INEGI's ENCRIGE database.
Note: The survey included an assessment of combustible-related services only until 2016.

MAP C.4

Mexico's Interconnected Natural Gas System (Sistrangas), 2019

Source: Based on information from the *Secretaría de Energía*.

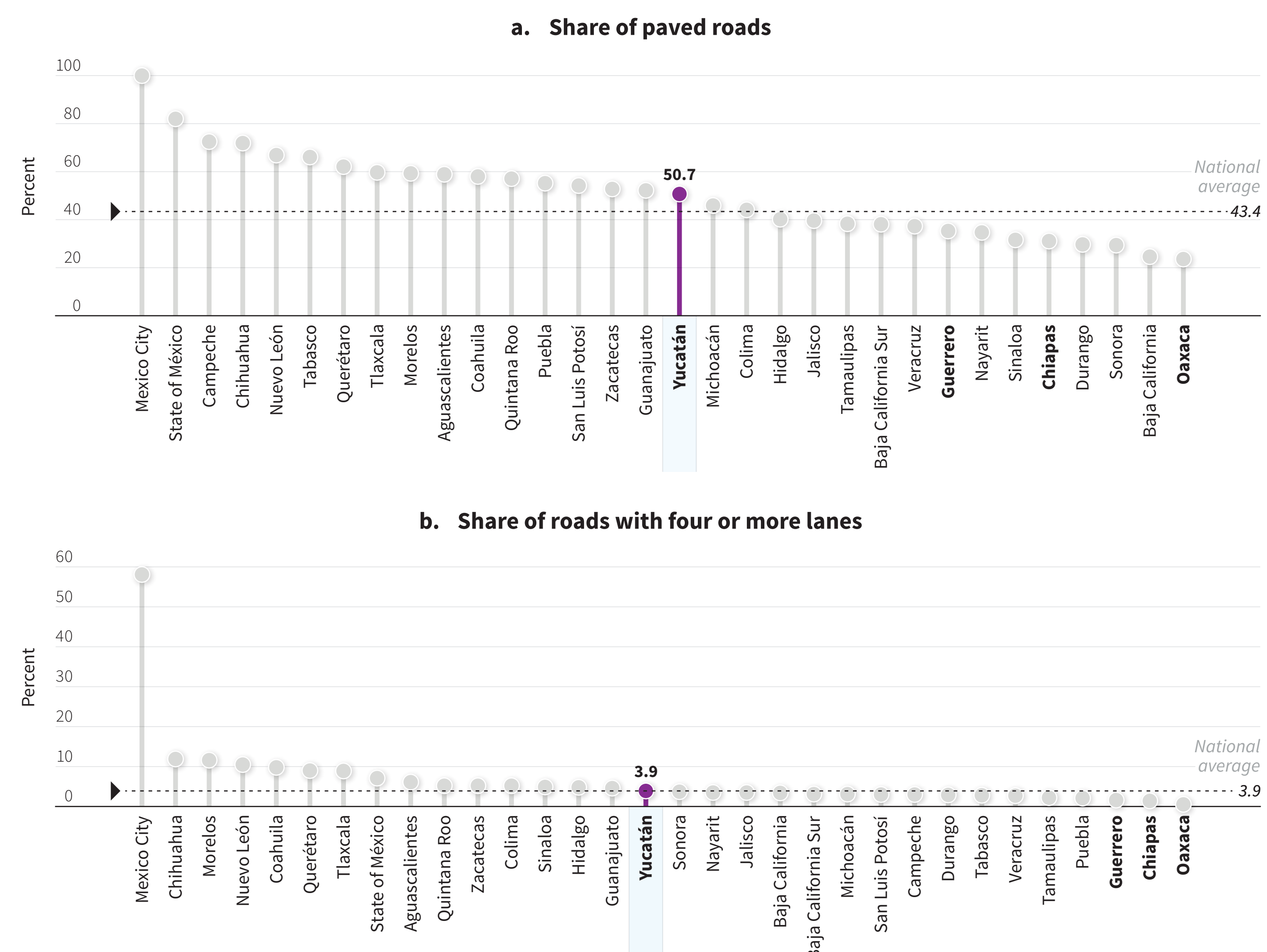
TRANSPORTATION

To evaluate whether transportation infrastructure conditions represent a binding constraint in Yucatán, three transport modes intensively used by manufacturing industries are assessed: roads, ports, and railways. Figure C.12, panel a shows that the road network conditions in Yucatán exceeds the national average, with paved roads accounting for 50.7 percent of its total, compared to the national average of 43.4 percent. The state also has a share of roads with four or more lanes similar to the national average of 3.9 percent (figure C.12, panel b).

Considering the density of roads per inhabitants and the extension of paved roads per land area, figures C.13 and C.14 show that Yucatán has a high rate in both metrics, at 32.2 kilometers (km) per 10,000 inhabitants and 15.9 km per 100 square km extension, respectively, above the national level in both cases.

FIGURE C.12

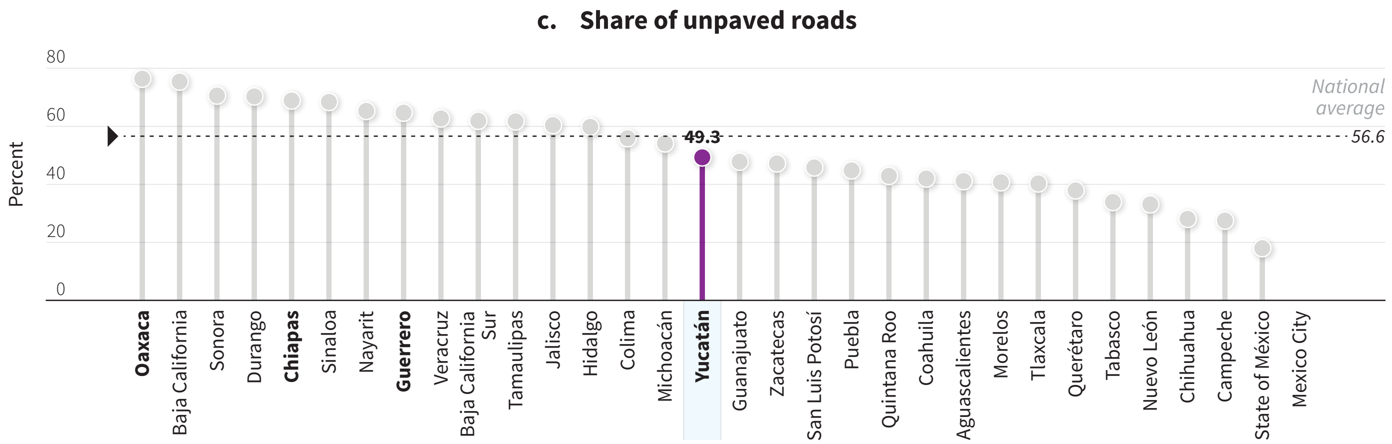
Road Conditions At the National Level, 2018



(Figure continues next page)

FIGURE C.12

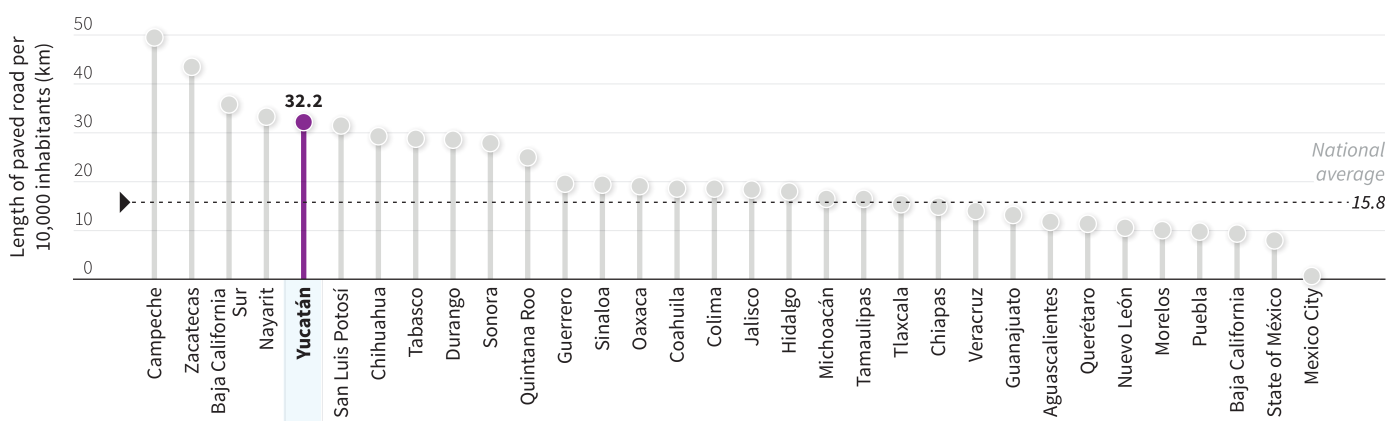
Road Conditions At the National Level, 2018 *(continued)*



Source: SCT 2020.

FIGURE C.13

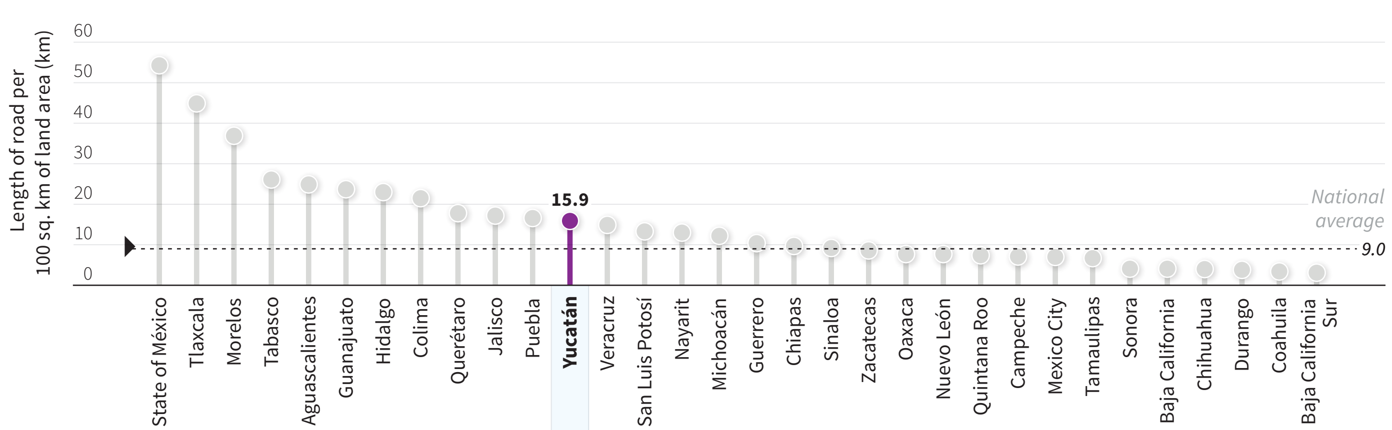
Length of Paved Roads per Number of Inhabitants, 2018



Source: Calculations are based on data from SCT 2018.
Note: km = kilometer.

FIGURE C.14

Length of Paved Roads per Land Area, 2018



Source: Calculations are based on data from SCT 2018.
Note: km = kilometer.

Paved roads are mostly managed and maintained by local, state, and federal governments, but toll roads are either operated by private entities or public-owned agencies. Federal roads are the primary routes connecting different regions within states and with other states. However, these roads often have free access, leading to traffic congestion, reduced average speed, and an increased travel time, especially in urban areas. On the other hand, toll roads are typically restricted and only have limited access points controlled by their operators. These roads are generally more efficient, with higher average speed and reduced travel time. As a result, toll roads are more efficient and appealing for logistical purposes for firms, provided the prices are competitive. Map C.5 shows that Yucatán only has one toll road, connecting Progreso to Cancún in Quintana Roo, while federal roads connect its main cities and are part of the country's road corridors.

Although Yucatán only has one toll road, the satisfaction of firms with the quality of toll-free roads in the state is one of the highest in the country. According to figure C.15, between 2016 and 2020, the proportion of firms satisfied with the toll-free roads in Yucatán increased significantly from 51.5 to 73.9 percent, the fifth highest among the 32 states. This condition is favorable to attract new industries using this transport infrastructure more intensively.

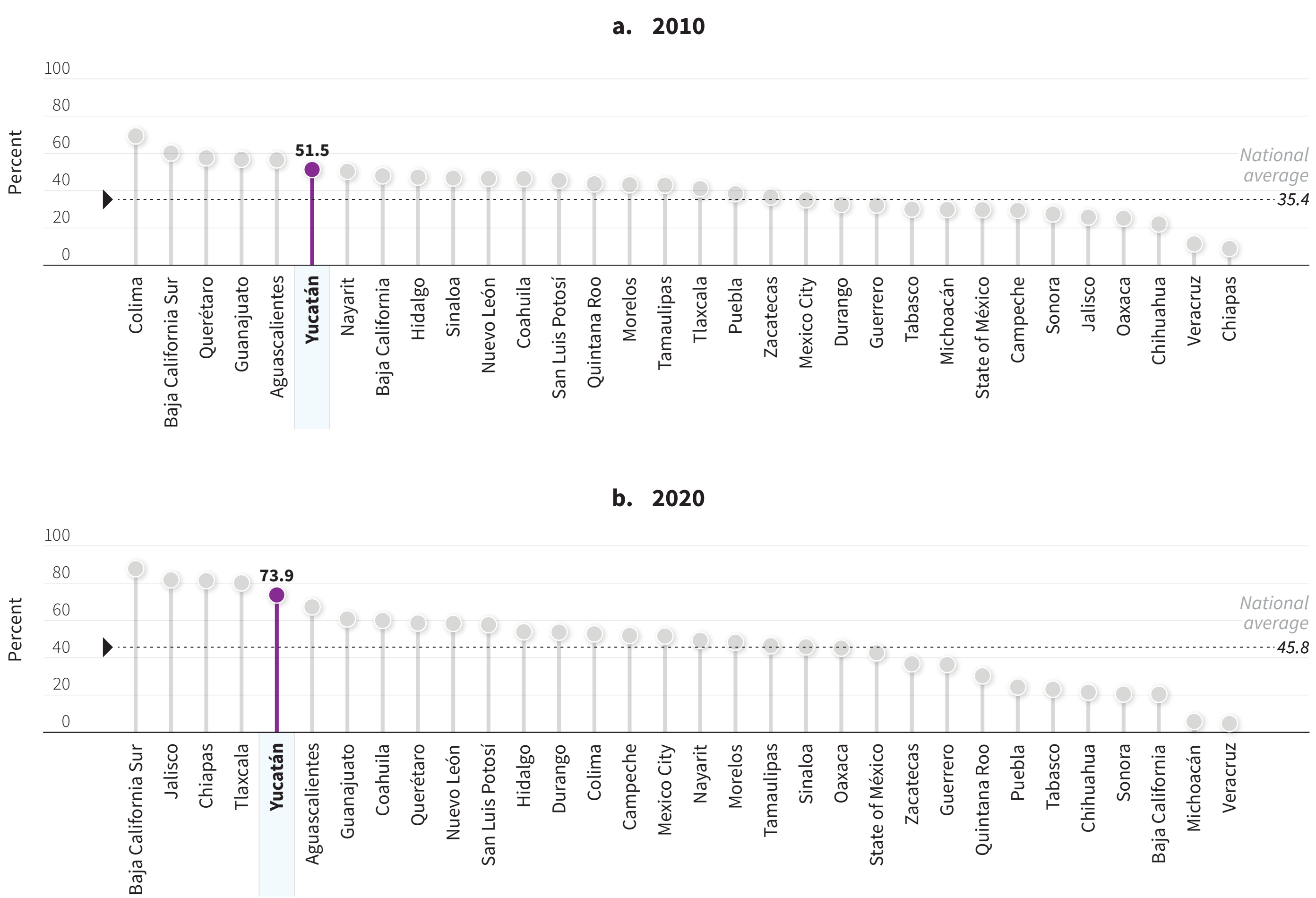
MAP C.5

Federal and Toll Roads in Yucatán, 2019

Source: Adapted from SCT-IMT's *Red Nacional de Caminos*.

FIGURE C.15

Firms' Satisfaction with Roads



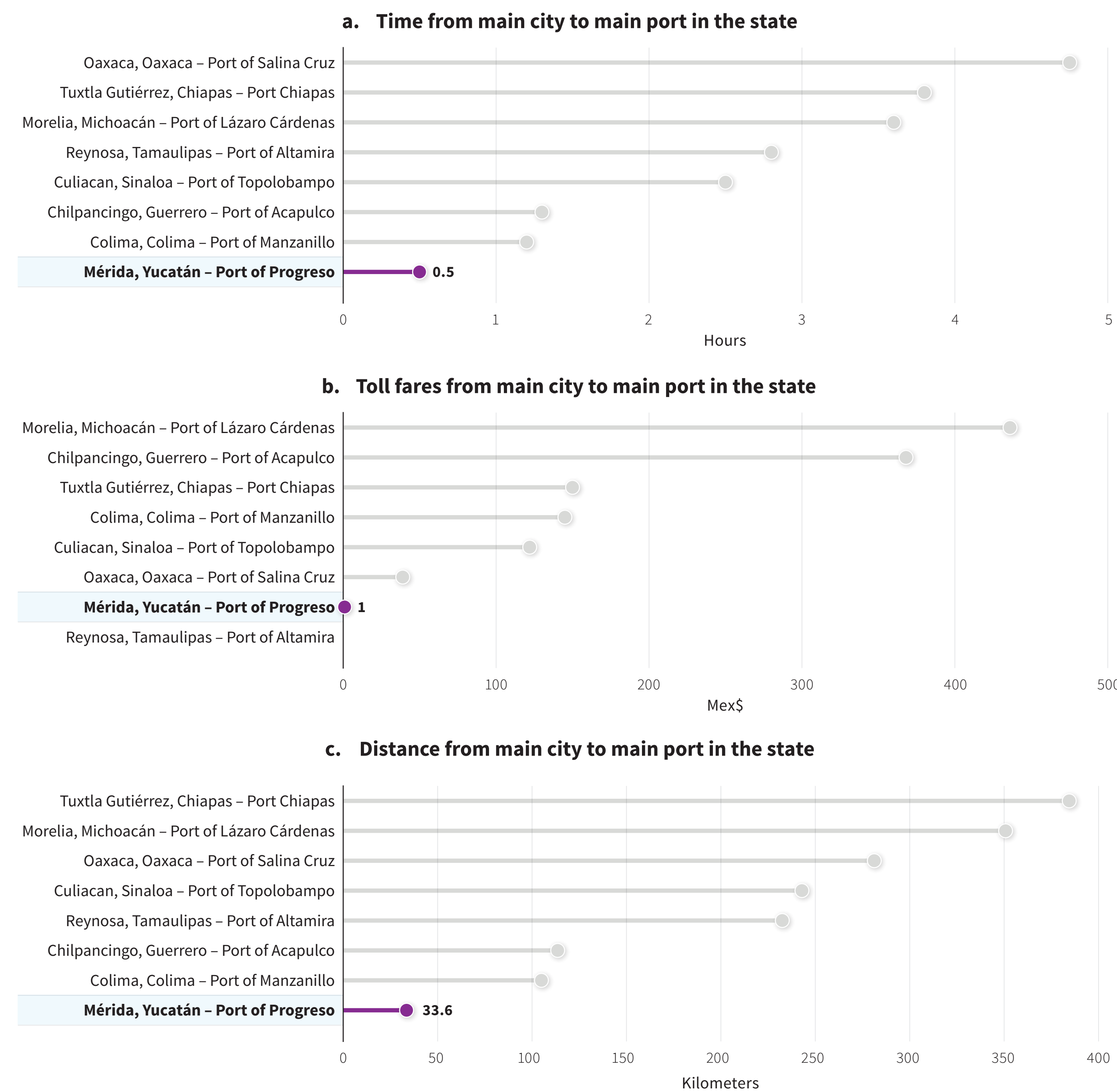
Source: ENCRIGE 2016 and 2020.
Note: Toll roads are excluded from the figure.

Regarding port infrastructure and operation in Yucatán, there are 12 ports, but only one has the capacity for international trade, which is the main port in the state, Puerto Progreso. Figure C.16 compares three indicators that measure connectivity and accessibility of ports from the main economic regions of the states where they are located: time, cost, and distance. Among the analyzed ports, Puerto Progreso has the lowest levels in all three metrics. It takes less than one hour to transport from Mérida (main city) to Progreso (port city). No toll fares are required, and the distance is below 50 km.

In figure C.17, the saturation levels and capacities of selected ports are compared to assess the potential utilization of incoming firms based on the existing infrastructure. In the case of Puerto Progreso, it has a saturation rate of 65.1 percent, indicating that there is still room for growth before expansion investments become necessary, despite its relatively lower capacity compared to larger ports. Puerto Progreso has a draft of 10.4 meters, terminals for agriculture and mineral bulk and cruise ships, shipyard, and private containers terminal. The private container terminal has recently been equipped with a gantry crane to enhance the efficiency of container handling from post-Panamax ships by 30 percent.

FIGURE C.16

Port Availability to Main Cities, Selected Ports, 2020

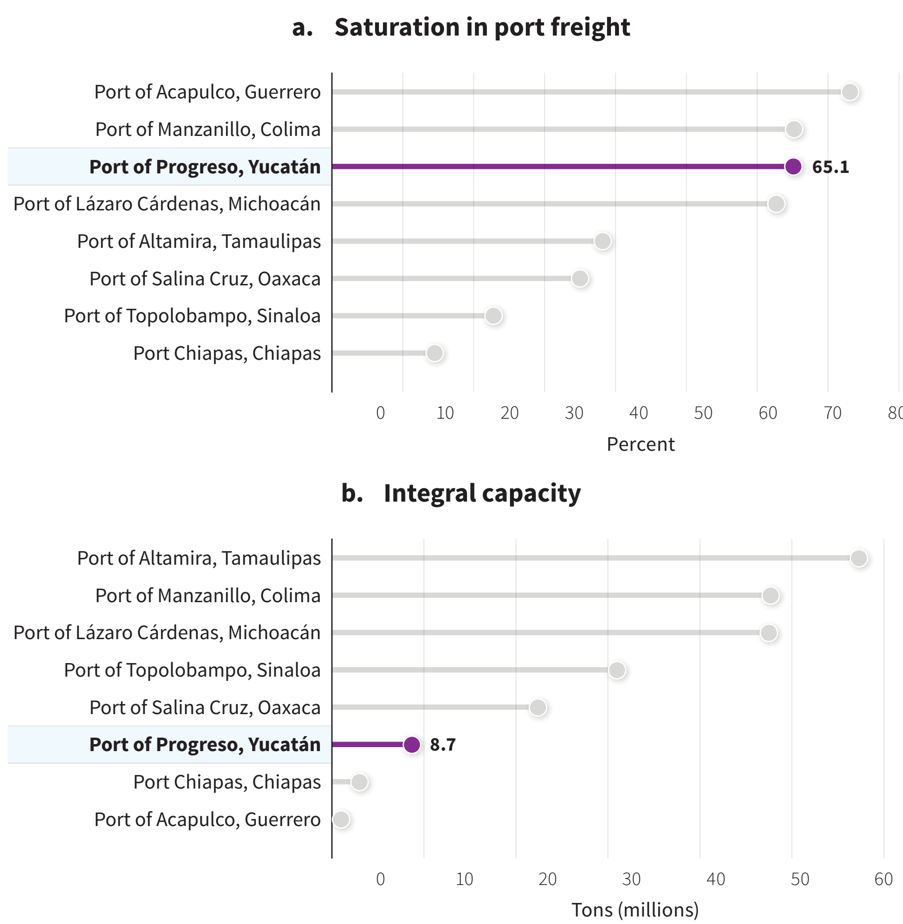


Source: Based on data from SCT's MAPPIR application.
Note: For panel b, toll fares were estimated for an automobile.

In figure C.18, the satisfaction levels of firms using the closest port infrastructures in each state of the country are compared. Yucatán stands out with the third largest share of firms satisfied with port services and facilities at 93 percent. This figure is well above the national rate of 55 percent.

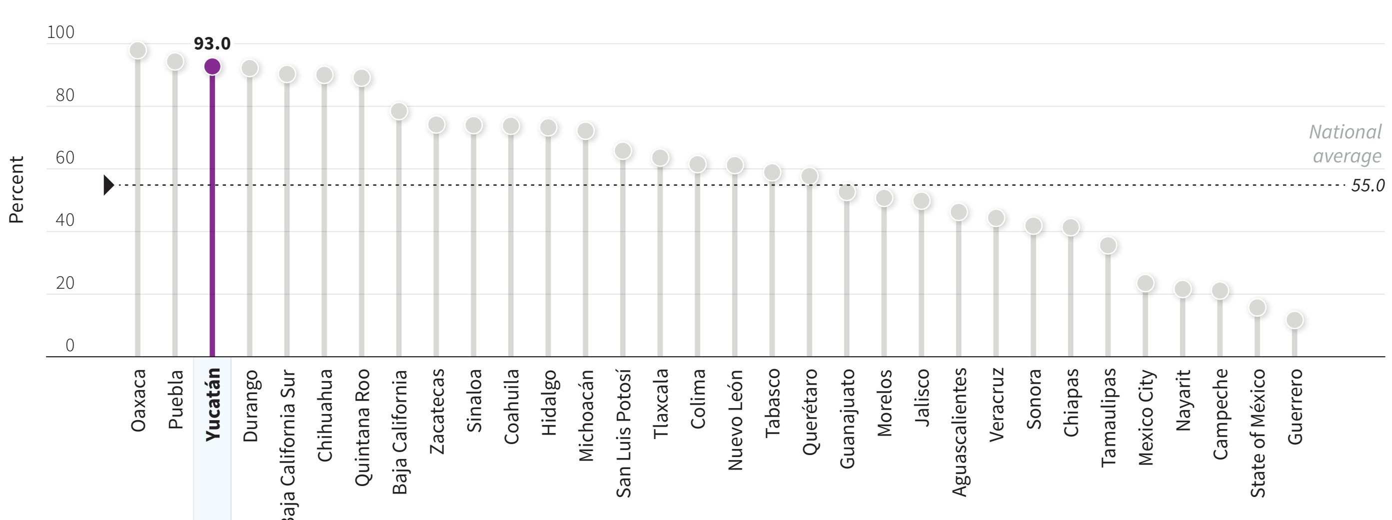
To complete the transportation infrastructure analysis, an evaluation of railway infrastructure is conducted. Figure C.19 shows that Yucatán has an index

FIGURE C.17
Port Saturation Level and Absolute Integral Capacity, Selected Ports, 2017



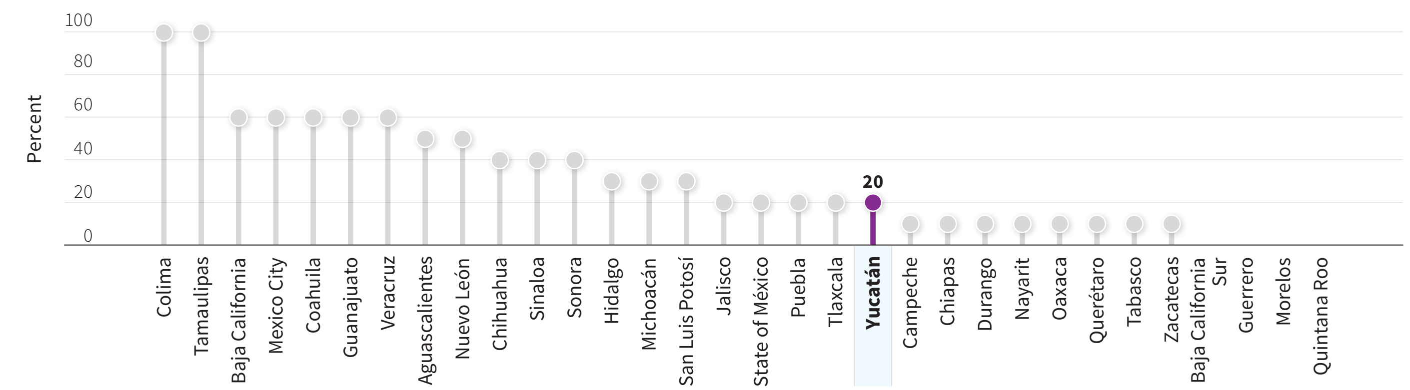
Source: Calculations based on data from SCT 2020; Idom Consulting 2017.

FIGURE C.18
Firms' Satisfaction with Port Infrastructure by State, 2016



Source: Based on INEGI's ENCRIGE database.
Note: The survey included an assessment of port services only until 2016.

FIGURE C.19
Rail Freight Density Index, by State, 2018



Source: ARTF 2018.
Note: Normalized values are based on total products transported using the available rails within each state. A value of 100 percent represents a high density, 10 percent represents a low density, and 0 percent represents either no movement of products or no railways available for freight.

of density of freight moved by railways of 20 percent. This places the state in the middle of the ranking among the 32 Mexican states.

Finally, we assess how the state is connected to Mexico's railway system. Map C.6 shows that Yucatán is connected to the country's railway system through the Chiapas-Mayab line, which is linked to the *Ferrocarril Transístmico* (Isthmus of Tehuantepec Railway). The Mayab line crosses the state and links Valladol-

MAP C.6
Mexico's Railway System, 2021

Source: ARTF 2022.

id with the rest of Mexico's railway system in Veracruz. The line also connects to the Mayan Train, a flagship project of the federal government.[85]

Regarding the airport infrastructure, map C.7 provides the national airport network. In 2021, Mexico had a total of 77 airports. Out of these, 64 airports had international routes. In addition, there were 1,492 aerodromes, which are sites designed for take-off and landing of small airships. Figure C.20 shows that Yucatán is well served in terms of air connectivity by its two airports in Kaua

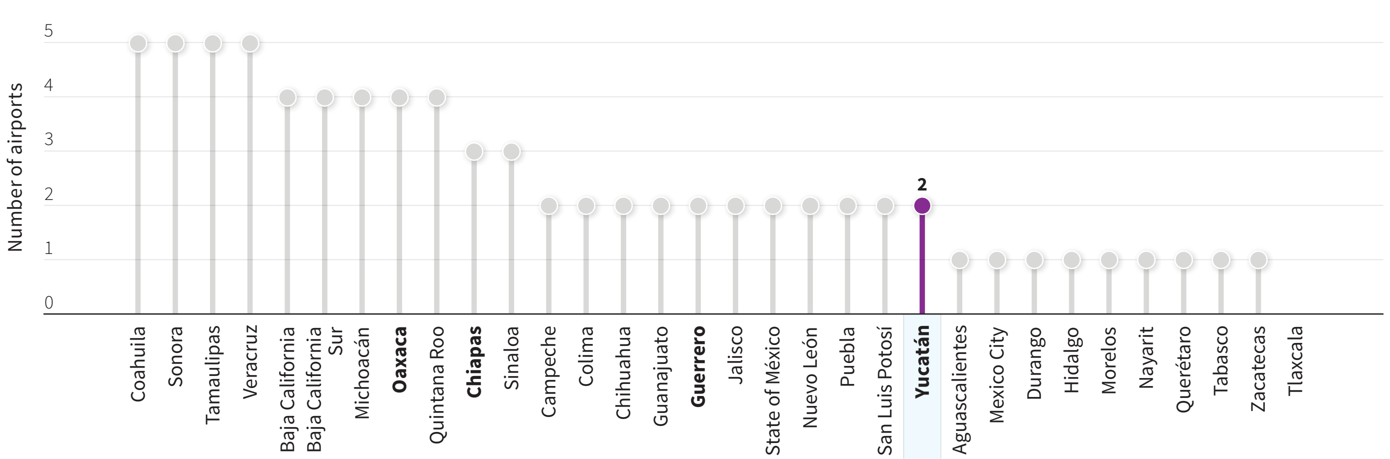
MAP C.7

Main Airports in Mexico, 2021

Source: SCT 2022.

FIGURE C.20

Number of Airports by State, 2021



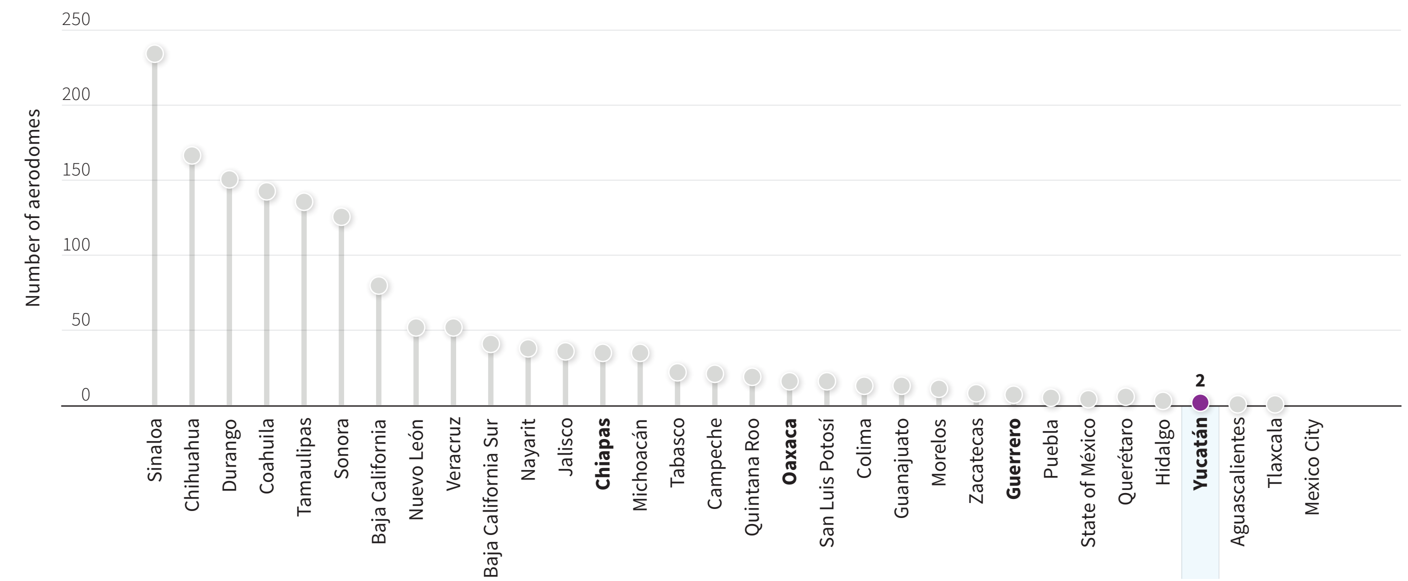
Source: SCT 2022.

and Mérida.[86] However, figure C.21 highlights that the state has a relatively small number of aerodromes, suggesting that it is underserved in terms of facilities dedicated to small airships.

In terms of freight and passengers movement, figures C.22 and C.23 show that Yucatán is among the top-10 states with the highest number of passengers and freight mobilized.

FIGURE C.21

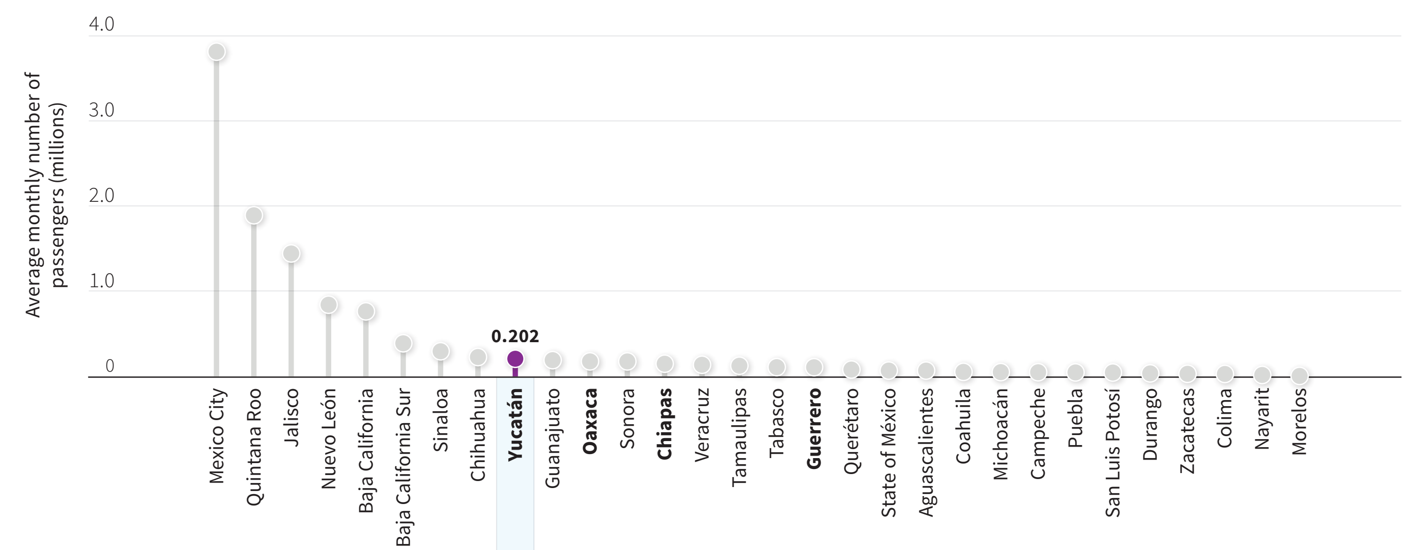
Number of Aerodromes by State, 2021



Source: SCT 2022.

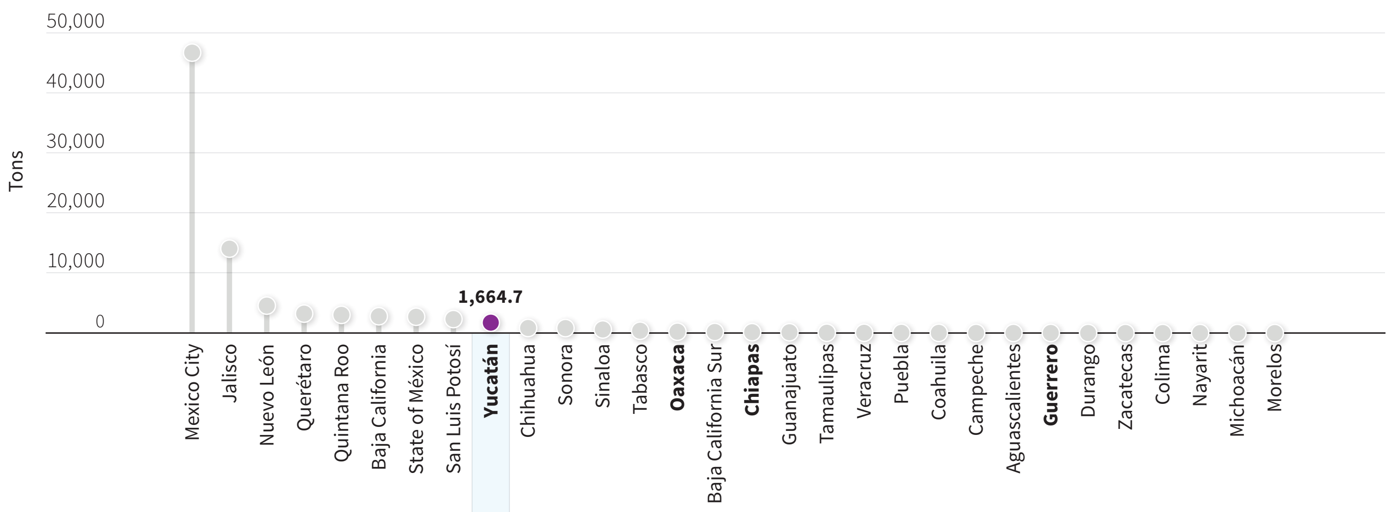
FIGURE C.22

Monthly Average Number of Passengers Mobilized by State, 2015–19



Source: Calculations based on data from SCT's *Estadística Operativa de Aeropuertos, Dirección General de Aeronáutica Civil*.
Note: The figure corresponds to the months of November from the years considered.

FIGURE C.23
Monthly Average Freight Transported by State, 2015–19

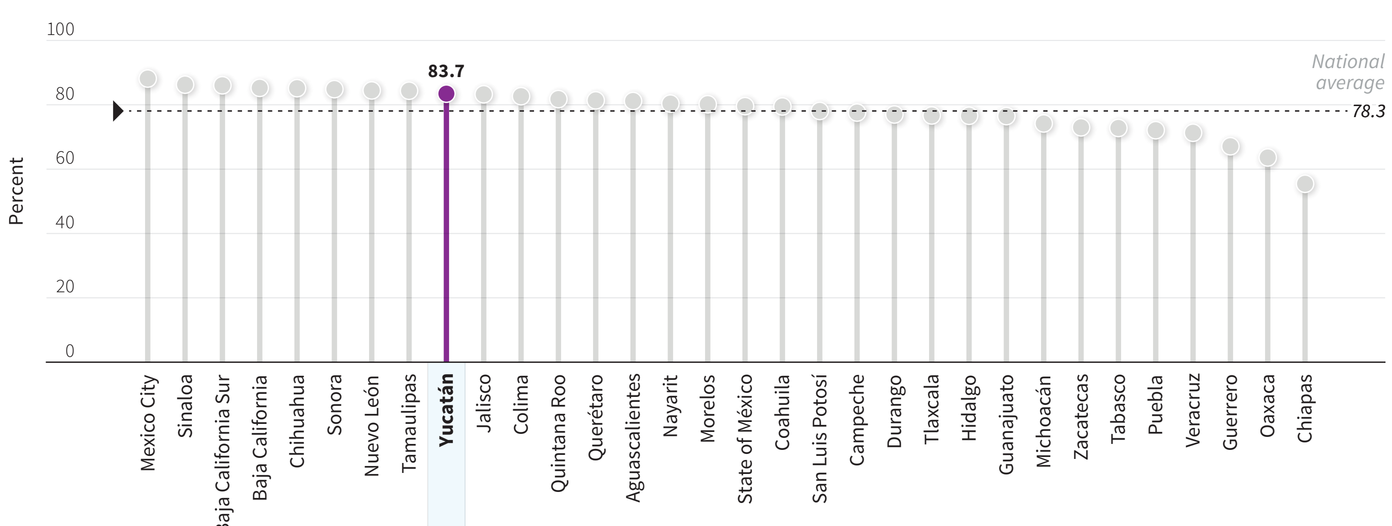


Source: Calculations based on data from SCT's *Estadística Operativa de Aeropuertos, Dirección General de Aeronáutica Civil.*
Note: The figure corresponds to the months of November from the years considered.

TELECOMMUNICATIONS

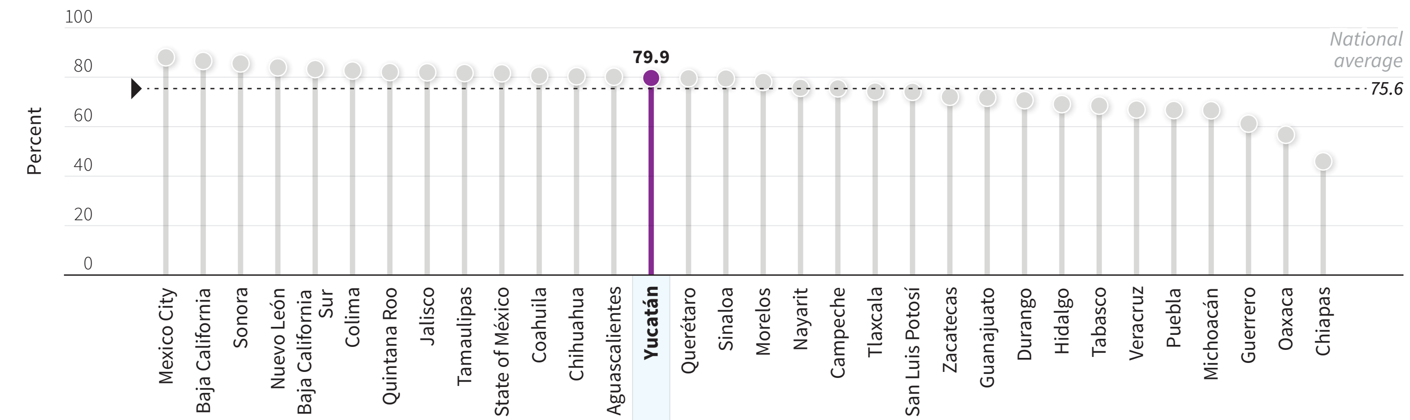
According to figures C.24 and C.25, the share of population that use mobile telephony and internet in Yucatán are above the national average (78.3 and 75.6 percent, respectively). In terms of households with internet connection, figure C.26 shows that Yucatán has reached the same proportion as the national level, but is still almost 20 percentage points below the most connected state. This suggests that despite a high number of telecommunication technologies users, internet connection is not available in all locations within the state.

FIGURE C.24
Share of Mobile Telephony Users, 2021



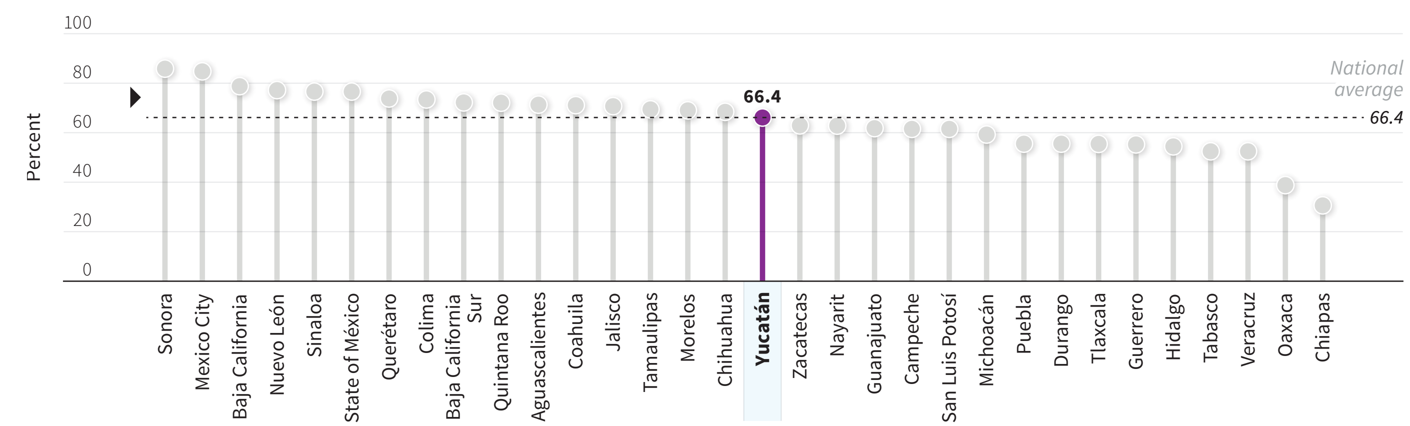
Source: Based on data from INEGI's EDUTIH database.

FIGURE C.25
Share of Internet Users, 2021



Source: Based on data from INEGI's EDUTIH database.

FIGURE C.26
Share of Households with Internet Connection, 2021



Source: Based on data from INEGI's EDUTIH database.

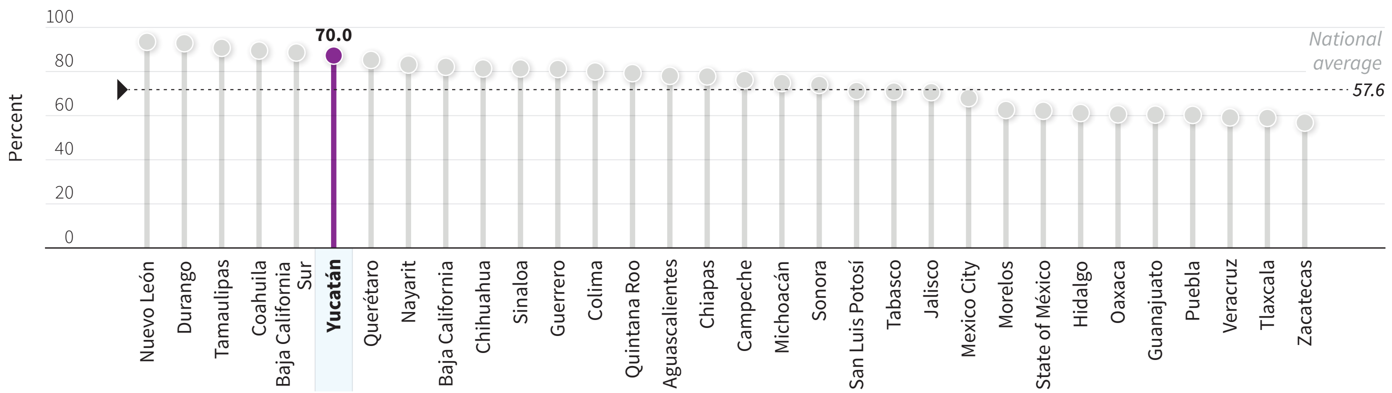
Despite the gap in broadband coverage, according to figure C.27, the satisfaction levels of firms in Yucatán with internet services exceeds the national average (57.6 percent) significantly. In terms of mobile telephony service, figure C.28 shows that the share of satisfied firms in the state of 65.7 percent is also higher than the national average (56.1 percent).

ICT INFRASTRUCTURE

Mexico has invested in the development of communication infrastructure to provide telephone and internet services across the country, including optical fiber networks for fixed and mobile broadband, satellite connections, and data centers. The country has an extensive web of optical fiber cables that are owned and operated by either public or private companies. The *Comisión Federal de Electricidad* (Federal Electricity Commission; CFE), which is a state-owned company, owns and operate a vast network of optical fiber spanning 43,000 km across the country. A significant portion of its infrastructure has been installed in lamp

FIGURE C.27

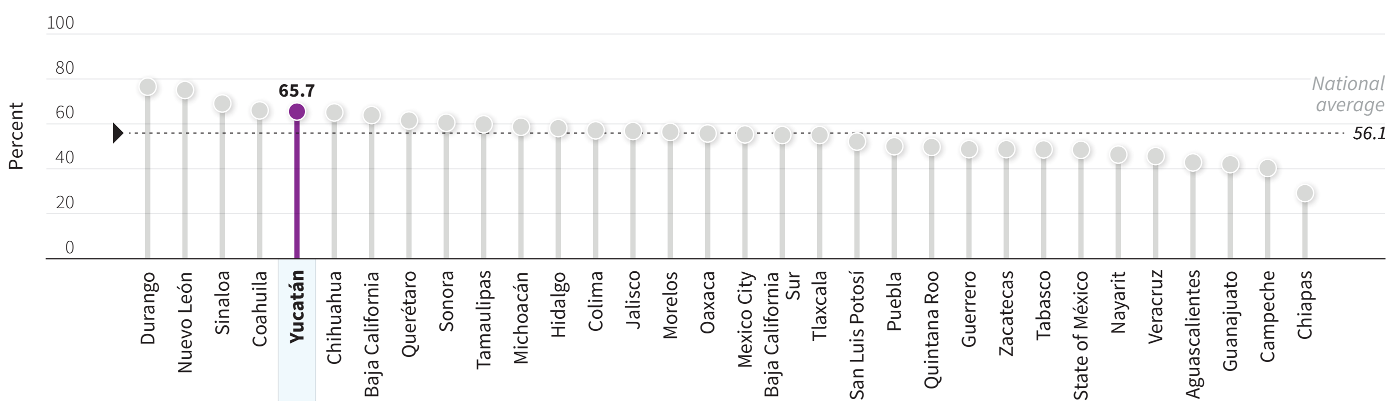
Firms' Satisfaction with Internet Service, 2016



Source: Based on INEGI's ENCRIGE database.
Note: The figure reflects the latest available data for internet services.

FIGURE C.28

Firms' Satisfaction with Mobile Telephony Service, 2016



Source: Based on INEGI's ENCRIGE database.
Note: The figure reflects the latest available data for mobile telephony services.

posts. The CFE utilizes two types of fiber. The first type is dense wavelength division multiplexing, shown in map C.9, which provides a high transport velocity of 25.6 terabits per second. The second type is synchronous digital hierarchy, shown in map C.10, which provides a transport velocity of up to 155 megabits per second. These fibers facilitate information transport across the country. In Yucatán, both types of fiber networks extend through its southern region, connecting from Campeche to the state of Quintana Roo. However, no fiber network reaches the main city of the state, Mérida. There are approximately 33,000 km of the fiber known as "*fibra oscura*" (dark fiber) available for use by the CFE.

On the other hand, private companies, such as América Móvil (Telcel) and Izzi Telecom also play a significant role in providing their own network of optical fiber connections throughout various regions in Mexico. América Móvil has the biggest network, spanning up to 110,000 km reaching across the country (map C.11). In addition to their national coverage, América Móvil's network and submarine cable also extend connections to Latin America, the Caribbean, and the United States (map C.12). In Yucatán, the optical fiber of América

MAP C.9

DWDM Optical Fiber Web in Mexico

Source: Telecomm 2018.
Note: DWDM = dense wavelength division multiplexing.

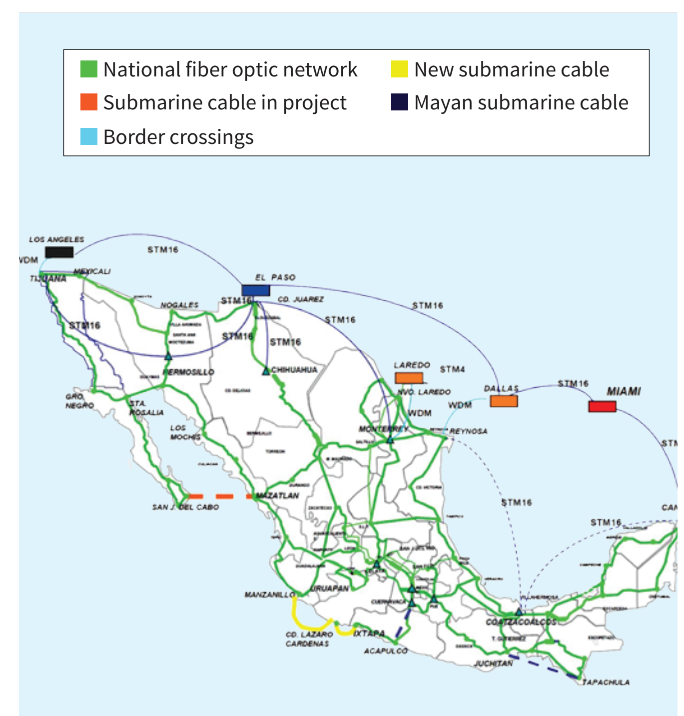
MAP C.10

SDH Optical Fiber Web in Mexico

Source: CFE 2018.
Note: SDH = synchronous digital hierarchy. Alcatel Lucent provides SDH services for the *Comisión Federal de Electricidad* (Federal Electricity Commission).

MAP C.11

Optical Fiber Network of América Móvil in Mexico



Source: Adapted from Fonseca 2010.

MAP C.12

Submarine Cables of América Móvil to Latin America, the Caribbean, and the United States

Source: Based on Telegeography Submarine Cable Map, www.submarinecablemap.com/.

Móvil originates from the state of Campeche, and traverses through key cities and towns such as Chemax, Kantunil, Kaua, Maxcanú, and Mérida, before it reaches Cancun in Quintana Roo.

In addition, Izzi Telecom, with support from the company Bestel, operates more than 27,000 km of optical fiber infrastructure in Mexico. This network extends its coverage across the country including in Yucatán, primarily in the cities of Mérida, Tucun, and Valladolid (map C.13).

Optical fiber infrastructure in Yucatán plays a crucial role in ensuring the availability of internet broadband connections. However, according to map C.14, out of 106 municipalities in the state, more than half do not have fixed access to the internet. Among the municipalities in Yucatán, Mayapan, Mérida, and Progreso have the highest number of internet accesses per 100 inhabitants. Moreover, map C.15 shows that only Mérida offers a variety of internet connections, with four operators of optical fiber infrastructure operating in the municipality. Kanasín, Progreso, Tizimín, and Umán follow with two operators each and Ticul and Valladolid with one operator, while the remaining municipalities do not have any operator offering internet services through optical fiber.

The state government in Yucatán also provides a public network for digital services comprised of broadcaster towers around the state (map C.16). The state has close to 3,000 public spaces connected to the internet, and these sites are connected through various wire connections. This network facilitates the provision of basic services (table C.1).

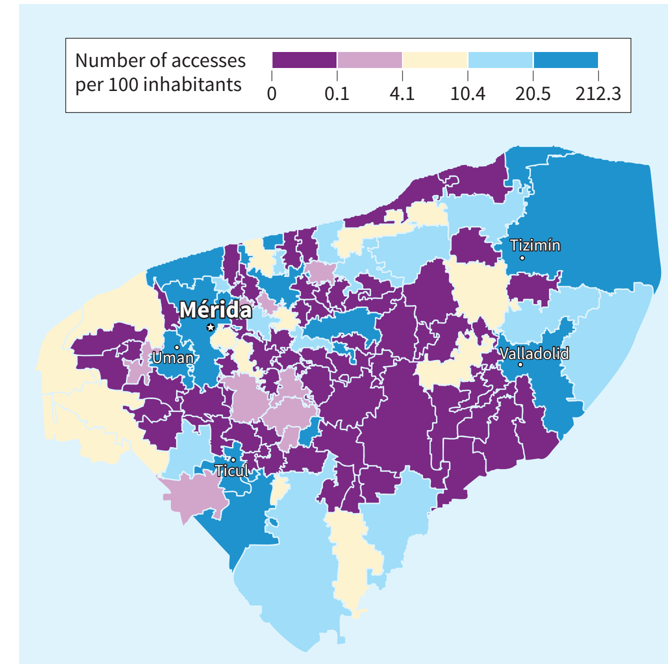
MAP C.13

Optical Fiber Network of Bestel and Izzi Telecom

Source: Adapted from Bestel's coverage map, https://www.bestel.com.mx/mapa-cobertura.

MAP C.14

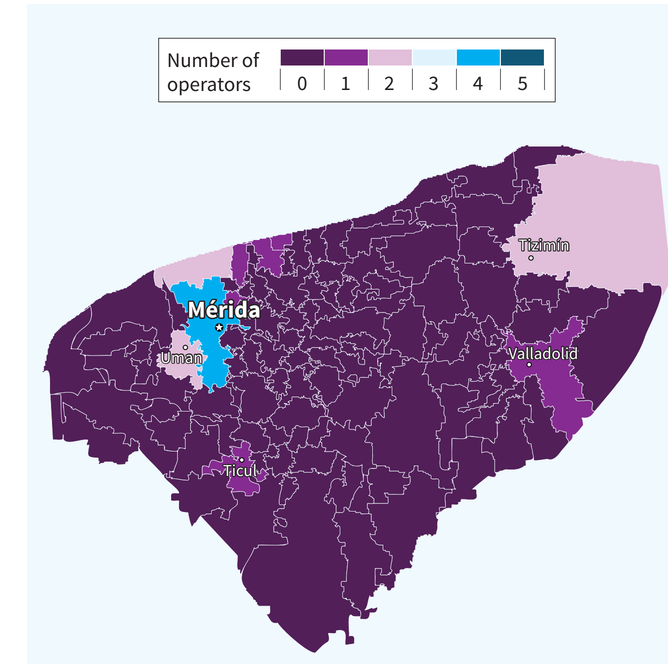
Broadband Connection Access per 100 Houses by Municipality in Yucatán



Source: Adapted from IFT 2018.

MAP C.15

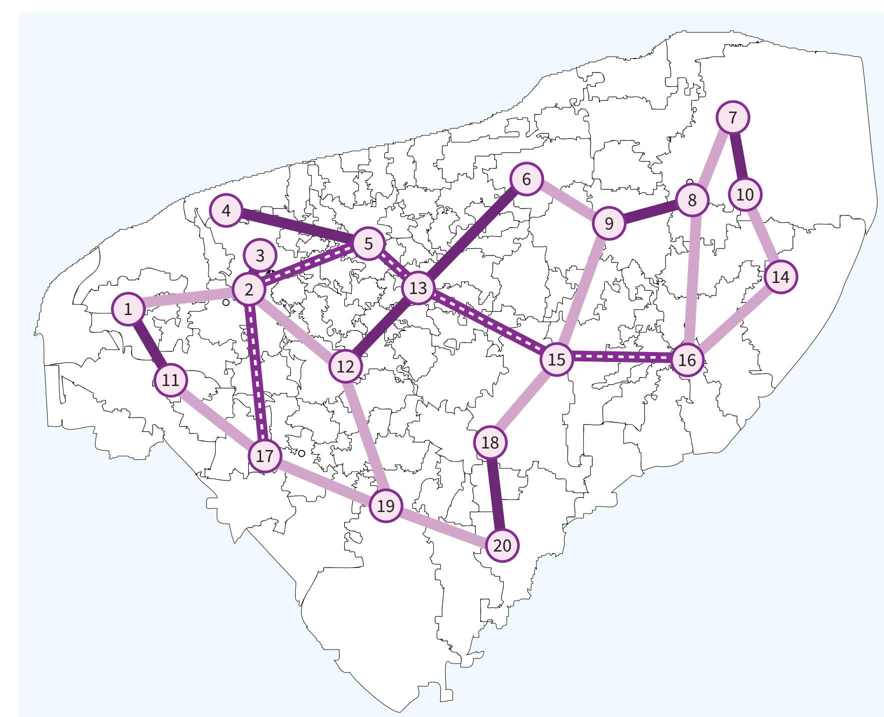
Number of Operators with Optical Fiber Infrastructure by Municipality in Yucatán



Source: Adapted from IFT 2018.

MAP C.16

Wimax Network for Public Services in Yucatán



1	KINCHIL	11	31ETV00170
2	C4-MÉRIDA	12	31ETV0027V
3	SEP	13	C4-IZAMAL
4	31ETV0057P	14	31ETV0022Z
5	C4-MOTUL	15	C4-PISTÉ
6	BUCTZOTZ	16	C4-VALLADOLID
7	31ETV0096R	17	C4-MUNA
8	TIZIMÍN	18	31ETV0008G
9	31ETV0065Y	19	31DST0031V
10	31ETV0054S	20	31ETV0126V

Source: Adapted from Gobierno del Estado de Yucatán 2015.

TABLE C.1

Public Places with Internet Connections in Yucatán

	Number of connected sites
SEGEY	1,618
Educational institutions	51
Health	119
City halls	93
Civil registries	71
Municipal cadastres	4
Prodemefa (DIF)	13
SSP (public security)	10
SAF (finance)	81
State judicial court	19
Security (SSP, FGE, administrative courts, police stations)	16

Source: Gobierno del Estado de Yucatán 2015.
Note: DIF = *Sistema para el Desarrollo Integral de la Familia*; FGE = *Fiscalía General*; Prodemefa = *Procuraduría de la Defensa del Menor y la Familia*; SEGEY = *Secretaría de Educación del Gobierno del Estado de Yucatán*; SSP = *Secretaría de Seguridad Pública*.

In Mexico, satellite connection services cater to the general population and companies who offer services including telephony services to rural regions. Yucatán, in particular, contributes about 0.4 percent to the national demand of these services.[87] According to table C.2, as of 2020, Mexico had six active satellites owned by the government. These satellites are operated by private firms through concessions or by state-owned companies. In addition, Mexico authorized 79 satellites from 10 countries (Brazil, Canada, Colombia, France, Luxemburg, the Netherlands, Papua New Guinea, Spain, the United Kingdom, and the United States) to provide services in the country.

Satellites in Mexico provide four types of communication services, with voice and data being the most prominent, accounting for 50.1 percent of the total. This is followed by television at 20.4 percent, mobile telephony at 4.6 percent, and radio at 0.3 percent. Additionally, there is approximately 24.6 percent of free capacity within the satellite system (figure C.29). In terms of usage breakdown by industry, telecommunication operators are the primary users, accounting for 38 percent of satellite utilization, as shown in figure C.30. Industry and commerce follows closely at 25.4 percent. The remaining usage is divided among government, transport and tourism, and education sectors.

Mobile internet availability is dependent on the company that provide the service. In Yucatán, América Móvil has the highest coverage in the state for all types of services, including second- (2G), third- (3G), and fourth-generation (4G) networks.[88] In addition, although limited in their coverage, other companies like AT&T, Cierto, Flash Mobile, Mobile Bandits, Movistar, Open Ip, and Simpati provide mobile internet services as well.

In terms of 2G networks (used for voice, short message service [SMS] and data with slow velocity), map C.17 shows that América Móvil provides guaranteed coverage as mandated by the *Instituto Federal de Telecomunicaciones* (Federal Telecommunications Institute) throughout all cities in Yucatán, as well as along main roads. On the other hand, companies like Cierto, Mobile Bandit, Open Ip, and Simpati have more limited coverage, focusing only on certain

TABLE C.2

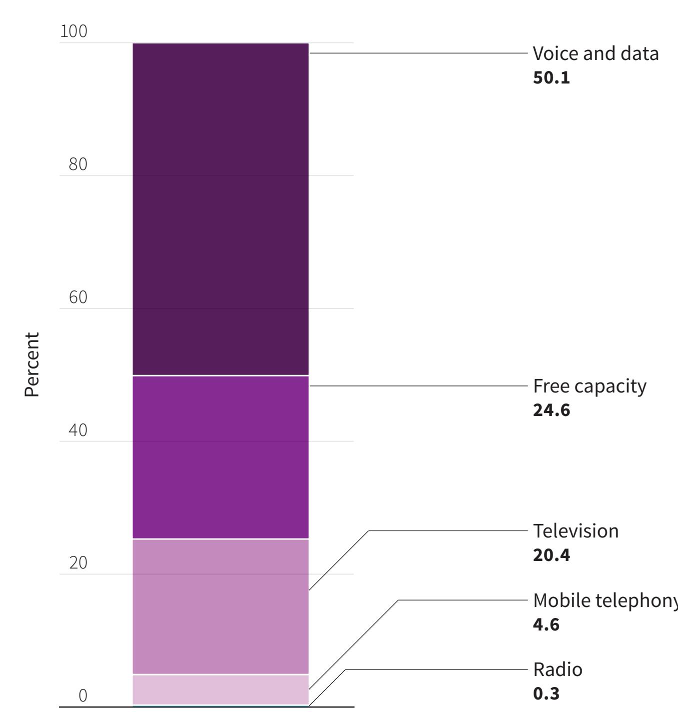
National Satellites Operating in Mexico, 2020

Satellite name	ITU file name	Frequency				Company
		Band	Uplink (MHz)	Downlink (MHz)	Service	
Bicentenario	MEXSAT 114.9 KU EXT	K_u extended	13,750–14,000	11,450–11,700	SFS	Telecomunicaciones de México
Bicentenario	MEXSAT114.9 L-CEXT-X	C extended	6,425–6,725	3,400–3,700	SFS	Telecomunicaciones de México
Eutelsat 113 West A	SATMEX 7	C	5,925–6,425	3,700–4,200	SFS	Satélites Mexicanos, S.A. de C.V.
Eutelsat 113 West A	SATMEX 7	K_u	14,000–14,500	11,700–12,200	SFS	Satélites Mexicanos, S.A. de C.V.
Eutelsat 115 West B	MEXSAT-114.9 C-KU	C	5,925–6,425	3,700–4,200	SFS	Satélites Mexicanos, S.A. de C.V.
Eutelsat 115 West B	MEXSAT-114.9 C-KU	K_u	14,000–14,500	11,700–12,200	SFS	Satélites Mexicanos, S.A. de C.V.
Eutelsat 117 West A	SATMEX 8	C	5,925–6,425	3,700–4,200	SFS	Satélites Mexicanos, S.A. de C.V.
Eutelsat 117 West A	SATMEX 8	K_u	14,000–14,500	11,700–12,200	SFS	Satélites Mexicanos, S.A. de C.V.
Morelos 3	MEXSAT 113 AP30B	K_u (AP30B)†	…	10,700–10,950	SFS	Telecomunicaciones de México
Morelos 3	MEXSAT 113 AP30B	K_u (AP30B)†	12,750–13,250	11,200–11,450	SFS	Telecomunicaciones de México
Morelos 3	MEXSAT113 L-CEXT-X	L	1,646.5–1,660.5	1,545–1,559	SMS	Telecomunicaciones de México
Morelos 3	MEXSAT113 L-CEXT-X	L	1,626.5–1,645.5	1,525–1,544	SMS	Telecomunicaciones de México
Morelos 3	MEXSAT 116.8 AP30B	K_u (AP30B)†	12,750–13,250	10,700–10,950	SFS	Telecomunicaciones de México
Morelos 3	MEXSAT 116.8 AP30B	Ku (AP30B)†	…	11,200–11,450	SFS	Telecomunicaciones de México
Morelos 3	MEXSAT 116.8 L	L	1,626.5–1,645.5	1,525–1,544	SMS	Telecomunicaciones de México
Morelos 3	MEXSAT 116.8 L	L	1,646.5–1,660.5	1,545–1,559	SMS	Telecomunicaciones de México
Quetzsat 1	Quetzsat-77	Ku (AP30/30A)*	17,300–17,800	12,200–12,700	SRS	Quetzsat S. de R.L. de C.V.

Source: Based on IFT's *Mapa de Satélites Geoestacionarios con Huella en México* database.
Note: ITU = International Telecommunication Union; MHz = megahertz; SFS = *servicio fijo por satélite* (fixed-satellite service); SMS = *servicio móvil por satélite* (mobile-satellite service); SRS = *servicio de radiodifusión por satélite* (broadcasting-satellite service).
*Refer to appendices 30 and 30A of ITU's Radio Regulations.
†Refer to appendix 30B of ITU's Radio Regulations.

FIGURE C.29

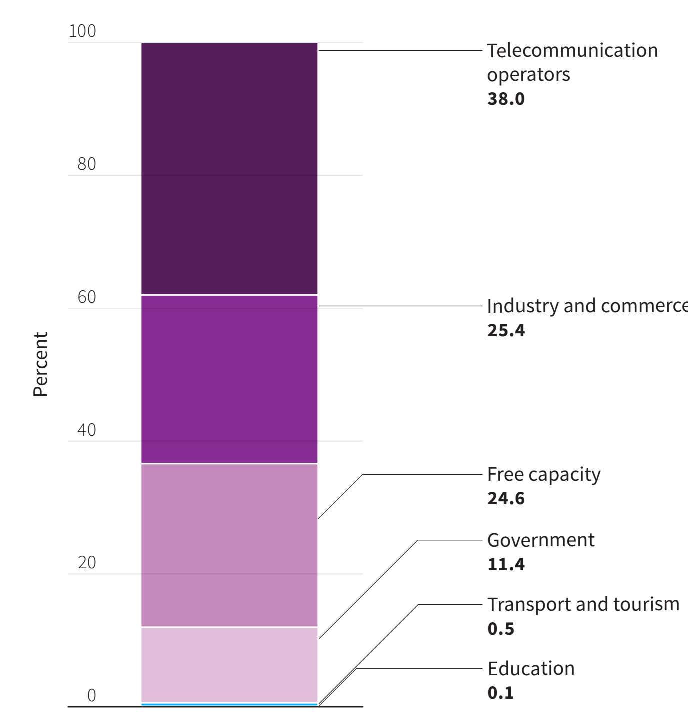
Use of Satellites by Service, 2018



Source: SCT 2020.

FIGURE C.30

Use of Satellites by Industry, 2018



Source: SCT 2020.

major cities in the state and with coverage limited only to the boundaries of those cities. Notably, Movistar do not offer 2G networks in the state (map C.18).

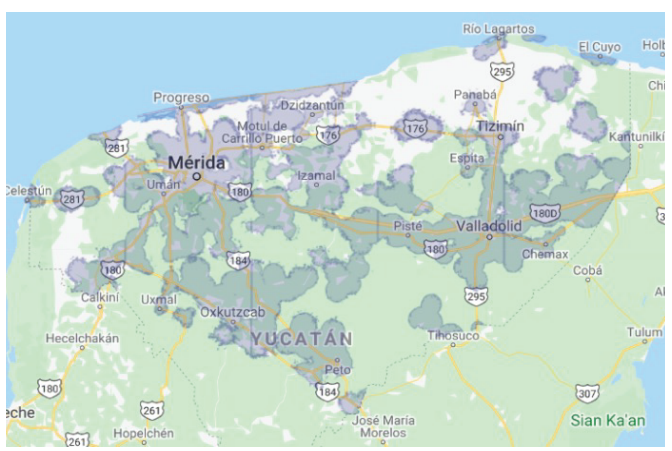
When it comes to 3G networks (used for voice, SMS, and data at a higher velocity than 2G), América Móvil has a higher coverage, but it is mainly concentrated around the areas of Mérida and Valladolid. Additionally, there is limited coverage in some cities within the state (map C.19). On the other hand, the remaining companies share similar coverage patterns in the state. Their coverage is highly concentrated in Mérida, while providing limited coverage in other cities of Yucatán. Notably, these companies do not offer coverage in cities in the eastern and southern regions of the state (map C.20).

In terms of 4G networks, América Móvil and Movistar have the widest coverage in Yucatán, primarily concentrated around the regions of Mérida and Progreso, as well as in the city of Valladolid (map C.21). However, access to 4G networks in the northeastern and southern regions of the state is limited. Other companies, such as AT&T, Cierto, Flash Mobile, Mobile Bandits, Open Ip, and Simpati offer smaller coverage in Yucatán (map C.22). AT&T, in particular, has coverage in different cities of the state, mainly in the Mérida-Tizmín-Valladolid circuit. The remaining companies have coverage restricted to the city of Mérida.

In conclusion, it is evident that there are remaining gaps on ICT and telecommunications infrastructure outside the major cities of Yucatán. These gaps could limit the development of industries that heavily rely on these services.

MAP C.17

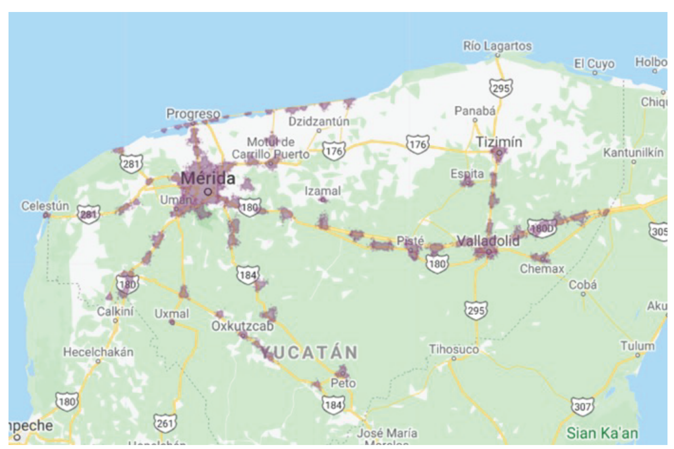
América Móvil's 2G Coverage for Mobile Internet in Yucatán



Source: Based on IFT's *Mapas de Cobertura Móvil* database.

MAP C.18

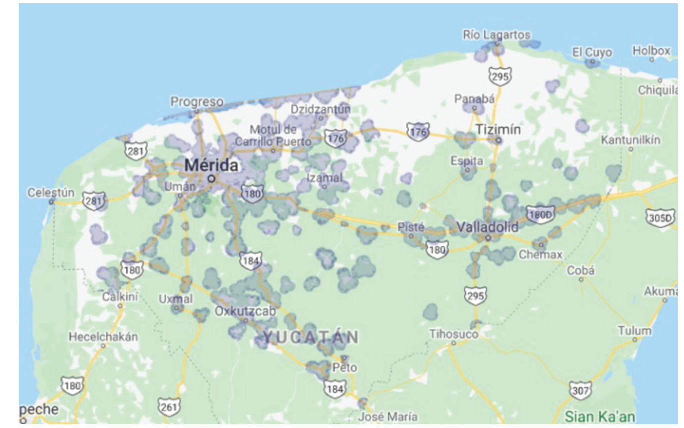
Other Companies' 2G Coverage for Mobile Internet in Yucatán



Source: Based on IFT's *Mapas de Cobertura Móvil* database.
Note: All firms have the same coverage.

MAP C.19

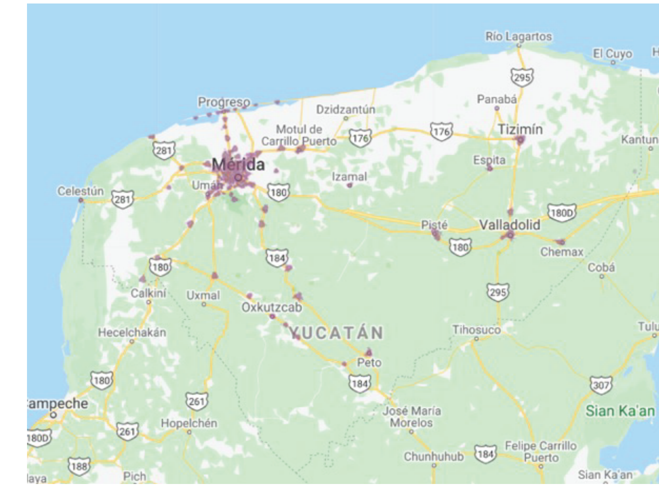
América Móvil's 3G Coverage for Mobile Internet in Yucatán



Source: Based on IFT's *Mapas de Cobertura Móvil* database.

MAP C.20

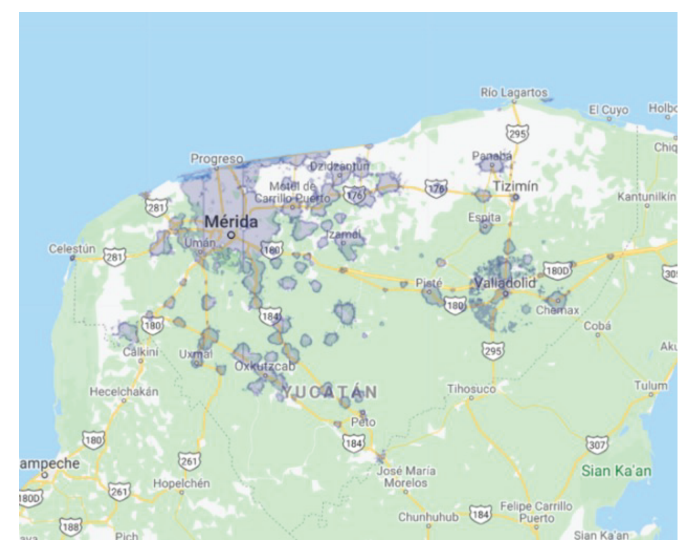
Other Companies' 3G Coverage for Mobile Internet in Yucatán



Source: Based on IFT's *Mapas de Cobertura Móvil* database.
Note: All firms have the same coverage.

MAP C.21

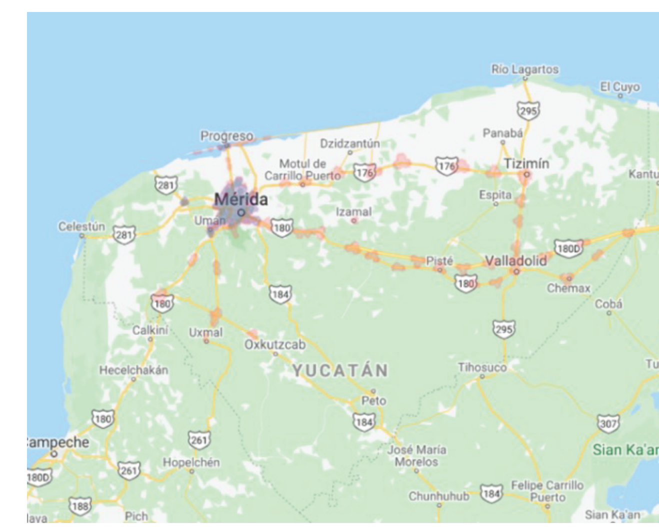
América Móvil's and Movistar's 4G Coverage for Mobile Internet in Yucatán



Source: Based on IFT's *Mapas de Cobertura Móvil* database.
Note: Both firms have the same coverage.

MAP C.22

Other Companies' 4G Coverage for Mobile Internet in Yucatán



Source: Based on IFT's *Mapas de Cobertura Móvil* database.
Note: The darker regions in Mérida indicate where internet providers like Cierto, Flash Mobile, Mobile Bandits, Open Ip, and Simpati overlap. The buffer zones of the first three providers is smaller than the last two. AT&T is the only company in the figure with a coverage beyond Mérida.

APPENDIX D
Factor Intensity

To identify infrastructure-related constraints that may hinder the development of the information and communication technology (ICT) sector in Yucatán, we analyze the use of key inputs in the production process including energy (electricity), water, combustibles, logistics (freight), and communications for ICT manufacturing firms, and contrast the results with the availability of each input (see appendix C). In the case of ICT services, an analysis of the availability of communications and energy infrastructure in Yucatán is conducted.

For ICT manufacturing, two metrics of factor usage intensity are deployed to measure how various manufacturing activities perform at the national level.[89] The first metric is the consumption or expenditure of a factor, as a percentage of intermediate consumption. The second metric is the consumption or expenditure of a factor, as a percentage of value added. The logic of this is if the sector is intensive in the use of one of these factors in which the state has deficiencies, this could represent a binding constraint.

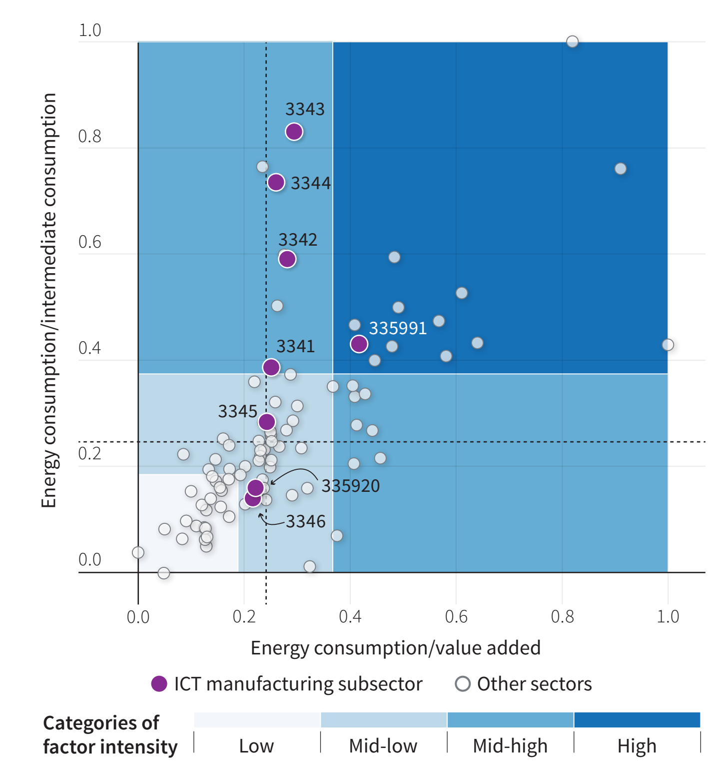
Two benchmarks to assess the use intensity of the factors are considered. First, the national average for all existing manufacturing activities, and second, the average of those ICT manufacturing activities in which the state of Yucatán has a revealed comparative advantage greater than one (a competitive sector for the state). Following the methodology Barrios and others (2018a; 2018b), based on the first benchmark, four categories are created to classify the factor usage intensity: (1) high intensity, for industry groups with a dependence of the factor higher than the sum of the national average and half a standard deviation for both metrics (dark blue quadrant); (2) mid-high intensity, for industry groups with a dependence of the factor higher than the sum of the national average and half a standard deviation in one of the metrics (medium-dark blue quadrant); (3) mid-low intensity, for those groups with a dependence of the factor below half standard deviation of national average in both or one of the metrics, and with the other metric below the sum of the national average and half a standard deviation (medium-light blue quadrant); (4) low intensity, for those industry groups with a factor below the difference between the national average and half a standard deviation for both metrics (light blue quadrant).

In terms of energy use, the results in figure D.1 suggest that none of the ICT manufacturing activities fall into the low-intensity quadrant. Navigational, measuring, electromedical and control instruments manufacturing (North American Industry Classification System [NAICS] four-digit code 3345), manufacturing and reproducing magnetic and optical media (3346), and wires for electric conduction manufacturing (NAICS six-digit code 335920) fall within the mid-low intensity quadrant. In contrast, computer and peripheral equipment manufacturing (3341), communications equipment manufacturing (3342), audio and video equipment manufacturing (3343), and semiconductor and other electronic component manufacturing (3344) fall in the mid-high intensity quadrant. These activities all have a comparative advantage in Yucatán. Coal and graphite electrical products manufacturing (335991) falls into the high intensity quadrant.

Given the limited energy generation capacity in Yucatán, which relies on coal power plants and wind farms (despite having a positive delta of generation-con-

FIGURE D.1

Energy Intensity by Sector, 2014 and 2019 Averages



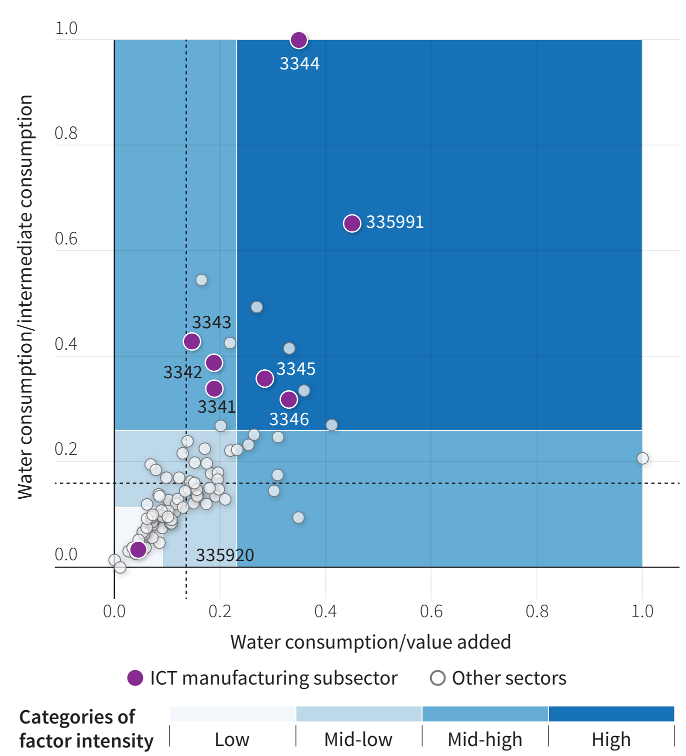
Source: Calculations based on data from INEGI 2014; 2019.
Note: ICT = information and communication technology. Sectors are classified using the North American Industry Classification System (NAICS). Dashed lines represent the average normalized value of the sectors with a revealed comparative advantage greater than one for Yucatán and those are NAICS sectors 3111, 3112, 3116, 3117, 3118, 3121, 3131, 3141, 3149, 3151, 3152, 3159, 3169, 3219, 3261, 3273, 3279, 3323, 3332, 3333, 3353, 3366, 3371, and 3399. Purple points represent group industries of the information and communication technology manufacturing sector in NAICS.

sumption), along with the presence of only one high-tension transmission line at 400 kilovolts and a few low-tension transmission lines ranging from 69 to 115 kilovolts, special attention should be paid to ICT manufacturing activities with mid-high and high energy intensity. This limitation is particularly relevant for ICT services, such as data processing, hosting, and related services (518), where energy consumption ratios can be significantly higher (up to 13:1) compared to ICT manufacturing firms.[90]

Figure D.2 provides insights into the water use intensity of ICT manufacturing activities, revealing a heterogeneous distribution. Semiconductor and other electronic component manufacturing (3344), navigational, measuring, electromedical, and control instruments manufacturing (3345), manufacturing and reproducing magnetic and optical media (3346), and coal and graphite electrical products manufacturing (335991) are positioned within the high intensity quadrant. Computer and peripheral equipment manufacturing (3341), communications equipment manufacturing (3342), and audio and video equipment manufacturing (3343) fall into the mid-high intensity quadrant, indicating a relatively higher water consumption as a percentage of intermediate consumption. Only wires for electronic conduction manufacturing (335920) falls within the low intensity quadrant and below the activities in Yucatán with a comparative advantage. Despite the varying water consumption intensities of these activi-

FIGURE D.2

Water Intensity by Sector, 2014 and 2019 Averages



Source: Calculations based on data from INEGI 2014; 2019.
Note: ICT = information and communication technology. Sectors are classified using the North American Industry Classification System (NAICS). Dashed lines represent the average normalized value of the sectors with a revealed comparative advantage greater than one for Yucatán and those are NAICS sectors 3111, 3112, 3116, 3117, 3118, 3121, 3131, 3141, 3149, 3151, 3152, 3159, 3169, 3219, 3261, 3273, 3279, 3323, 3332, 3333, 3353, 3366, 3371, and 3399. Purple points represent group industries of the information and communication technology manufacturing sector in NAICS.

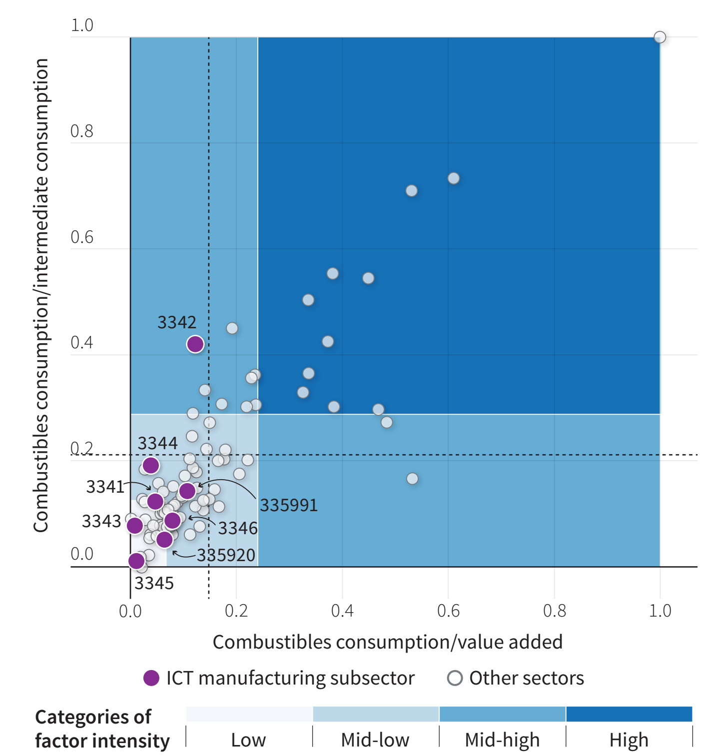
ties, there is sufficient water availability in Yucatán, and any necessary improvements would pertain to enhancing service quality. Therefore, water availability is not a binding constraint for further development of the ICT manufacturing activities. Similarly, water is not regarded as a constraint for ICT services, because firms in this sector do not require water as part of their production process. Their water usage is limited to facility operation, which amounts to three to five times less water consumption compared to ICT manufacturing.[91]

Figure D.3 presents results regarding the use of combustibles. All ICT manufacturing activities are within the low and mid-low intensity quadrants, except for communications equipment manufacturing (3342), which falls into the mid-high intensity quadrant. In addition, all ICT manufacturing group industries are below the intensity of group industries in which Yucatán has a comparative advantage. Hence, combustible availability in Yucatán is not a binding constraint for ICT manufacturing industries, as well as for ICT services because firms in the sector do not use combustibles intensively as part of their production process.[92]

In the case of freight, figure D.4 shows that all ICT manufacturing activities have a heterogeneous use intensity of this factor. Navigational, measuring, electromedical, and control instruments manufacturing (3345) falls within the low intensity quadrant. On the other hand, computer and peripheral equipment

FIGURE D.3

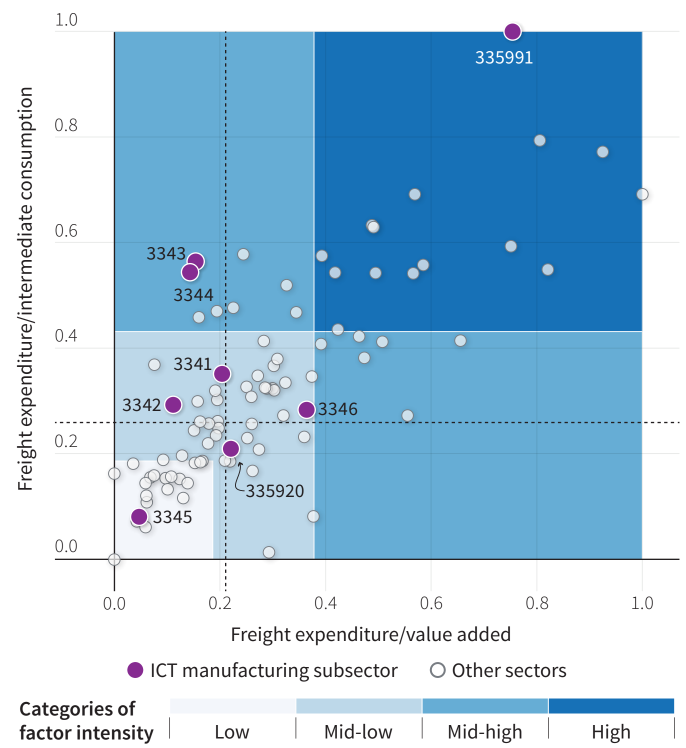
Combustible Intensity by Sector, 2014 and 2019 Averages



Source: Calculations based on data from INEGI 2014; 2019.
Note: ICT = information and communication technology. Sectors are classified using the North American Industry Classification System (NAICS). For this analysis of combustibles, petroleum and coal products manufacturing (NAICS 3241) was omitted, because combustibles is used as a raw material and a utility by the activity and would distort the analysis of the rest of the group industries (as values are normalized). Dashed lines represent the average normalized value of the sectors with a revealed comparative advantage greater than one for Yucatán and those are NAICS sectors 3111, 3112, 3116, 3117, 3118, 3121, 3131, 3141, 3149, 3151, 3152, 3159, 3169, 3219, 3261, 3273, 3279, 3323, 3332, 3333, 3353, 3366, 3371, and 3399. Yellow points represent group industries of the information and communication technology manufacturing sector in NAICS.

FIGURE D.4

Freight Intensity by Sector, 2014 and 2019 Averages



Source: Calculations based on data from INEGI 2014; 2019.
Note: ICT = information and communication technology. Sectors are classified using the North American Industry Classification System (NAICS). Dashed lines represent the average normalized value of the sectors with a revealed comparative advantage greater than one for Yucatán and those are NAICS sectors 3111, 3112, 3116, 3117, 3118, 3121, 3131, 3141, 3149, 3151, 3152, 3159, 3169, 3219, 3261, 3273, 3279, 3323, 3332, 3333, 3353, 3366, 3371, and 3399. Purple points represent group industries of the information and communication technology manufacturing sector in NAICS.

manufacturing (3341), communications equipment manufacturing (3342), manufacturing and reproducing magnetic and optical media (3346), and wires for electronic conduction manufacturing (335920) fall into the mid-low intensity quadrant. Audio and video equipment manufacturing (3343) and semiconductor and other electronic component manufacturing (3344) falls in the mid-high intensity quadrant, indicating a relatively higher freight expenditure as a percentage of intermediate consumption. Coal and graphite electrical products manufacturing (335991) falls into the high intensity quadrant, recording the highest freight expenditure as a percentage of intermediate consumption.

Nevertheless, the road infrastructure is not a significant obstacle for developing the ICT sector in Yucatán. The proportion of paved roads in the state exceeds the national average, and there is an equal proportion of four or more lanes compared to the national average. Moreover, Yucatán ranks fifth in the country in terms of satisfaction with its roads and streets (see appendix C). Regarding railway infrastructure, the Mayab line runs through the state, connecting Valladolid and linking with the rest of the Mexico's railway system in the state of Veracruz. This line primarily transports cement and mineral bulk.[93] However, with the ongoing plan for the "Tren Maya" (Mayan Train), a flagship project of the Mexican government,[94] the supply of freight transportation could increase. [95] In terms of maritime transportation, Yucatán has 12 ports,

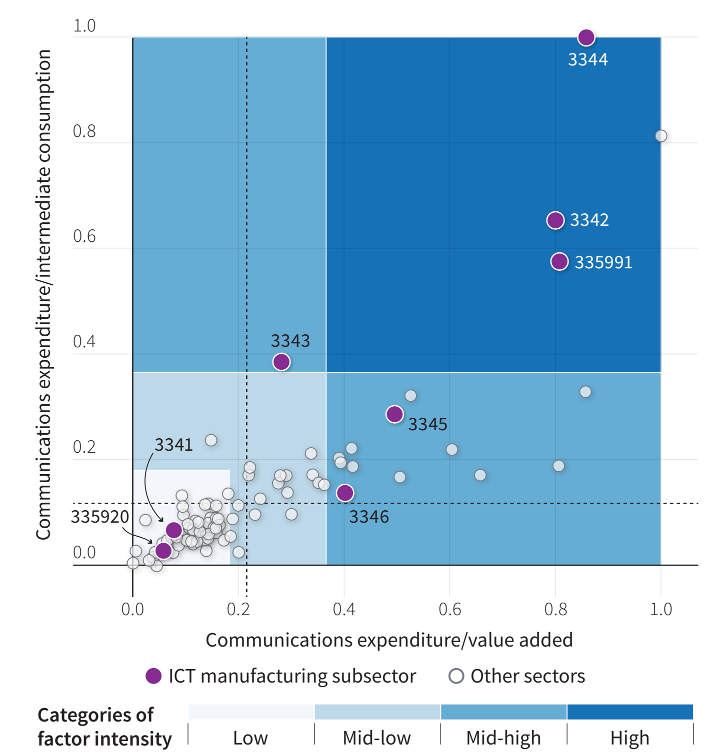
with Puerto Progreso being the most important because of its national and international trade and growth potential. The capacity of Puerto Progreso is sufficient for transporting ICT manufactured products. Additionally, there is an ongoing interest in establishing a public-private partnership to modernize the port, increase draft capacity, improve maritime infrastructure, and build, operate, and maintain a combustible terminal.[96]

Taking these factors into account, the existing supply and ongoing projects aimed at improving the logistical and transportation infrastructure suggest that any gaps in transportation infrastructure will not act as a binding constraint on the further development of ICT manufacturing activities in Yucatán in the short term. Furthermore, the transportation infrastructure should not represent a significant constraint for ICT services either, because these activities primarily focus on delivering services rather than physical products.

Finally, figure D.5 shows the results of the use intensity analysis for communications systems and reveals that electronic conduction wire manufacturing (335920) and computer and peripheral equipment manufacturing (3341) fall into the low intensity quadrant. The only activity within the mid-high intensity quadrant in terms of communications expenditure as a percentage of intermediate consumption is audio and video equipment manufacturing (3343). The only activity in the mid-high intensity quadrant in terms of communications expen-

FIGURE D.5

Communications Intensity by Sector, 2009 and 2014 Averages



Source: Calculations based on data from INEGI 2014; 2019.
Note: ICT = information and communication technology. Sectors are classified using the North American Industry Classification System (NAICS). Dashed lines represent the average normalized value of the sectors with a revealed comparative advantage greater than one for Yucatán and those are NAICS sectors 3111, 3112, 3116, 3117, 3118, 3121, 3131, 3141, 3149, 3151, 3152, 3159, 3169, 3219, 3261, 3273, 3279, 3323, 3332, 3333, 3353, 3366, 3371, and 3399. Purple points represent group industries of the information and communication technology manufacturing sector in NAICS.

diture as a percentage of value added is manufacturing and reproducing magnetic and optical media (3346). The remaining ICT manufacturing sector group industries are within the high intensity quadrant. Semiconductor and other electronic component manufacturing (3344) have the highest intensity in the metric of communications expenditure as a percentage of intermediate consumption.

ICT services firms are more intensive in their use of communications services compared to ICT manufacturing firms.[97] In Yucatán, telephony and mobile internet services are relatively accessible, but there is a limited supply of fixed-broadband internet. More than half of the municipalities in the state lack internet access for households, mainly because of the ownership and operation of optical fiber infrastructure by only a few operators. In addition, the coverage of this infrastructure extends only throughout the primary corridors of the state, including routes such as from Mérida to Valladolid, from Mérida to Progreso, from Calkiní in Campeche to Mérida, and from Mérida to Tizimín. As a result, the lack of telecommunications infrastructure in regions outside the city of Mérida and primary corridors represents a binding constraint for the development of the ICT sector in Yucatán. Notably, although the ICT index for 2015 and 2017 places the state in a mid-low position in terms of connectivity, the implementation of the Red Compartida could have improved its connectivity status.[98]

APPENDIX E
Access to Finance

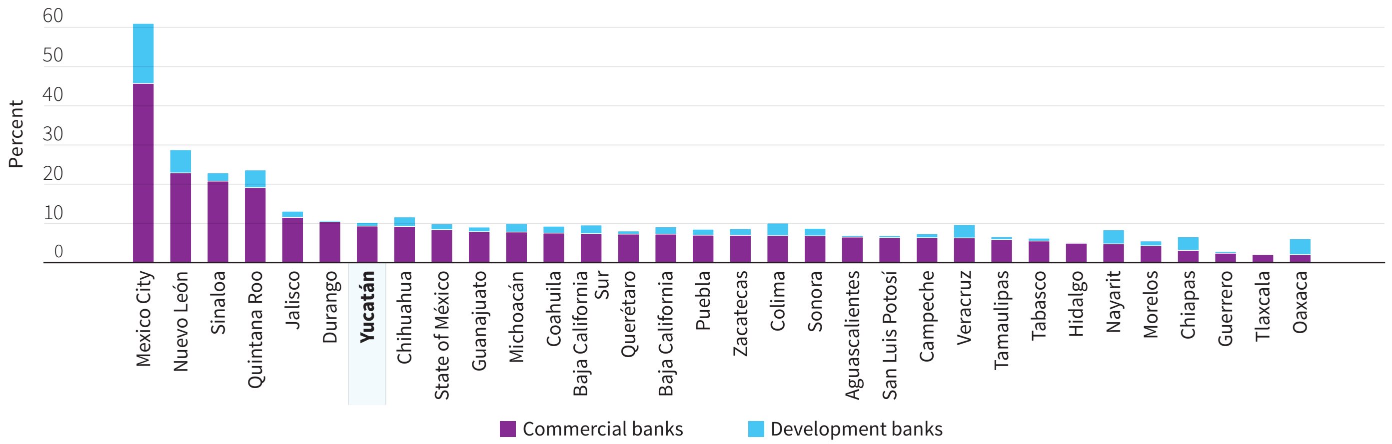
Between 2003 and 2021, foreign direct investment (FDI) inflows to the information and communication technology (ICT) sector in Mexico experienced a favorable trend, accounting for 8.1 percent of total inflows. Similarly, in Yucatán, the sector received 7.5 percent of the state's FDI inflows during the same period. Notably, major international ICT firms such as Apple, Cisco, Google, IBM, Microsoft, Oracle, and others have full access to international capital markets. Furthermore, many of these firms have established presence in Mexico. The ICT sector, at the regional level, benefits from investments and facilitation by development banking institutions such as the *Corporación Andina de Fomento* (Development Bank of Latin America), the Inter-American Development Bank, and the World Bank Group. Based on these factors, lack of access to international finance as a constraint to developing the ICT sector in Yucatán is discarded

However, there is a significant opportunity to improve access to domestic finance for local firms in Yucatán. Indeed, Yucatán faces challenges in terms of financial accessibility, with 27 out of 106 municipalities lacking financial access points,[99] only topped by the states of Puebla (54 out of 217) and Oaxaca (344 out of 570). Although Yucatán has 13.1 financial access points per 10,000 inhabitants, surpassing roughly half of the states in the country, it ranks relatively low (18th) in terms of personal deposit accounts per 10,000 adults, with 224. The deficient financial penetration in the state poses a potential challenge to further the development of the ICT sector in the state.

To further analyze the demand for finance, figure E.1 compares Yucatán with leading ICT states in the country, including Jalisco, Mexico City, Nuevo León, Quintana Roo, and State of México.[100] In terms of portfolio balance as a percentage of nonoil gross domestic product (GDP) (including commercial and de-

FIGURE E.1

Total Portfolio Balance as a Percentage of Nonoil GDP, 2019



Source: Based on data from Banxico and INEGI's National Accounts.
Note: Figure refers to the credit portfolio for all sectors, as state-level data is not disaggregated by public and private sectors. Bars are ordered by the size of commercial bank's credit portfolio as percentage of nonoil GDP. GDP = gross domestic product.

velopment banks), Yucatán (10.3 percent) is only ahead of the State of México (9.9 percent). Mexico City (61.0 percent), Nuevo León (28.8 percent), and Quintana Roo (23.6 percent) are the top three states in the country. Similarly, when considering commercial banks alone, Yucatán is only higher than the State of México (9.3 percent compared to 8.4 percent). It is evident that states with greater ICT development have a higher portfolio balance as a percentage of GDP.

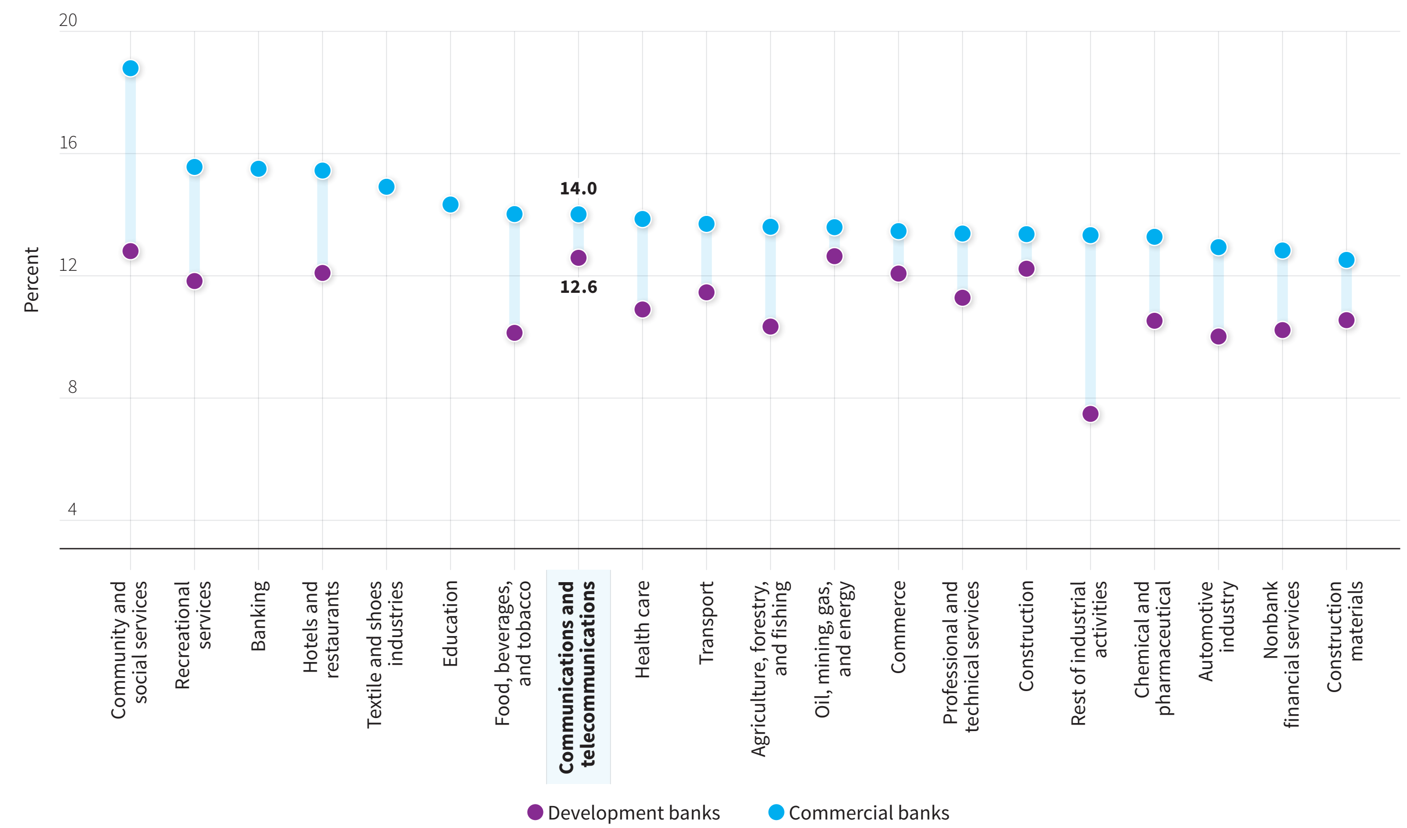
Although data on interest rates charged to firms in all ICT activities is not available, data for communication and telecommunications is available at the national level. Figure E.2 shows that among the sectors considered, interest rates for ICT firms fall on the higher-end of the spectrum when considering commercial banking. Furthermore, when looking at development banking, interest rates for ICT firms are the third highest. This could reflect a scarcity of financial resources or a higher risk aversion affecting the development of ICT sector activities.

By examining sector and firm size together, it becomes evident that micro and small firms in the communications and telecommunications sectors face the highest interest rates compared to other sectors. According to figure E.3, medium-sized firms fall in the middle, while large-sized firms face comparatively lower interest rates. Consistent with previous findings, the combination of high interest rates and lower levels of bank penetration in Yucatán reflect potential issues related to the access to finance. These factors could represent a potential binding constraint for the development of the ICT industry, particularly depending on who takes the lead as the first movers in Yucatán.

The available data on interest rates at the state level is limited. However, there is data on access to external financial sources of firms at the state level, categorized by economic activity. To account for the heterogeneity within the ICT sector, the manufacturing and services components are analyzed separately (figure E.4). Across all economic activities, Yucatán has one of the lowest percentages of firms reporting access to external financial sources. This is also observed within the manufacturing component, although this component represents a small part of the ICT sector in the state. Conversely, for ICT services, access to external fi-

FIGURE E.2

Weighted Average Interest Rates Paid by Firms in Various Industries, October 2022



Source: Based on data from CNBV's *Portafolio de Información* (Information Portfolio) for December 2016 and October 2022; Banxico.
Note: The figure only considers credits in local currency. The CNBV's latest Information Portfolio does not provide interest rate data at the sector level. To estimate the interest rates charged to firms by sector, the spread between (1) the monetary policy rate from December 2016 and (2) the weighted average interest rate charged by commercial and development banks by sector in December 2016 (the latest year for which the CNBV's previous information portfolio offers data), was calculated. By maintaining the spread constant for each sector, the interest rates for October 2022 were estimated using the monetary policy rate from October 2022 (the latest month for which the CNBV's latest portfolio provides data). Development banking institutions, which include Nafin, Bancomext, and Banobras, had no reported interest rates for the sectors of education, textiles, footwear, and banking services. CNBV = *Comisión Nacional Bancaria y de Valores*.

FIGURE E.3

Interest Rates Paid by Enterprises in Various Industries by Size, October 2022

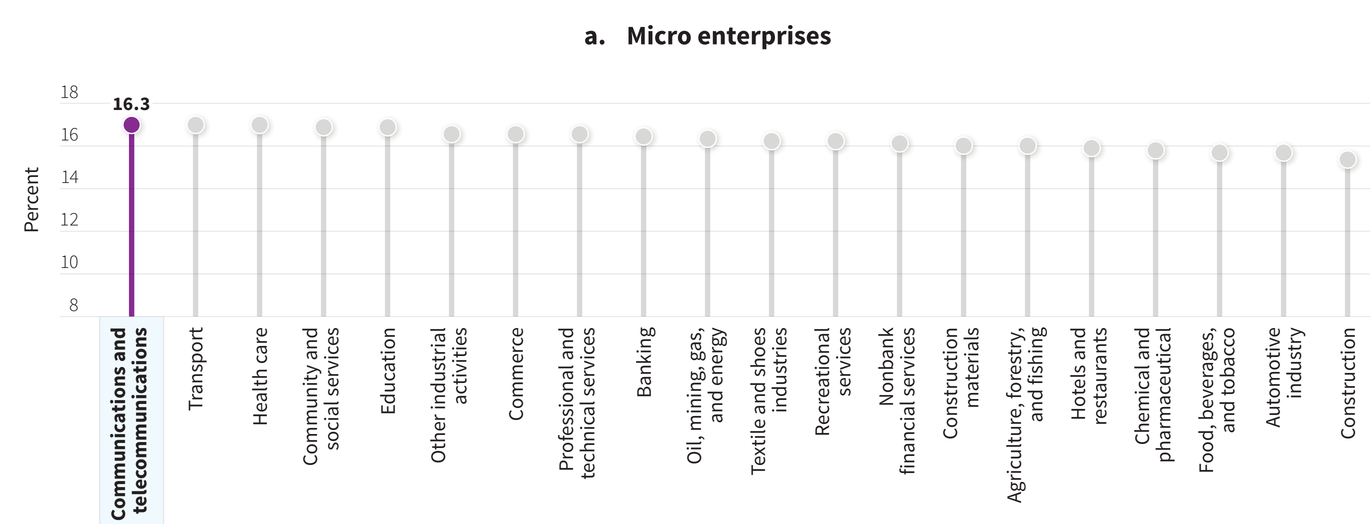


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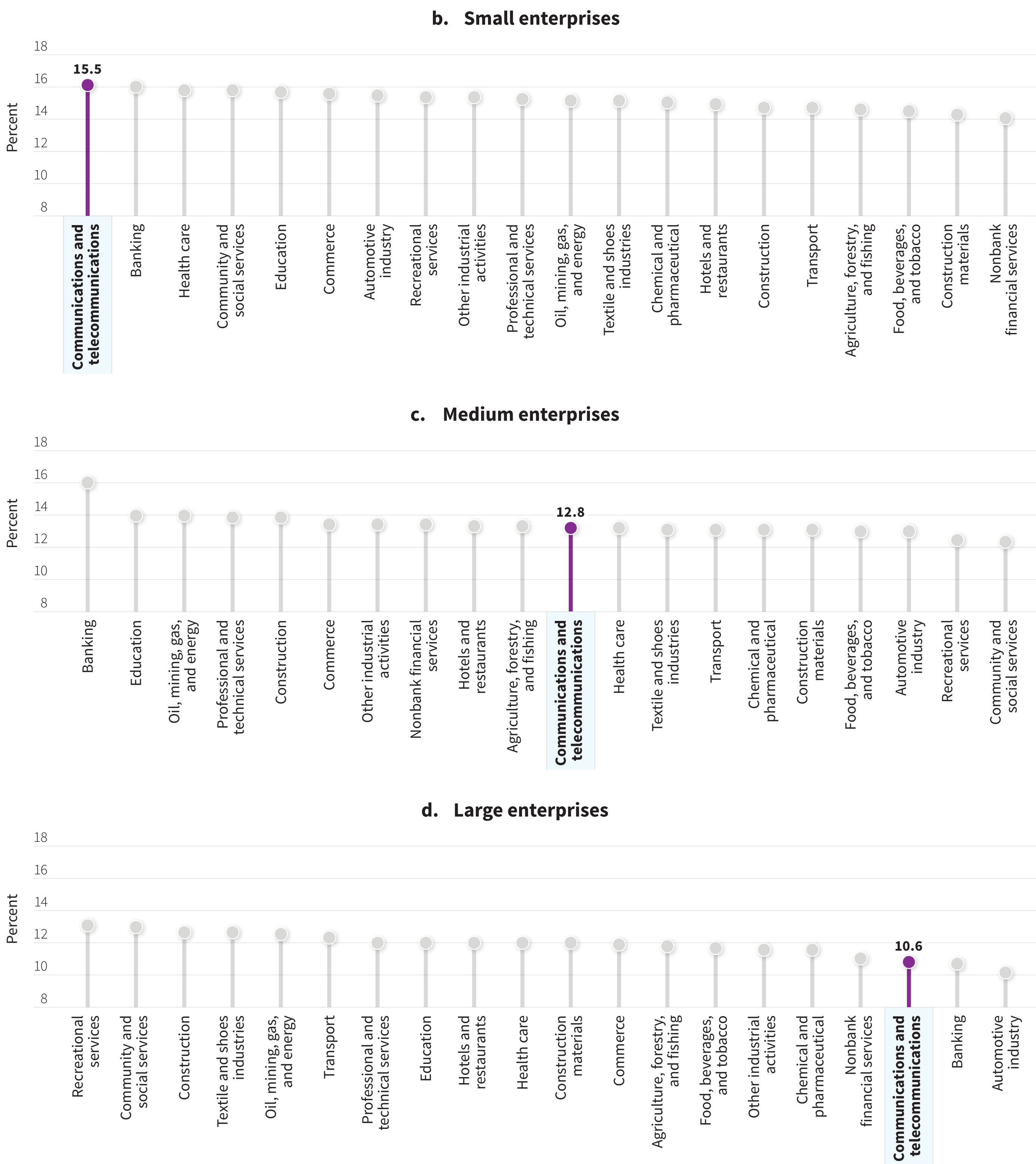
FIGURE E.3

Interest Rates Paid by Enterprises in Various Industries by Size, October 2022 *(continued)*



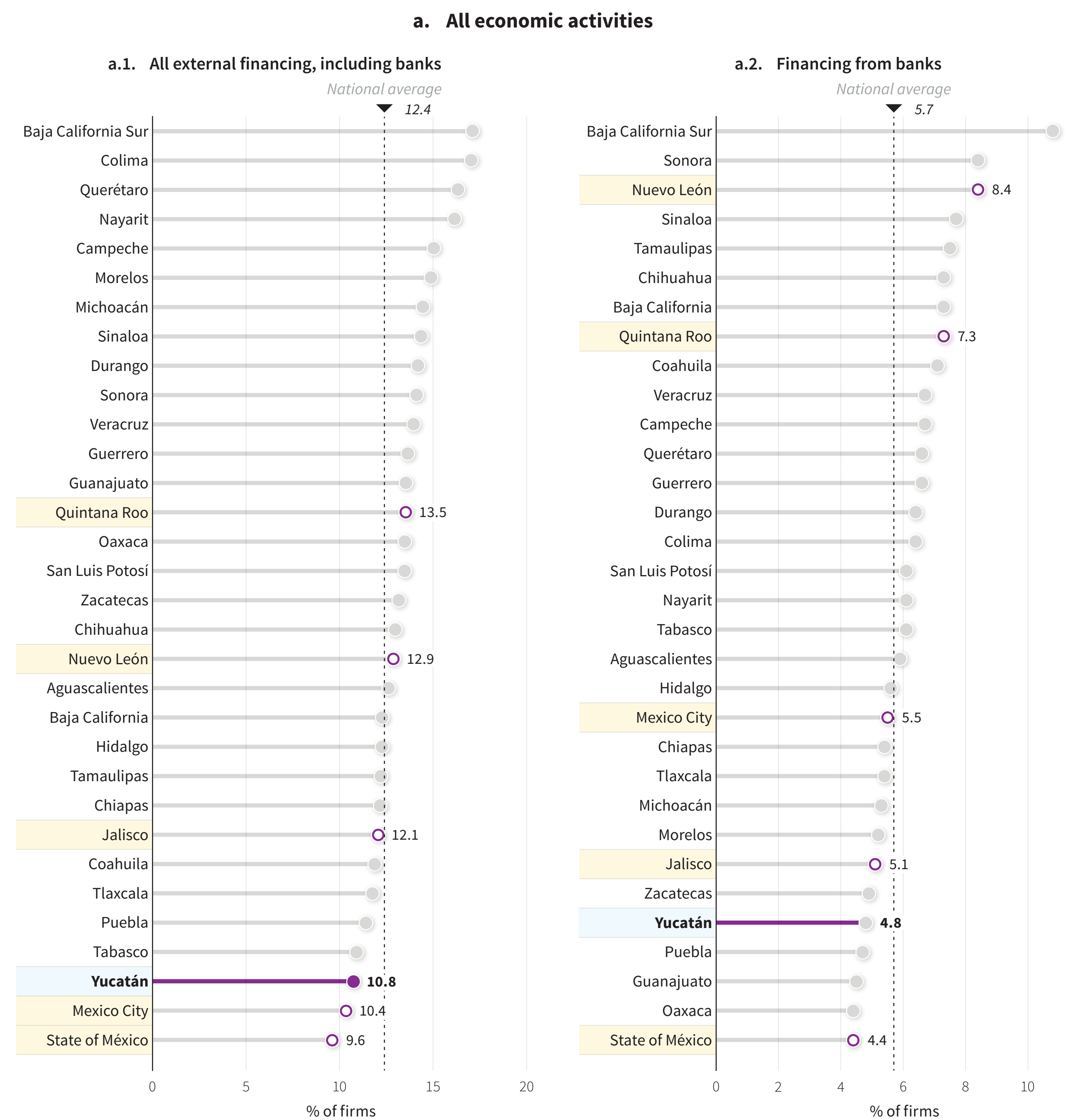
Source: Based on data from CNBV's *Portafolio de Información* (Information Portfolio) for December 2016 and October 2022; Banxico.

Note: The figure only considers credits in local currency. The CNBV's latest Information Portfolio does not provide interest rate data at the sector level. To estimate the interest rates charged to firms by sector, the spread between (1) the monetary policy rate from December 2016 and (2) the weighted average interest rate charged by commercial and development banks by sector in December 2016 (the latest year for which the CNBV's previous information portfolio offers data), was calculated. By maintaining the spread constant for each sector, the interest rates for October 2022 were estimated using the monetary policy rate from October 2022 (the latest month for which the CNBV's latest portfolio provides data). Development banking institutions, which include Nafin, Bancomext, and Banobras, had no reported interest rates for the sectors of education, textiles, footwear, and banking services. CNBV = *Comisión Nacional Bancaria y de Valores*.

nancial sources appears to be more balanced, in general and from banks alone. Approximately 8.1 percent of firms in ICT services reported having access to external finance (higher than Mexico City, Nuevo León, and the State of México), and 4.2 percent of firms reported having access to finance from banks (higher than Jalisco, Mexico City, and the State of México). In this regard, firms pro-

FIGURE E.4

Firms' Access to External Financing, State Comparison, 2018



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viding ICT-related services seem to have some degree of access to finance, despite the low financial penetration and high interest rates in the state.

Next, the utilization of external financing by enterprises in ICT manufacturing activities is analyzed. The findings are similar to the previous for ICT manufacturing (figure E.5). Only one firm in this segment reported having access

FIGURE E.4

Firms' Access to External Financing, State Comparison, 2018 *(continued)*

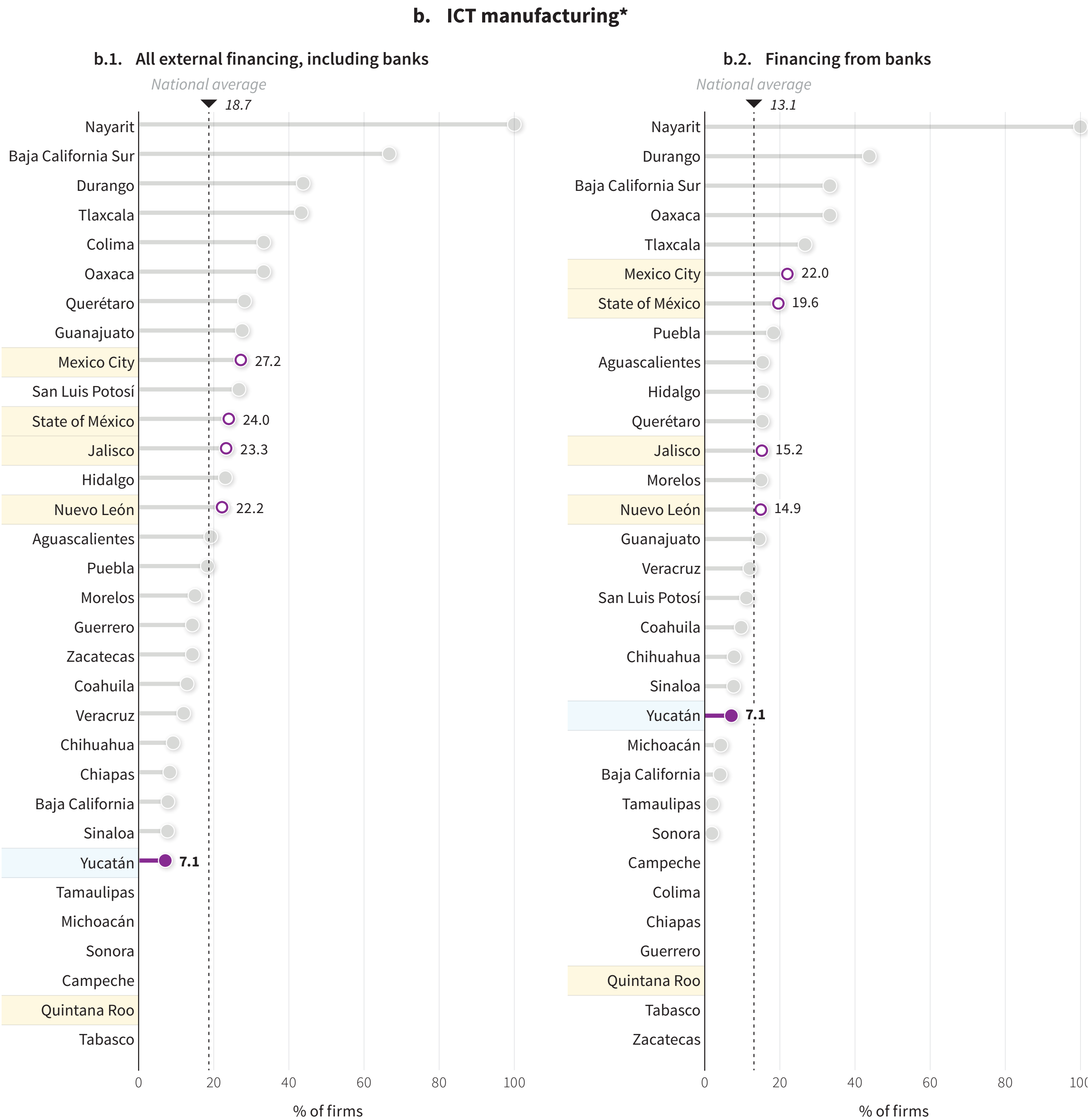

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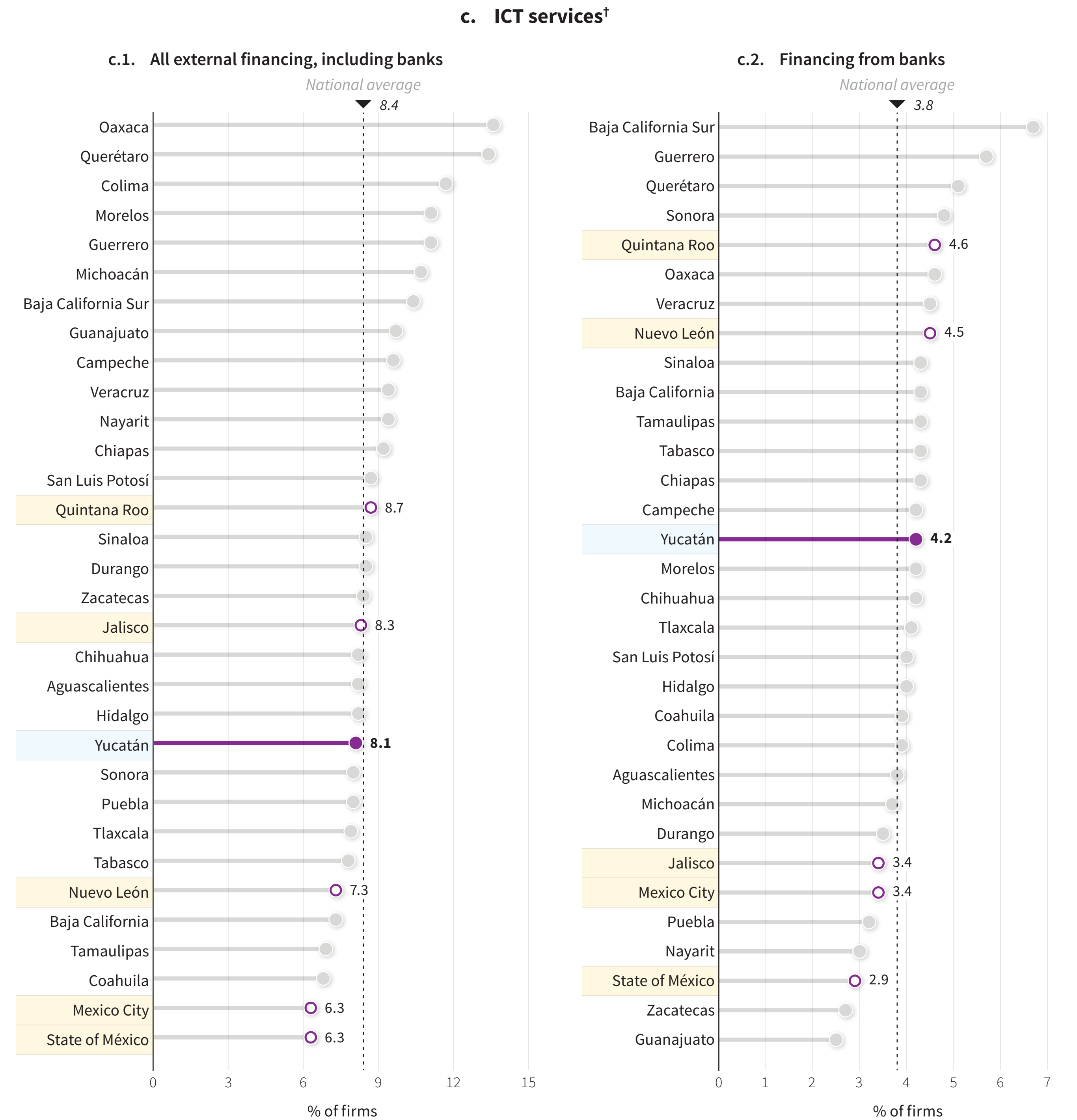
FIGURE E.4

Firms' Access to External Financing, State Comparison, 2018 *(continued)*



Source: INEGI 2019.

Note: ICT = information and communication technology; NAICS = North American Industry Classification System. The level of disaggregation in INEGI's 2019 Economic Census was limited to three digits in the NAICS classification. Highlighted in yellow are leading ICT states in the country.

*ICT manufacturing activities refer to computer and electronic product manufacturing (NAICS three-digit code 334) and electrical equipment, appliance, and component manufacturing (335).

†ICT services refer to telecommunications (517), data processing, hosting, and related services (518), and repair and maintenance (811).

FIGURE E.5

ICT Manufacturing Firms' Use of Financial Resources, State Comparison, 2018

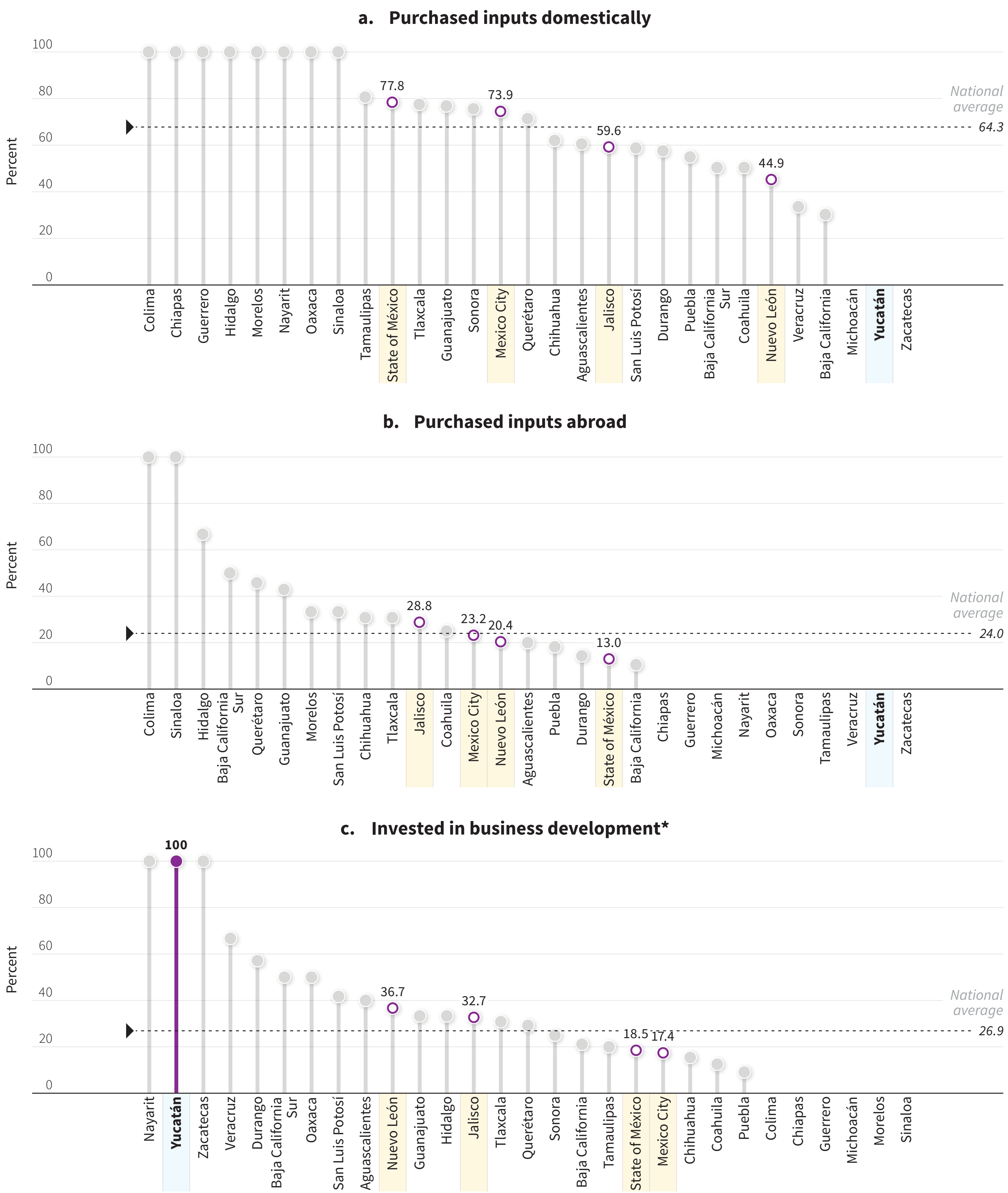


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FIGURE E.5

ICT Manufacturing Firms' Use of Financial Resources, State Comparison, 2018 *(continued)*

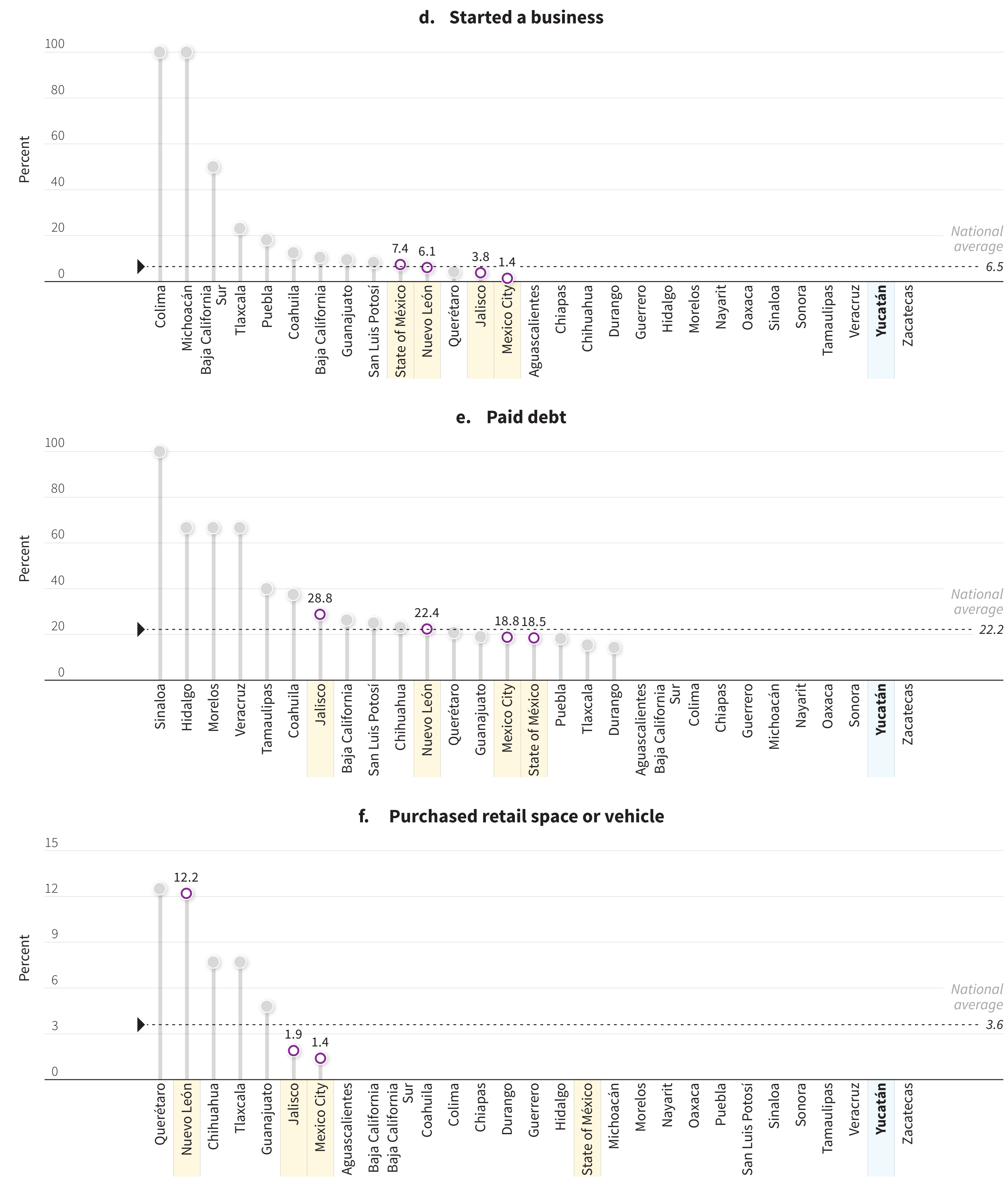

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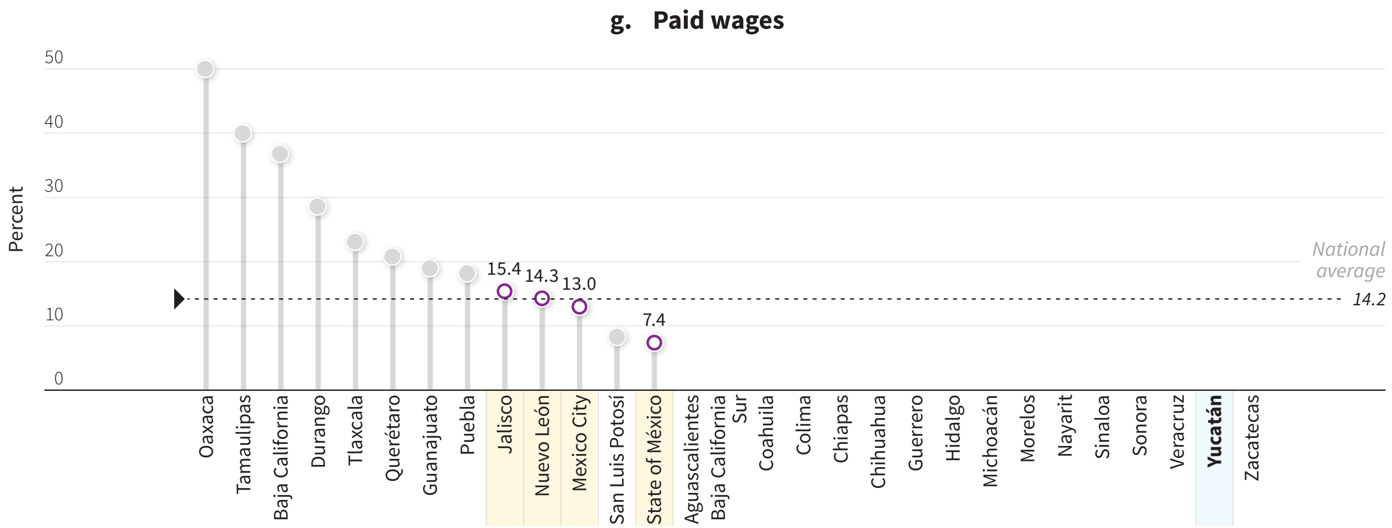
FIGURE E.5

ICT Manufacturing Firms' Use of Financial Resources, State Comparison, 2018 *(continued)*



Source: NEGI 2019.
Note: ICT = information and communication technology. Highlighted in yellow are leading ICT states in the country.
*Refers to equipment purchases or business expansion.

to external finance, and that firm invested the funds for business development. Therefore, the low access to finance of ICT manufacturing firms, combined with Yucatán's low financial penetration and high interest rates, poses a reason for concern. Notably, for firms in the leading ICT states, the highest proportion was seen in purchasing inputs domestically, suggesting that loans and credits from suppliers may be a key factor for developing manufacturing-related ICT activities.

As for ICT services firms, those in Yucatán and in the leading ICT states utilize borrowed resources in similar ways (figure E.6). However, a clear trend is that, on average, firms in Yucatán are less likely to use borrowed resources for purchasing inputs abroad. Nevertheless, the difference does not seem large enough to raise concerns. The highest reported proportion for purchasing inputs abroad is 3.9 percent, while Yucatán reports 1.1 percent.

In summary, access to finance is a binding constraint for the development of the ICT sector in Yucatán because of the low financial services penetration and high interest rates charged to firms in this sector by commercial and development banks. The constraint could be more severe in the ICT manufacturing by domestic firms. Although the constraint is less severe for ICT services, the low financial penetration in Yucatán and high interest rates could still be a problem for further development of the sector, particularly considering their intangible nature and lower availability of assets to be used as collateral.

FIGURE E.6

ICT Services Firms' Use of Financial Resources, State Comparison, 2018

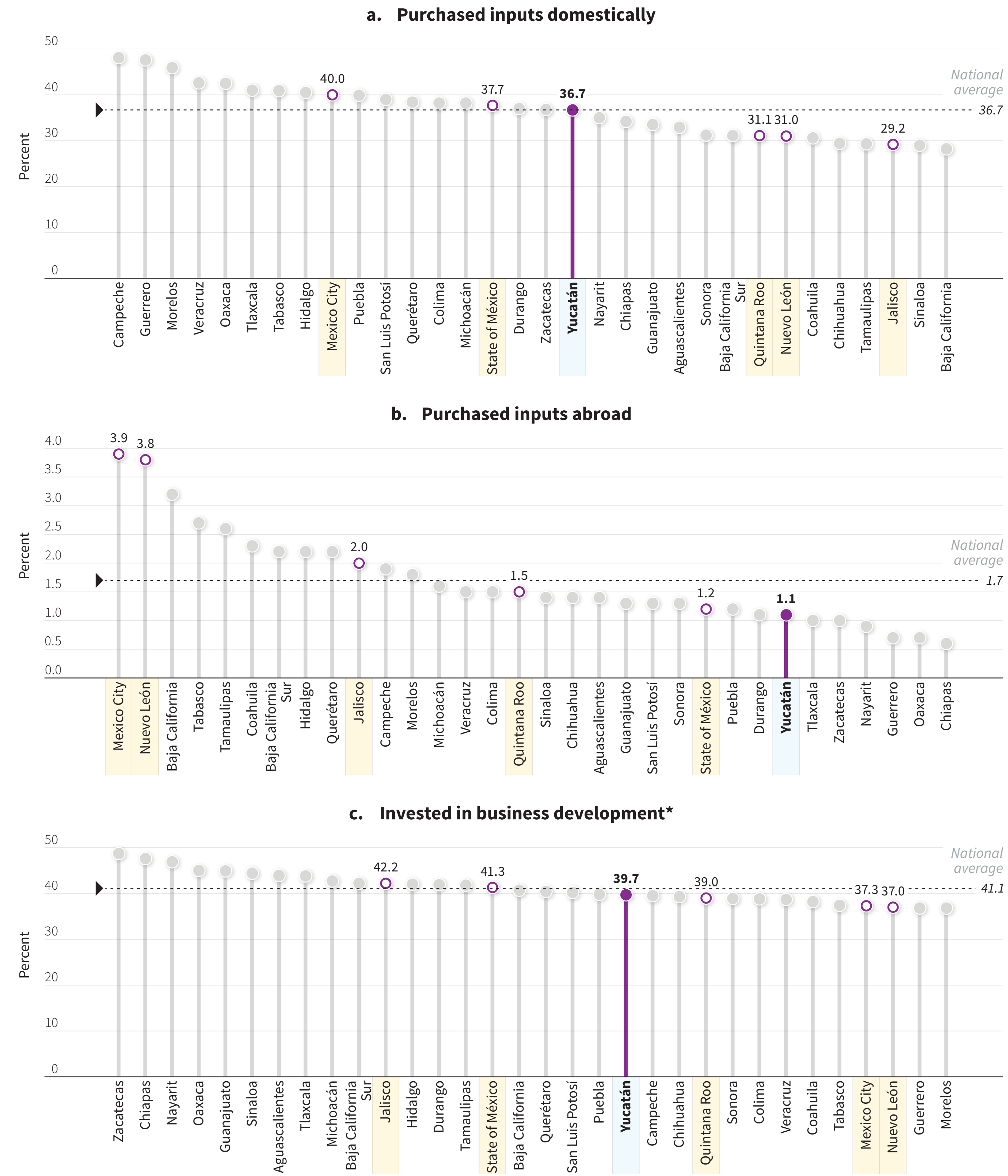


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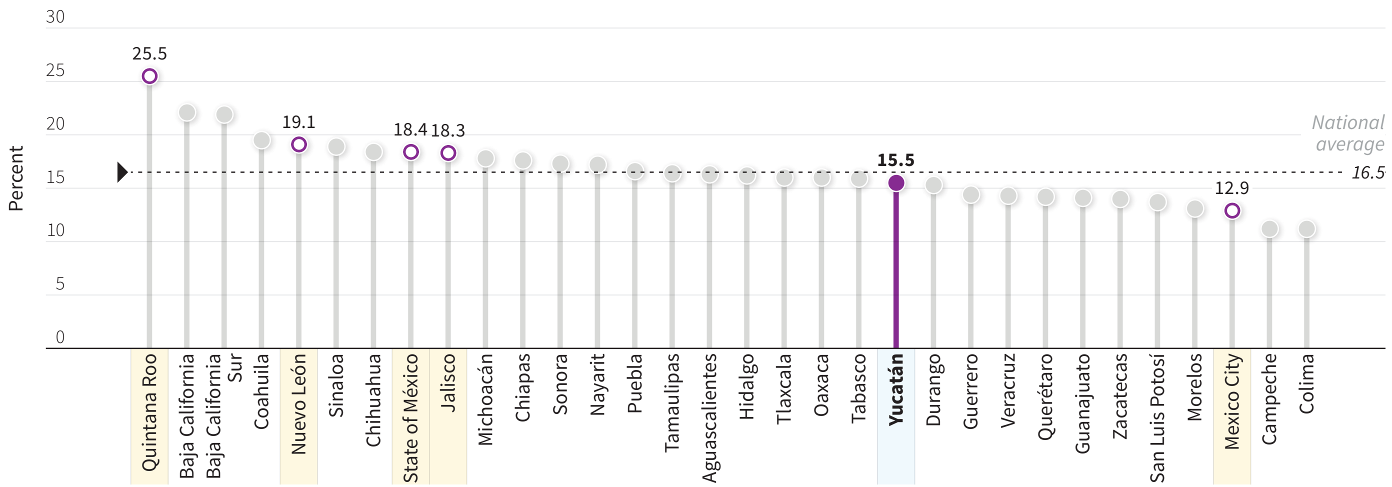
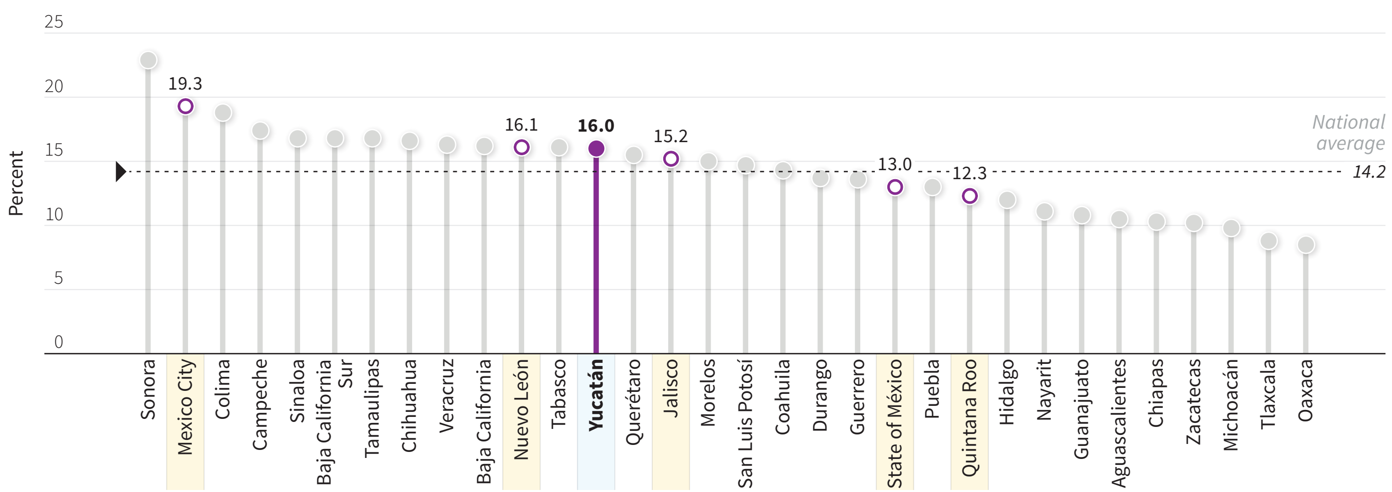
FIGURE E.6

ICT Services Firms' Use of Financial Resources, State Comparison, 2018 *(continued)*

d. Started a business



e. Paid debt



f. Purchased retail space or vehicle

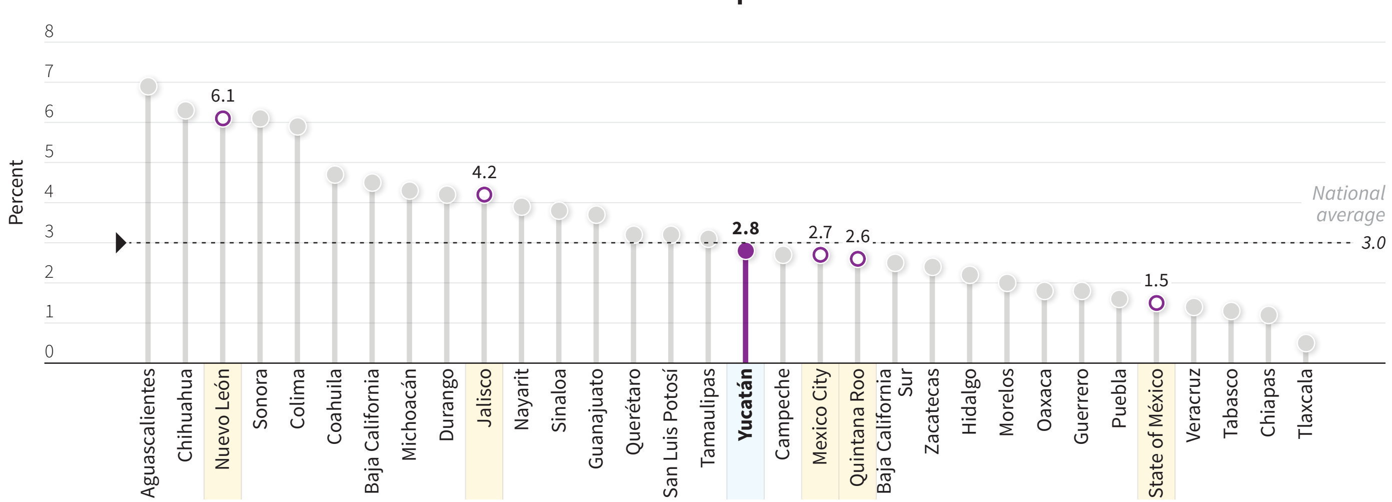


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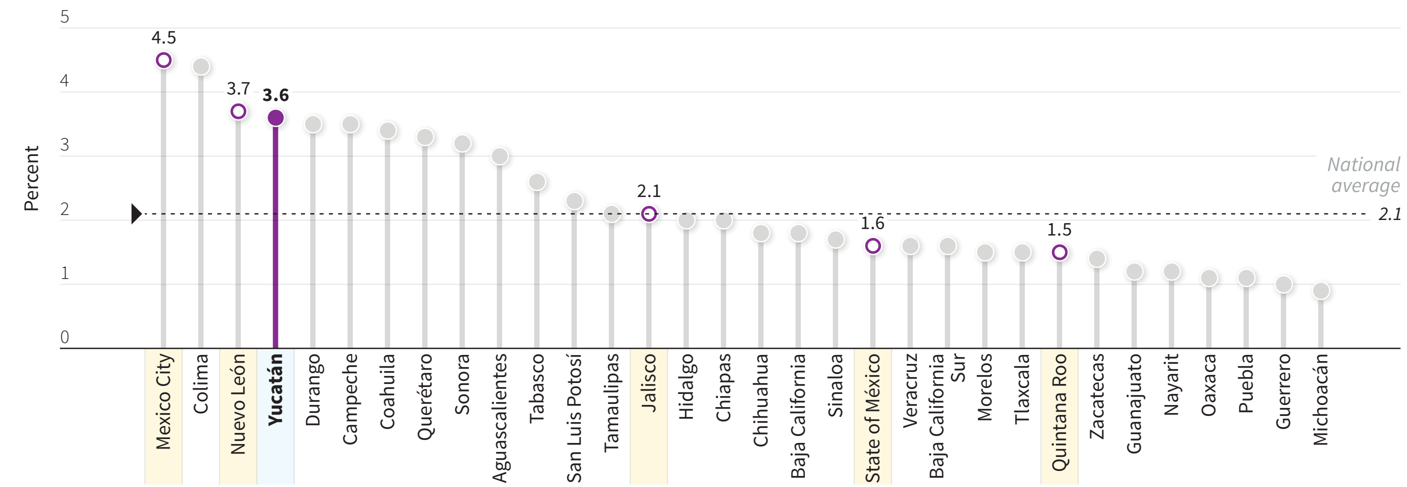
FIGURE E.6

ICT Services Firms' Use of Financial Resources, State Comparison, 2018 *(continued)*

g. Paid wages



Source: INEGI 2019.
Note: ICT = information and communication technology. Highlighted in yellow are leading ICT states in the country.
*Refers to equipment purchases or business expansion.

APPENDIX F

Identification of Potential Locations

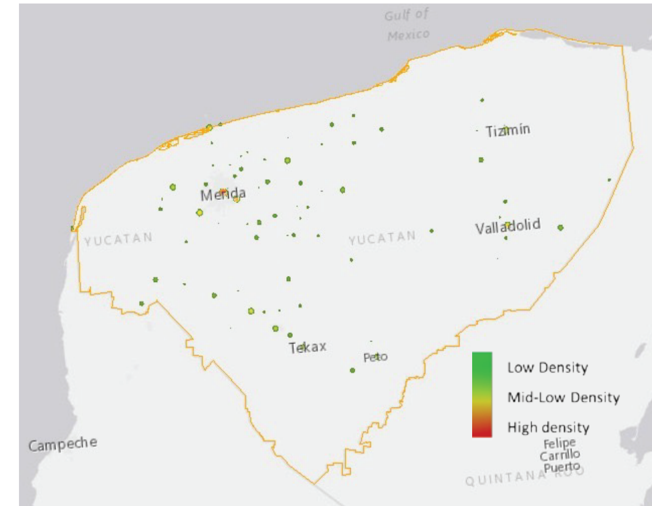
The following three dimensions were used to assess potential locations for the development of the information and communication technology (ICT) sector in Yucatán.

1. Regions with the highest population density[101] within the state: Mérida, along with its surrounding municipalities, exhibits the highest population density in the state. The coastal city of Progreso, situated in the north of Mérida, also shows significant population density. In the southern part of the state, Ticul has the highest population density, while Valladolid holds this characteristic in the eastern part. The remaining municipalities generally have a moderate to low population density, especially in the northeastern part of the state (maps F.1 and F.2).

2. Access to transport, energy (electricity), and telecommunications infrastructure: The primary road network in the state enables connection between the city of Mérida and other significant cities, such as Progreso in the north, Valladolid in the east, Tizimín in the northeast, and Ticul in the south. Similarly, the railway line connects Campeche to Mérida and navigates to Valladolid. In terms of transmission lines, they form a circuit that spans from Mérida, Tizimín, Valladolid, to Ticul. Multiple operators, including América Móvil, the *Comisión Federal de Electricidad* (Federal Electricity Commission), and Izzi Telecom, provide optical fiber connections that originate from Campeche and primarily serving Mérida, Tizimín, and Valladolid, extending all the way to Cancun. Regarding internet availability with 4G (fourth-generation) networks, Mérida and Valladolid have the highest coverage in the state (map F.3).

MAP F.1

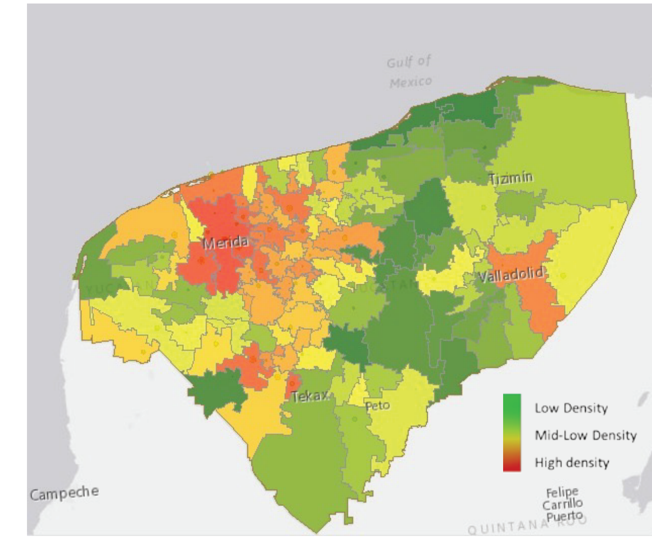
Population Density in Yucatán by Town, 2010



Source: World Bank Group staff, calculated in ARCGIS with information of the Census 2010, INEGI.
Note: Density is calculated as a kernel density model with the population by village in the state. Colors are calculated by quartile. Villages with the lowest density were put in blank to have a tidier visualization of the model.

MAP F.2

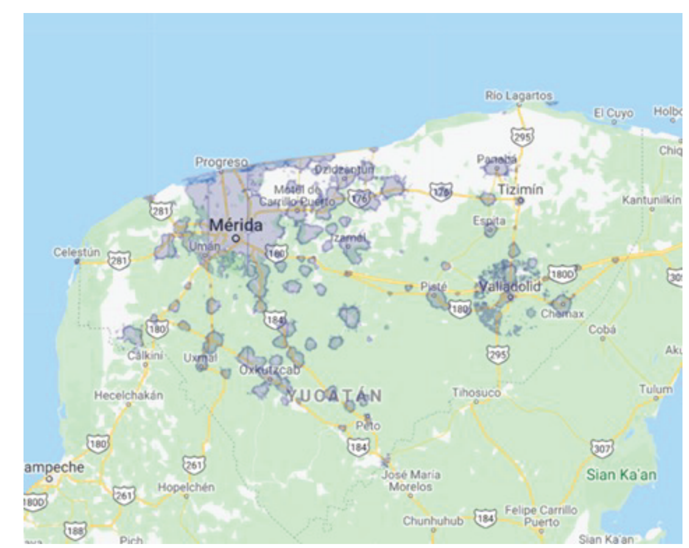
Population Density in Yucatán by Municipality, 2010



Source: World Bank Group staff, calculated in ARCGIS with information of the Census 2010, INEGI.
Note: Density is calculated as population divided by extension of municipalities in square kilometers.

MAP F.3

4G Coverage in Yucatán (América Móvil and Movistar Only)



Source: Based on IFT's *Mapas de Cobertura Móvil* database.
Note: América Móvil and Movistar are the companies with the highest coverage in 4G technology in the state.

3 Table F.1 lists existing education and innovation and ICT-related centers in the state. Out of 121 higher education institutions in the state, 12 are public academic and research institutions that are associated with the *Sistema de Investigación, Innovación y Desarrollo Tecnológico del Estado de Yucatán* (SIIDETEY). There are also 25 higher education institutions that offer at least one education program focusing on the ICT industry (table F.2). Additionally, there are two industrial innovation centers in the state, which were funded and developed through Prosoft (*Programa para el Desarrollo de la Industria de Software*) of the *Secretaría de Economía* (Secretariat of Economy). One of these innovation centers is on the parcel of land that originally was designated as a special economic zone (SEZ) in 2017. Despite the abrogation of the SEZ decree in 2019, the current state administration planned to provide alternative incentives to foster the development of the ICT sector.[102] Moreover, the strategic location of the land close to the port of Progreso and the city of Mérida, along with last-mile infrastructure such as a four-lane road and earthworks, makes it attractive for investment opportunities.[103]

TABLE F.1

Academic and Industrial Innovation Centers in Yucatán

	Institution	Responsible institution	Location
	Academic institutions affiliated with the SIIDETEY		
1	Centro de Investigación Científica de Yucatán	Civil association	Mérida
2	Centro de Investigación y Estudios Avanzados, Unidad Mérida	Instituto Politécnico Nacional	Mérida
3	Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, Unidad Sureste	Government of Jalisco	Mérida
4	Unidad Peninsular del Centro de Investigaciones y Estudios Superiores en Antropología Social	Federal government: CONACYT	Mérida
5	Universidad Autónoma de Yucatán, Ingeniería y Matemáticas	Government of Yucatán	Mérida
6	Unidad Multidisciplinaria de Docencia e Investigación de Sisal	UNAM	Sisal
7	Centro Peninsular en Humanidades y Ciencias Sociales	UNAM	Mérida
8	Universidad Tecnológica Metropolitana	Government of Yucatán	Mérida
9	Instituto Tecnológico de Conkal	Federal government: SEP	Mérida
10	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias	Federal government: SADER	Conkal
11	Instituto Tecnológico de Mérida	Federal government: SEP	Mérida
12	Universidad Anáhuac Mayab*	Private	Mérida
	Institutions with ICT-related programs		
13	Centro de Estudios Superiores Francisco de Montejo	Civil association	Valladolid
14	Centro de Estudios Superiores Miguel Alemán Valdés	Civil association	Mérida
15	Instituto Compax	Private	Mérida
16	Instituto de Educación Superior Excelencia y Humanismo	Private	Dzidzantún
17	Instituto de Educación Superior Excelencia y Humanismo Campus Izamal	Civil association	Izamal
18	Instituto de Estudios Superiores Lux	Civil association	Mérida
19	Instituto Ingenihum Soft	Civil association	Mérida
20	Instituto Tecnológico del Petróleo y Energía	Private	Mérida
21	Instituto Tecnológico Superior de Motul	Federal government: SEP	Motul
22	Instituto Tecnológico Superior de Valladolid	Federal government: SEP	Valladolid
23	Instituto Tecnológico Superior del Sur del Estado de Yucatán	Federal government: SEP	Oxkutzcab
24	Instituto Tecnológico Superior Progreso	Federal government: SEP	Progreso
25	Universidad del Valle de México, Campus Mérida	Private	Mérida
26	Universidad Interamericana del Norte, Campus Mérida	Private	Mérida
27	Universidad Latino	Private	Mérida
28	Universidad Marista de Mérida	Civil association	Mérida
29	Universidad Mesoamericana de San Agustín	Civil association	Mérida
30	Universidad Modelo	Private	Mérida
31	Universidad Politécnica de Yucatán	Government of Yucatán	Mérida
32	Universidad Privada de la Península	Private	Mérida
33	Universidad Privada de la Península, Plantel Tekax	Private	Tekax
34	Universidad Tecnológica del Centro	Federal government: SEP	Izamal
35	Universidad Tecnológica del Mayab	Federal government: SEP	Peto
36	Universidad Tecnológica del Poniente	Federal government: SEP	Maxcanu
37	Universidad Tecnológica Regional del Sur	Federal government: SEP	Tekax
	Industrial innovation centers		
1	Centro de Innovación Industrial de Ingeniería en Inteligencia Artificial	Government of Yucatán	Mérida
2	Centro de Innovación Industrial en Ciencia de Datos	Government of Yucatán	Progreso
	Other		
1	Parque Científico Tecnológico de Yucatán	Government of Yucatán	Mérida
2	Central Business Park†	...	Mérida

Sources: Based on information from SC's *Sistema de Información Cultural* platform; SIIES n.d.; SIIDETEY n.d.; Prosoft n.d.
Note: CONACYT = *Consejo Nacional de Ciencia y Tecnología* (National Council of Science and Technology); SADER = *Secretaría de Agricultura y Desarrollo Rural* (Secretariat of Agriculture and Rural Development); SEP = *Secretaría de Educación Pública* (Secretariat of Public Education); SIIDETEY = *Sistema de Investigación, Innovación y Desarrollo Tecnológico del Estado de Yucatán*; UNAM = *Universidad Nacional Autónoma de México*.
*The university established an affiliation with the SIIDETEY in 2017, see https://merida.anahuac.mx/noticias/ingreso-al-sistema-de-investigacion-innovacion-y-desarrollo-tecnologico-de-yucatan.
†Communications technologies is among industries the park is hosting, see https://cbpark.com.mx/central-business-park/.

TABLE F.2

Offer of Institutions for Higher Education in the State of Yucatán

	Academic institution	SIIDETEY member	ICT-related programs	Other programs
1	Centro de Investigación Científica de Yucatán	✓		
2	Centro de Investigación y Estudios Avanzados, Unidad Mérida	✓		
3	Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, Unidad Sureste	✓		
4	Unidad Peninsular del Centro de Investigaciones y Estudios Superiores en Antropología Social	✓		
5	Universidad Autónoma de Yucatán, Ingeniería y Matemáticas	✓		
6	Unidad Multidisciplinaria de Docencia e Investigación de Sisal	✓		
7	Centro Peninsular en Humanidades y Ciencias Sociales	✓		
8	Universidad Tecnológica Metropolitana	✓		
9	Instituto Tecnológico de Conkal, Yucatán	✓		

(Table continues next page)

TABLE F.2

Offer of Institutions for Higher Education in the State of Yucatán *(continued)*

	Academic institution	SIIDETEY member	ICT-related programs	Other programs
10	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias	✓		
11	Instituto Tecnológico de Mérida	✓		
12	Universidad Anáhuac Mayab	✓		
13	Centro de Estudios Superiores Francisco de Montejo		✓	
14	Centro de Estudios Superiores Miguel Alemán Valdés		✓	
15	Instituto Compax		✓	
16	Instituto de Educación Superior Excelencia y Humanismo		✓	
17	Instituto de Educación Superior Excelencia y Humanismo Campus Izamal		✓	
18	Instituto de Estudios Superiores Lux		✓	
19	Instituto Ingenihum Soft		✓	
20	Instituto Tecnológico del Petróleo y Energía		✓	
21	Instituto Tecnológico Superior de Motul		✓	
22	Instituto Tecnológico Superior de Valladolid		✓	
23	Instituto Tecnológico Superior del Sur del Estado de Yucatán		✓	
24	Instituto Tecnológico Superior Progreso		✓	
25	Universidad del Valle de México, Campus Mérida		✓	
26	Universidad Interamericana del Norte, Campus Mérida		✓	
27	Universidad Latino		✓	
28	Universidad Marista de Mérida		✓	
29	Universidad Mesoamericana de San Agustín		✓	
30	Universidad Modelo		✓	
31	Universidad Politécnica de Yucatán		✓	
32	Universidad Privada de la Península		✓	
33	Universidad Privada de la Península, Plantel Tekax		✓	
34	Universidad Tecnológica del Centro		✓	
35	Universidad Tecnológica del Mayab		✓	
36	Universidad Tecnológica del Poniente		✓	
37	Universidad Tecnológica Regional del Sur		✓	
38	Centro de Estudios de las Américas, A.C.			✓
39	Centro de Estudios de Posgrado, Campus Mérida			✓
40	Centro de Estudios Superiores Justo Sierra O´Reilly			✓
41	Centro Regional Universitario Península de Yucatán			✓
42	Centro Universitario Interamericano			✓
43	Centro Universitario República de México			✓
44	Escuela Bancaria y Comercial, Campus Mérida			✓
45	Escuena Nacional de Estudios Superiores, Campus Mérida			✓
46	Instituto de Especialización para Ejecutivos, Plantel Mérida			✓
47	Instituto Universitario Eloísa Patrón de Rosado			✓
48	Universidad Aliat, Campus Mérida			✓
49	Universidad de Valladolid Yucatán			✓
50	Universidad Humanitas, Campus Mérida			✓
51	Universidad Latinoamericana, Campus Mérida			✓
52	Universidad Santander, Sede Mérida			✓

(Table continues next page)

TABLE F.2

Offer of Institutions for Higher Education in the State of Yucatán *(continued)*

	Academic institution	SIIDETEY member	ICT-related programs	Other programs
53	Universidad TecMilenio, Campus Mérida			✓
54	Academia de Ciencias Sociales y Desarrollo Humano Acanits			✓
55	Academia Internacional de Yucatán			✓
56	Centro de Estudios David Alfaro Siqueiros			✓
57	Centro de Estudios de las Américas			✓
58	Centro de Estudios Superiores de Yucatán			✓
59	Centro de Estudios Superiores del Sureste			✓
60	Centro de Estudios Superiores en Sexualidad			✓
61	Centro de Estudios Superiores San Jorge			✓
62	Centro de Estudios Superiores Zaci			✓
63	Centro de Estudios, Clínica e Investigación Psicológica			✓
64	Centro de Formación Profesional de Yucatán			✓
65	Centro Educacional Evelio González Montalvo			✓
66	Centro Educativo Coreamex			✓
67	Centro Educativo José Dolores Rodríguez Tamayo			✓
68	Centro Educativo José Dolores Rodríguez Tamayo, Campus Mérida			✓
69	Centro Educativo República de México			✓
70	Centro Educativo Santander			✓
71	Centro Escolar Felipe Carrillo Puerto			✓
72	Centro Universitario Interamericano			✓
73	Centro Universitario Siglo XXI			✓
74	Colegio de Estudios Universitarios del Mayab			✓
75	Colegio de Gastronomía del Sureste			✓
76	Colegio de Negocios Internacionales			✓
77	Colegio Libre de Estudios Universitarios			✓
78	Colegio San Agustín			✓
79	Escuela Culinaria del Sureste			✓
80	Escuela de Negocios de Yucatán			✓
81	Escuela de Turismo Tecnología Turística Total			✓
82	Escuela de Vuelo Ifly			✓
83	Escuela Ignacio Comonfort			✓
84	Escuela Internacional de Chefs			✓
85	Escuela Judicial del Poder Judicial del Estado de Yucatán			✓
86	Escuela Peninsular de Lenguas Modernas			✓
87	Escuela Rafael Ramírez Castañeda			✓
88	Escuela Superior Turístico Administrativa			✓
89	Estudios de Postgrado de Excelencia			✓
90	Instituto Comercial Bancarios			✓
91	Instituto Culinario de Yucatán			✓
92	Instituto de Ciencias Humanas			✓
93	Instituto de Enseñanza Tributaria			✓
94	Instituto de Especialidades Estomatológicas			✓
95	Instituto de Estudios de la Comunicación de Yucatán			✓

(Table continues next page)

TABLE F.2

Offer of Institutions for Higher Education in the State of Yucatán *(continued)*

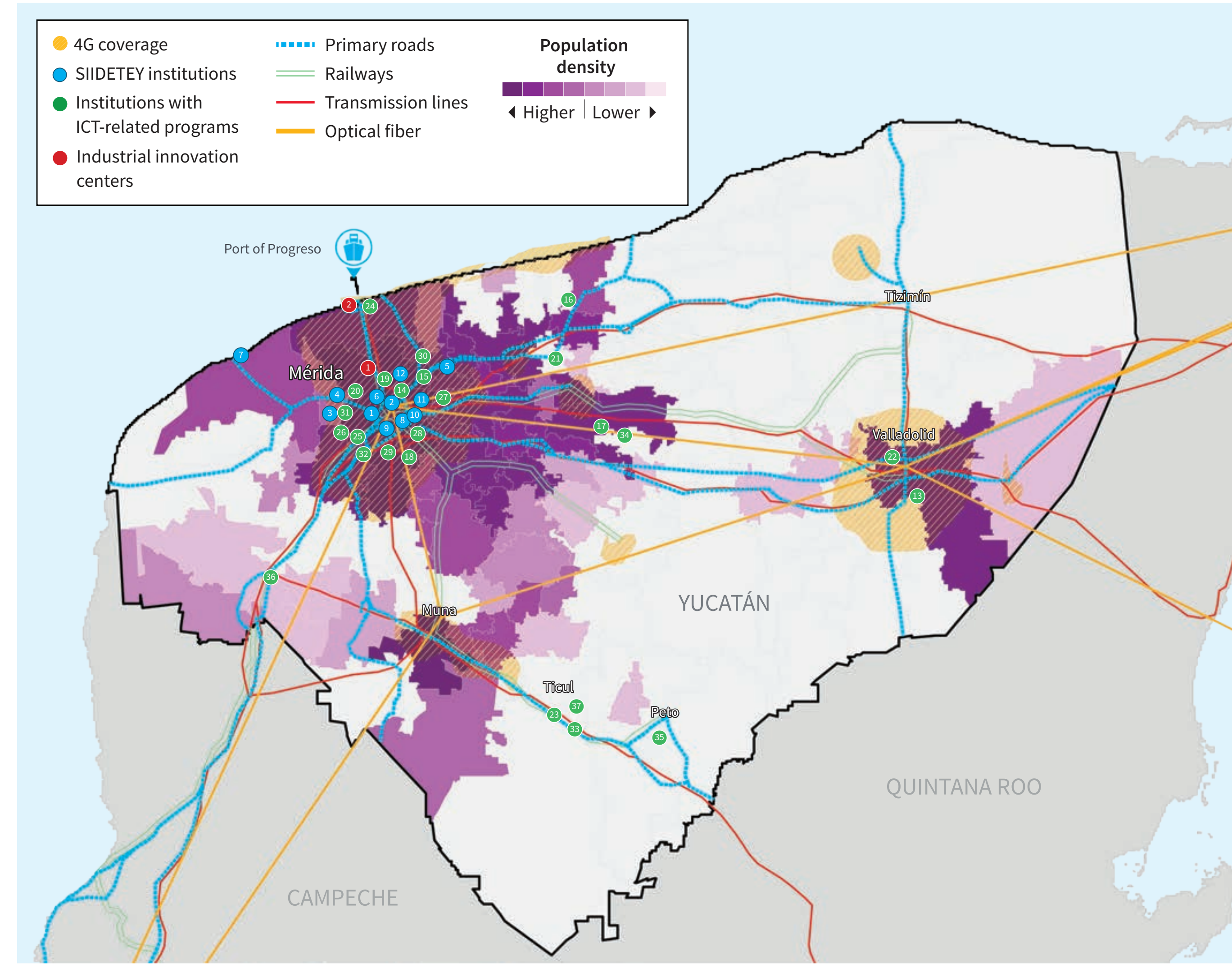
	Academic institution	SIIDETEY member	ICT-related programs	Other programs
96	Instituto de Estudios de Posgrado en Ciencias y Humanidades			✓
97	Instituto de Estudios Superiores de Motul			✓
98	Instituto de Estudios Superiores las Américas			✓
99	Instituto de Estudios Superiores las Américas, Plantel Santa Ana			✓
100	Instituto de Estudios Superiores Yucatán			✓
101	Instituto de Investigación y Formación en Educación			✓
102	Instituto de Investigación, Docencia y Análisis de Política Pública			✓
103	Instituto Eloisa Patrón de Rosado			✓
104	Instituto Gastronómico de Mérida			✓
105	Instituto Generador de Negocios Internacionales			✓
106	Instituto Interamericano de la Salud			✓
107	Instituto Internacional de Gobierno Corporativo y Mejores Prácticas			✓
108	Instituto Kanankil			✓
109	Instituto Megamedia			✓
110	Instituto Panamericano de Estudios Superiores			✓
111	Instituto Ramón López Velarde			✓
112	Instituto Superior José Vasconcelos			✓
113	Instituto Superior Rubén Darío Herrera			✓
114	Instituto Universitario de Yucatán			✓
115	Instituto Universitario del Sureste			✓
116	Instituto Universitario Patria			✓
117	Servicios Educativos en Salud			✓
118	Universidad Interamericana para el Desarrollo Campus Francisco de Montejo			✓
119	Universidad Interamericana para el Desarrollo, Campus Mérida			✓
120	Universidad Modelo Valladolid			✓
121	Universidad Vizcaya de las Américas			✓

Sources: Based on information from SC's *Sistema de Información Cultural platform*; SIIES n.d.; SIIDETEY n.d.; Prosoft n.d.
Note: ICT = information and communication technology.

Map F.4 illustrates a convergence of the three dimensions primarily centered around the city of Mérida and its surrounding regions. This area exhibits the highest population density in the state and holds the highest telecommunication infrastructure capacity. Mérida serves as the hub for optical fibers connections, allowing full internet coverage across the entire region. The city also has a short connection to other points of the state, such as Progreso, Ticul, Tizimín, and Valladolid, through the primary roads. Additionally, out of the 11 academic institutions associated with the SIIDETEY, nine are located in Mérida and Progreso, one is in the coastal municipality of Chuburná, and another in Uxmal. Industrial innovation centers are also strategically situated in Mérida and between the city and Progreso.

MAP F.4

Dimensions Considered for Potential Locations of ICT Sector in Yucatán



Source: Base map for primary roads, railways, ports and transmission lines was elaborated using ArgGIS with shapefiles from the INEGI's *Biblioteca digital de Mapas* 2019 edition and optical fiber location was according to Bestel n.d.
Note: 4G = fourth generation; ICT = information and communication technology; SIIDETEY = *Sistema de Investigación, Innovación y Desarrollo Tecnológico del Estado de Yucatán*. The industrial innovation centers in Progreso have approximate locations because of limited specific information. The symbols used are for representation purposes only. The locations for optical fiber, 4G coverage, and research centers are also approximations. For the corresponding SIIDETEY institutions, institutions with ICT-related programs, and industrial innovation centers, see table F.1 in this appendix.

APPENDIX G
Potential Investors

A list of potential investors for the information and communication technology (ICT) sector at the national level are presented in table G.1. These firms were identified either based on their intention to invest at the national level or their documented interest in previous studies regarding the state of Yucatán.[104]

Furthermore, there is a notable interest from Chinese companies to invest in the country. According to the *Cámara de Comercio y Tecnología México-China*, on a monthly basis, up to 10 Chinese firms seek information about establishing operations in Mexico. Out of these, three to four companies ultimately proceed with investments in the country,[105] including firms dedicated to the ICT sector.

Additionally, there is growing interest from companies and start-ups based in prominent technology hubs such as the "Silicon Valley" in California to establish their operations in countries like Mexico.[106] Various entities provide support for funding these endeavors.[107] Identifying these start-ups and companies will be crucial to attract such investments to the state of Yucatán.

Three local firms in Yucatán have been identified based on their significant job creation, each employing at least 101 individuals. These firms operate in the manufacturing component of the ICT sector. These firms confirm the viability of this component in the state (table G.2).

In 2019, Elecnor Deimos, a Spanish firm, made a significant commitment to invest US$130 million in establishing a technological center focused on satellite and space technology. This center, set to be the first of its kind in Mexico, would play a crucial role in supporting the development of a satellite manufacturing plant in Yucatán. The potential investment is seen as a by-product of Yucatán's ICT and advanced technology ecosystem, which has been revolutionized

TABLE G.1
Potential Investors in the ICT Sector in Mexico

Company	Subsector	Reason
Kio Networks	Technology solutions provider	This Mexican IT company provides specialized infrastructure services and solutions with 29 core and 11 edge data centers across Latin America and the Caribbean. It is considering Yucatán for future data center developments because of the state's potential.[a]
Plenumsoft	Technology solutions provider	It is a company, with currently several investments in the state. Plenumsoft, a Yucatán-based company with several local investments, is a pioneer in the Yucatán ICT industry as one of the first companies in the state's first ICT cluster. It expressed interest in joining the SEZ in Progreso in 2017.
Gignet	Technology solutions provider	Gignet, a leading ICT company in the Yucatán Peninsula based in Quintana Roo, operates an extensive regional fiber-optic broadband network in strategic consumer centers including Cancun and Tulum. The company intends to acquire a 1,200 kilometers advanced subsea fiber-optic cable system ("Gignet 1") that will link Cancun and the U.S. state of Florida from FB Submarine Partners.[b] This first new fiber-optic cable in over 2 decades aims to meet the growing connectivity demand in Mexico´s Caribbean, further solidifying Gignet's regional lead and advancing connectivity in Quintana Roo and Yucatán.
Veritran	Data center service provider	In 2017, Veritran showed interest in joining the SEZ in Progreso, which if pursued, would be the first data center in Yucatán.
Compax Ideas y Tecnología	ICT manufacturer and software developer	This company produces computers, mobile devices, and software, with manufacturing sites in Torreón, Coahuila, and an R&D institute in Yucatán. It showed interest in joining the SEZ in Progreso in 2017.
Blue Ocean Technologies	Software developer	This company develops software for companies and governments, with offices in Mérida. expressed interest in joining the SEZ in Progreso in 2017.
Aimarine	Satellite communications service provider for maritime transport	Based in Ciudad del Carmen, Campeche, this company provides specialized water transport telecommunications solutions, and expressed interest in joining the SEZ in Progreso in 2017.
Logismic Software	Software developer	Based in Chuburna, this company provides technology consulting services and offers two main products for the tourism and agriculture sectors. It showed interest in joining the SEZ in Progreso in 2017.
Cega Security	Cybersecurity service provider	Based in Cancún, Quintana Roo, this company provides cloud data protection services for financial transactions and other resources. It expressed interest in joining the SEZ in Progreso in 2017.
Kwan Tecnología	Software developer	Based in Mérida, this company is a solution developer for global companies, and expressed interest in joining the SEZ in Progreso in 2017.
Centro de Soluciones Inalámbricas	Satellite communications solution provider for transportation	This company provided security services for tracking freight vehicles via satellite, with offices in Jalisco, Mexico City, Nuevo León, Querétaro, Quintana Roo, Tabasco, and Yucatán. It showed interest in joining the SEZ in Progreso in 2017.
Samsung de México	ICT manufacturer	Although this leading electronic manufacturing firm only has industrial facilities in northern Mexico and offices in Mexico City, its establishment in Yucatán would represent the presence of an anchor firm.
Flextronics Manufacturing Mexico	ICT manufacturer	Although this leading electronic manufacturing firm only has industrial facilities in northern Mexico and offices in Mexico City, its establishment in Yucatán would represent the presence of an anchor firm.
Huawei México	ICT manufacturer and service provider	The firm is implementing a strategy to expand its presence in Mexico, currently limited to Mexico City, potentially expanding to other states.
América Móvil	Telecommunications service provider	América Móvil provides the most extensive internet service in Yucatán. It owns a submarine cable (AMX-1) linking Quintana Roo to Latin America and the Caribbean. The firm could potentially expand its fiber-optic infrastructure in the state to strengthen its connectivity with the rest of the country.
Softtek	ICT services	Softtek, a unicorn in the ICT sector, provides technology and software solutions, with offices in Aguascalientes, Mexico City, and Nuevo León. It could potentially consider expanding to southern Mexico.

Source: Based on information from SHCP 2017; INEGI's DENUE database; and the listed companies' official websites.
Note: ICT = information and communication technology; IT = information technology; R&D = research and development; SEZ = special economic zone.
a. Yucatán Ahora 2018.
b. The engineering, procurement, and construction contract for the project was awarded to Xtera, an industry leader in subsea network deployments.

TABLE G.2
Key ICT Industry Players in Yucatán

NAICS six-digit code	Sector	Enterprise	Municipality
334410	Semiconductor and other electronic component manufacturing	Falco Electronics México S.A. de C.V.*	Umán
335920	Communication and energy wire and cable manufacturing	Argos Eléctrica S.A. de C.V.	Umán
517311	Wired telecommunications carriers	Telesistemas Peninsulares S.A. de C.V.	Mérida

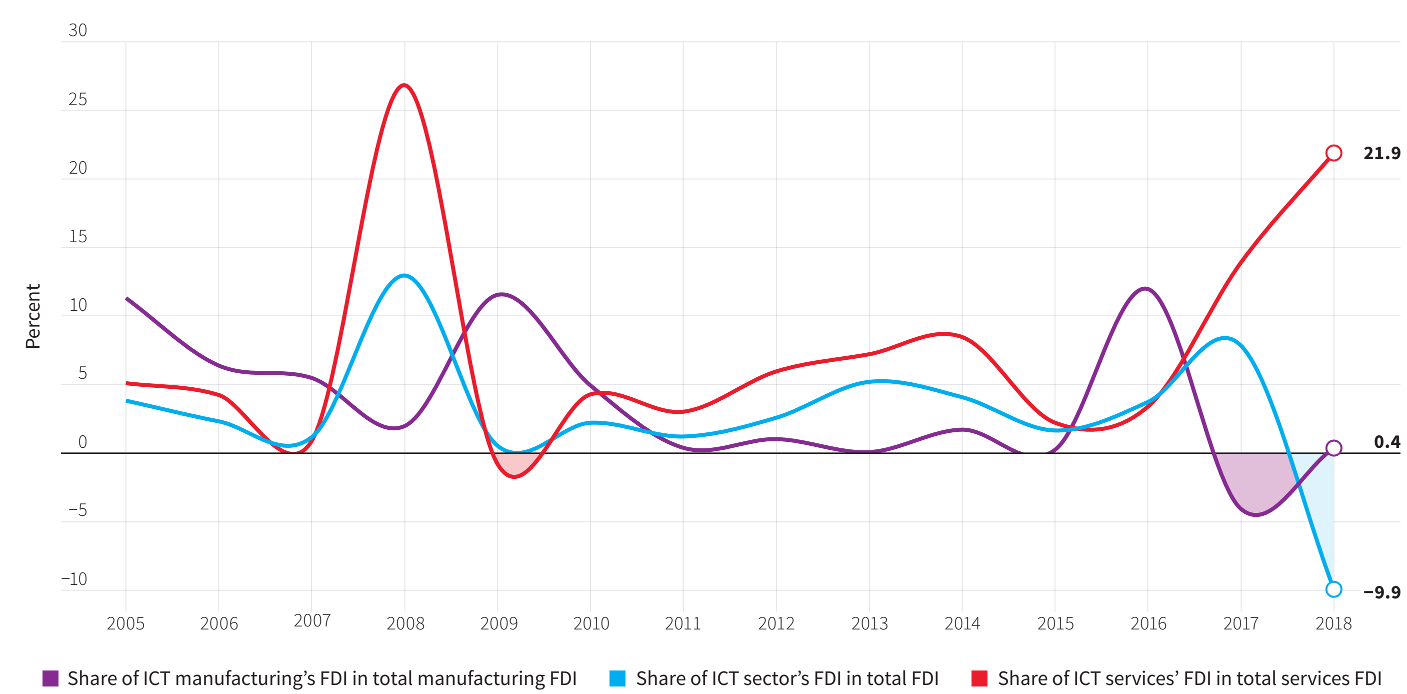
Source: Based on data from INEGI's DENUE database.
Note: ICT = information and communication technology; NAICS = North American Industry Classification System. The table lists firms with 101 workers or more.
*The firm has at least 251 workers.

by the *Universidad Politécnica de Yucatán*. The university would provide aeronautics engineers to support the operations of the center.[108]

There are ongoing projects in the tourism and infrastructure sectors aimed at enhancing wireless internet coverage, potentially including 5G (fifth-generation) technology. However, detailed information about these projects are not yet publicly available, as they are still in the early stages of the investment process.[109]

APPENDIX H
Additional Information and Statistics

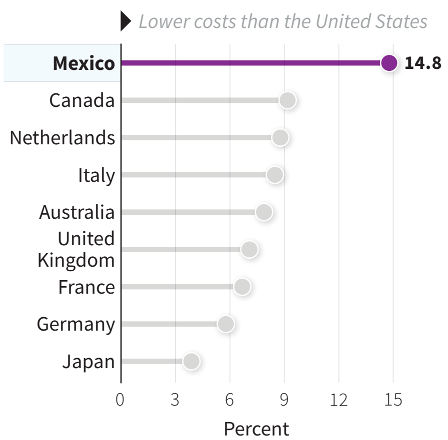
FIGURE H.1
FDI Inflows in the ICT Sector, OECD Countries



Source: Based on data form OECDSTAT database.
Note: FDI = foreign direct investment; ICT = information and communication technology; OECD = Organisation for Economic Co-operation and Development. The figure should be seen as an approximation because of the inconsistency in the number of reporting countries during the time period. Both FDI inflows (ICT services and all services) were negative for 2018.

FIGURE H.2

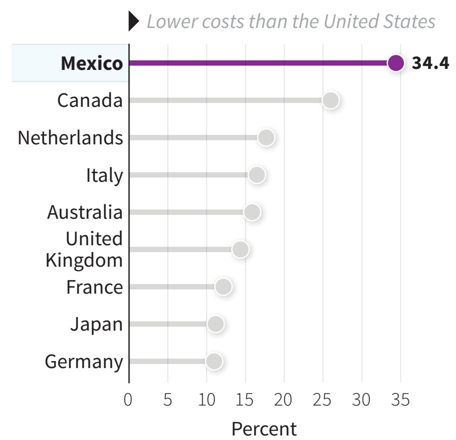
Cost Index for ICT Manufacturing Firms, 2016



Source: KMPG 2016.
Note: ICT = information and communication technology. Business cost scores above zero indicate lower costs than the United States (baseline).

FIGURE H.3

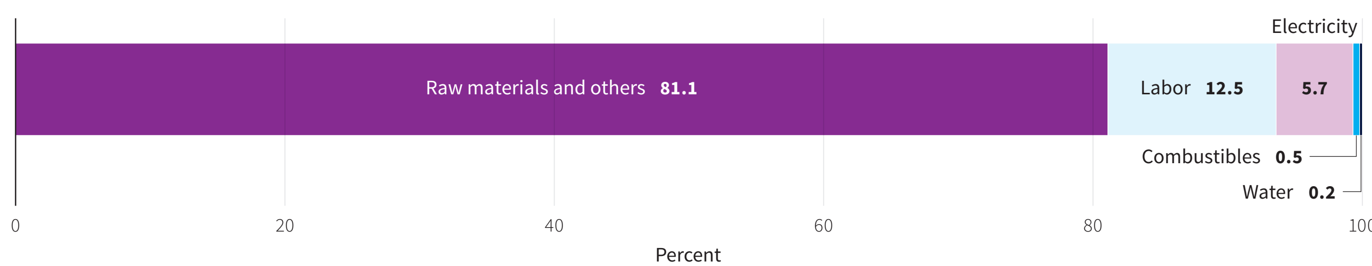
Cost Index for ICT Services Firms, 2016



Source: KMPG 2016.
Note: ICT = information and communication technology. Business cost scores above zero indicate lower costs than the United States (baseline).

FIGURE H.4

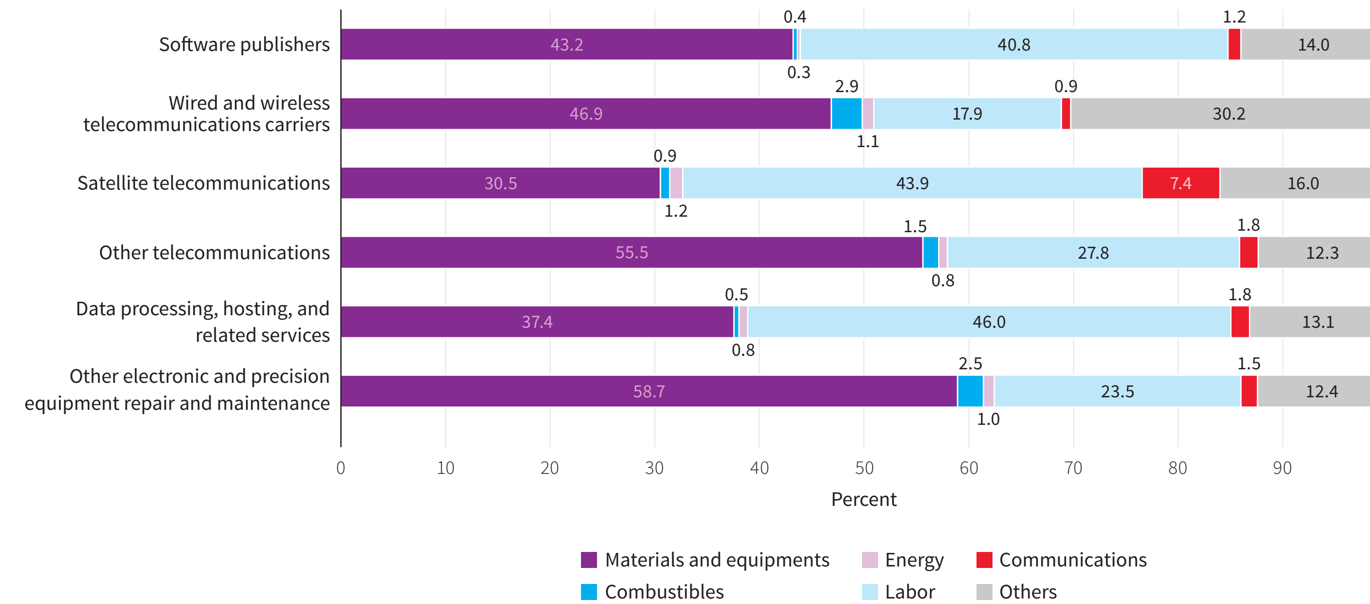
Cost Structure for ICT Manufacturing Firms in Mexico, Share in Total Production Cost



Source: SHCP 2017.
Note: ICT = information and communication technology.

FIGURE H.5

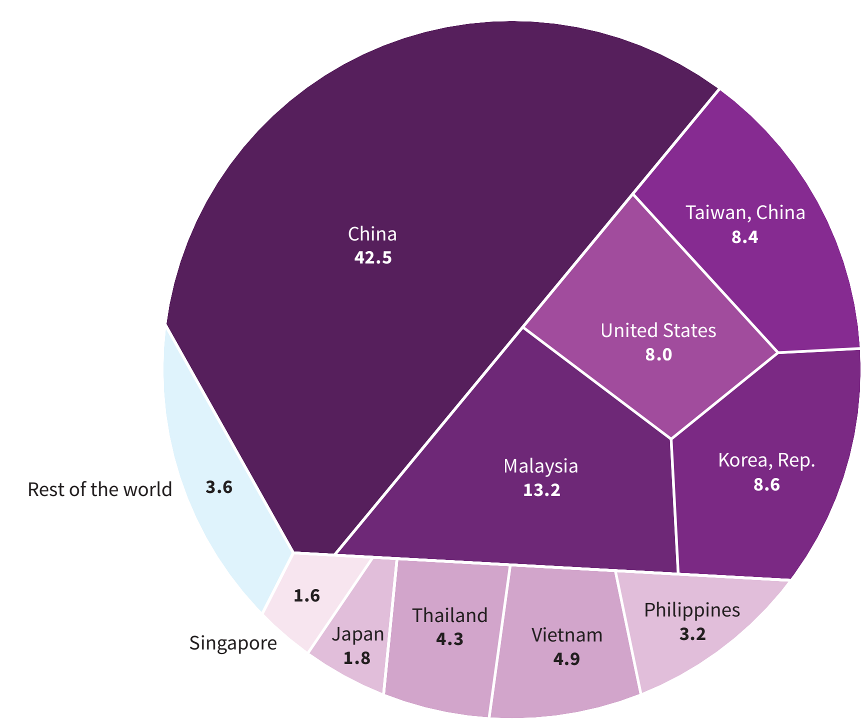
Cost Structure for ICT Services in Mexico by Sector



Source: Based on data from INEGI 2019.
Note: ICT = information and communication technology. The corresponding North American Industry Classification System sector code for software publishers is 5112; wired and wireless telecommunications carriers is 5173; satellite telecommunications is 5174; other telecommunications is 5179; data processing, hosting, and related services is 5182; and other electronic and precision equipment repair and maintenance is 811219.

FIGURE H.6

Main ICT Goods Import Partners of Mexico, 2021



Source: Based on data from UNCTADSTAT database.
Note: ICT = information and communication technology.

TABLE H.1
Main ICT Goods Imports of Mexico

	Value, 2021 (US$, billions)	Share in total value, 2021 (%)	CAGR, 2000–21 (%)
Electronic components	28.2	36.7	7.1
Computers and peripheral equipment	22.7	29.5	5.5
Communication equipment	13.7	17.8	2.0
Miscellaneous	7.9	10.2	2.6
Consumer electronic equipment	4.4	5.7	6.5
Total	76.9	100.0	4.4

Source: Based on data from UNCTADSTAT database.
Note: CAGR = compound annual growth rate; ICT = information and communication technology.

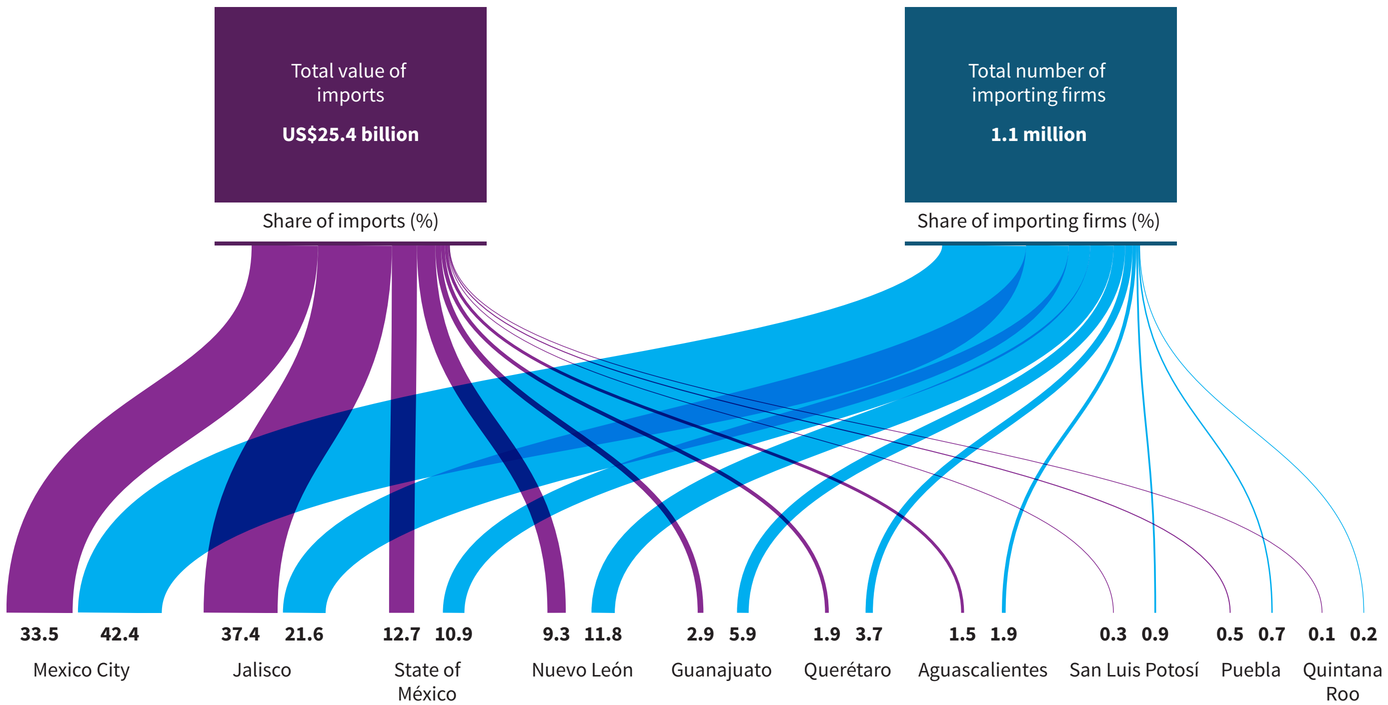
TABLE H.2
ICT Goods Imports of Yucatán

HS code	Description	Value, 2014 (US$, thousands)	Share in total value, 2014 (%)	CAGR, 2004–14 (%)
8517	Telephone sets for cellular networks or other wireless networks, and other apparatus for the transmission or reception of voice, images, or other data	9,620.3	30.4	6.7
8471	Automatic data processing machines and their units; magnetic or optical readers, machines for transcribing data onto data media in coded form, and machines for processing such data, nes	8,738.7	27.6	9.6
8443	Printing machinery used for printing by means of plates, cylinders and other printing components of heading no. 8442 and other printers, copying machines, and facsimile machines, whether or not combined; parts and accessories	2,308.0	7.3	14.6
8529	Parts suitable for use solely or principally with the apparatus of headings 8525 to 8528	2,176.2	6.9	13.3
8523	Discs, tapes, solid-state nonvolatile storage devices, smart cards, and other media for the recording of sound or of other phenomena, whether or not recorded, including matrices and masters for the production of discs, nes	1,328.3	4.2	20.3
8528	Monitors and projectors, not incorporating television reception apparatus; reception apparatus for television, whether or not incorporating radio-broadcast receivers, sound, video recording, or reproducing apparatus	1,178.7	3.7	17.1
8521	Video recording or reproducing apparatus, whether or not incorporating a video tuner	1,037.9	3.3	−1.4
8518	Microphones and stands; loudspeakers, whether or not mounted in their enclosures; headphones and earphones, whether or not combined with a microphone, and sets consisting of a microphone and one or more loudspeakers; audio-frequency electric amplifiers; electric amplifier sets	890.6	2.8	13.5
8525	Transmission apparatus for radio-broadcasting or television, whether or not incorporating reception apparatus or sound recording or reproducing apparatus; television cameras, digital cameras, and video camera recorders	871.5	2.7	−10.0
8470	Calculating machines and pocket-size data recording, reproducing and displaying machines with calculating functions; accounting machines, postage-franking machines, ticket-issuing machines, and similar machines incorporating a calculating device; cash registers	808.9	2.6	11.1
8531	Electric sound or visual signaling apparatus (for example, bells, sirens, indicator panels, burglar, or fire alarms), nes; parts	742.5	2.3	24.4
8473	Parts and accessories (other than covers, carrying cases, and the like) suitable for use solely or principally with machines of headings 8469 to 8472	633.8	2.0	−11.8
8541	Diodes, transistors, and similar semiconductor devices; photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made-up into panels; light-emitting diodes; mounted piezoelectric crystals; parts	556.4	1.8	17.9
9504	Articles for arcade, table or parlor games, including pinball machines, bagatelle, billiards and special tables for casino games; automatic bowling alley equipment; parts and accessories	164.1	0.5	4.0
8527	Reception apparatus for radio broadcasting, whether or not combined in the same housing with sound recording, reproducing apparatus, or a clock	161.2	0.5	−11.4
8472	Other office machines (for example, hectograph or stencil duplicating machines, addressing machines, automatic banknote dispensers, coin-sorting machines, coin-counting or wrapping machines, pencil-sharpening machines, perforating or stapling machines)	160.3	0.5	10.9
8542	Electronic integrated circuits and their parts	135.3	0.4	−20.0
8519	Sound recording or reproducing apparatus	66.0	0.2	−3.8
8534	Electronic printed circuits	49.9	0.2	22.0
9013	Liquid crystal devices not constituting articles provided for more specifically in other headings; lasers, other than laser diodes; other optical appliances and instruments, nes; parts and accessories	35.7	0.1	3.1
8540	Thermionic, cold cathode or photocathode tubes (for example, vacuum, vapor, or gas-filled tubes, mercury arc rectifying tubes, cathode-ray tubes, television camera tubes); parts	29.3	0.1	−8.2
8522	Parts and accessories suitable for use solely or principally with the apparatus of headings 8519 to 8521	1.2	0.0	−35.6
	Total ICT Goods	31,694.9	100.0	5.2

Source: Based on data from Mexico Atlas of Economic Complexity.
Note: CAGR = compound annual growth rate; HS = Harmonized System; ICT = information and communication technology; nes = not elsewhere specified. Includes all 22 HS four-digit code products considered as ICT goods.

FIGURE H.7

Distribution of ICT Goods Imports and Importing Firms of Leading ICT States in Mexico, 2014



Source: Based on data from Mexico Atlas of Economic Complexity.
Note: ICT = information and communication technology.

TABLE H.3

ICT Goods Imports of Leading ICT States in Mexico

HS code	Description	Value, 2014 (US$, millions)	Share in total value, 2014 (%)	CAGR, 2004–14 (%)
8517	Telephone sets for cellular networks or other wireless networks, and other apparatus for the transmission or reception of voice, images, or other data	4,965.2	19.5	21.2
8471	Automatic data processing machines and their units; magnetic or optical readers, machines for transcribing data onto data media in coded form, and machines for processing such data, nes	4,742.1	18.6	3.9
8525	Transmission apparatus for radio-broadcasting or television, whether or not incorporating reception apparatus or sound recording or reproducing apparatus; television cameras, digital cameras, and video camera recorders	3,933.1	15.5	14.1
8542	Electronic integrated circuits and their parts	3,428.0	13.5	−1.5
8529	Parts suitable for use solely or principally with the apparatus of headings 8525 to 8528	1,670.9	6.6	8.4
8473	Parts and accessories (other than covers, carrying cases, and the like) suitable for use solely or principally with machines of headings 8469 to 8472	1,379.7	5.4	−5.8
8541	Diodes, transistors, and similar semiconductor devices; photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made-up into panels; light-emitting diodes; mounted piezoelectric crystals; parts	824.7	3.2	7.3
8534	Electronic printed circuits	802.9	3.2	3.8
8443	Printing machinery used for printing by means of plates, cylinders and other printing components of heading 8442; other printers, copying machines, and facsimile machines, whether or not combined; parts and accessories	776.2	3.1	17.0
9504	Articles for arcade, table or parlor games, including pinball machines, bagatelle, billiards and special tables for casino games; automatic bowling alley equipment; parts and accessories	537.3	2.1	18.5
8521	Video recording or reproducing apparatus, whether or not incorporating a video tuner	391.4	1.5	−5.1
8518	Microphones and stands; loudspeakers, whether or not mounted in their enclosures; headphones and earphones, whether or not combined with a microphone, and sets consisting of a microphone and one or more loudspeakers; audio-frequency electric amplifiers; electric amplifier sets	384.2	1.5	6.4
8531	Electric sound or visual signaling apparatus (for example, bells, sirens, indicator panels, burglar, or fire alarms), nes; parts	306.5	1.2	11.5
8528	Monitors and projectors, not incorporating television reception apparatus; reception apparatus for television, whether or not incorporating radio-broadcast receivers, sound, video recording, or reproducing apparatus	296.2	1.2	5.6
8527	Reception apparatus for radio broadcasting, whether or not combined in the same housing with sound recording, reproducing apparatus, or a clock	232.6	0.9	1.5
8523	Discs, tapes, solid-state nonvolatile storage devices, smart cards, and other media for the recording of sound or of other phenomena, whether or not recorded, including matrices and masters for the production of discs, nes	216.2	0.9	3.7
9013	Liquid crystal devices not constituting articles provided for more specifically in other headings; lasers, other than laser diodes; other optical appliances and instruments, nes; parts and accessories	211.9	0.8	−0.1
8472	Other office machines (for example, hectograph or stencil duplicating machines, addressing machines, automatic banknote dispensers, coin-sorting machines, coin-counting or wrapping machines, pencil-sharpening machines, perforating or stapling machines)	114.7	0.5	21.4
8470	Calculating machines and pocket-size data recording, reproducing and displaying machines with calculating functions; accounting machines, postage-franking machines, ticket-issuing machines, and similar machines, incorporating a calculating device; cash registers	108.2	0.4	10.9
8519	Sound recording or reproducing apparatus	57.5	0.2	−0.3
8522	Parts and accessories suitable for use solely or principally with the apparatus of headings 8519 to 8521	46.7	0.2	−8.1
8540	Thermionic, cold cathode or photocathode tubes (for example, vacuum, vapor, or gas-filled tubes, mercury arc rectifying tubes, cathode-ray tubes, television camera tubes); parts	6.4	0.0	−19.4
	Total ICT Goods	25,432.8	100.0	5.1

Source: Based on data from Mexico Atlas of Economic Complexity.
Note: CAGR = compound annual growth rate; HS = Harmonized System; ICT = information and communication technology; nes = not elsewhere specified. Includes all 22 HS four-digit code products considered as ICT goods.

Notes

1. Huawei (2015).
2. Kvochko (2013).
3. Based on Mexico Atlas of Economic Complexity.
4. Flores, Ceballos, and Bojórquez (2016).
5. Programa para el Desarrollo de la Industria de Software y la Innovación (Software Industry and Innovation Development Program)
6. Based on IT industry data from Fitch Connect database.
7. Data at the NAICS four-digit code level from Mexico's Secretariat of Economy.
8. The South-Southeast region of Mexico covers nine states: Campeche, Chiapas, Guerrero, Oaxaca, Puebla, Quintana Roo, Tabasco, Veracruz, and Yucatán. Given the differences in economic structure, social development, and institutional capacities of each state, and potential flaws of having a "one-size-fits-all" approach, this Deep Dive by the International Finance Corporation focused on the three poorest states in Mexico: Chiapas, Guerrero, and Oaxaca—all located in the southern part of the country, and Yucatan, one of the more dynamic and developed states in the southeast.
9. Because of limited disaggregation, the activities considered as part of the ICT sector include machinery manufacturing; computer; computer and electronic product manufacturing; electrical; electrical equipment, appliance, and component manufacturing; transportation; transportation equipment manufacturing (NAICS three-digit codes 333–336); information (NAICS two-digit code 51); and other services excluding public administration (81).
10. Data at the NAICS four-digit code level from from Mexico's Secretariat of Economy.
11. Beardsley and others (2010).
12. Kvochko (2013).
13. Huawei' (2015).
14. García and Iglesias (2017).
15. Based on INEGI's Input-Output Matrix, https://en.www.inegi.org.mx/programas/mip/2013/.
16. De Backer and Miroudot (2013).
17. Gereffi and Fernández-Stark (2011).
18. Prior to 2019, the Consejo Nacional de Ciencia y Tecnología offered programs to enhance the development of technologies through its Fondo Mixto (or "Mixed Funds"). However, no new convocatorias (or calls) for this specific fund have been made available since 2018.
19. Certain products within this subsector are not considered ICT goods. However, INEGI's total factor productivity calculations is limited up to NAICS three digits, ecept for computer and electronic product manufacturing.
20. Labor productivity is measured as the value added per worker.
21. Those states include Baja California, Chihuahua, Jalisco, Sonora, and Tamaulipas.
22. KPMG's (2016) Competitive Alternatives study analyzed 100 cities from various countries including Australia, Canada, France, Germany, Italy, Japan, Mexico, the Netherlands, the United Kingdom, and the United States. The analysis focused on modelling sectors over a 10-year horizon.
23. For more details of cost structures by sector, see appendix H.
24. See CSI Market's total market profitability, https://csimarket.com/Industry/industry_Profitability_Ratios.php.
25. Expansión (2019).
26. For more details, see appendix G.
27. Arrieta and others (2017).
28. This section uses international trade in ICT goods and services estimates by UNCTAD.
29. There were no up-to-date information of ICT goods exports for Korea and Singapore in 2021. However, both countries have been significant players in the ICT sector, with an average export concentration of 6.4 and 5.4 percent, respectively, during the period of 2016–20.
30. Although official disaggregated data on ICT exports at the subnational level is limited, an assessment of the main ICT goods exports at the subnational level is possible using the most recent data from the Mexico Atlas of Economic Complexity. The data is derived from cross-registers of the Servicio de Administración Tributaria (Tax Revenue Service; SAT) and the Instituto Mexicano del Seguro Social (Mexican Institure of Social Security; IMSS). Customs data by product from SAT is presented using HS codes. Exports values by state may not adjust perfectly with official statistics from INEGI because of an imputation of exports by location using establishment data from IMSS. As a result, the analysis is conducted in relative tems rather than absolute terms. The Mexico Atlas of Economic Complexity uses HS codes at a four-digit level disaggregation, which prevents the isolation of specific products identified by UNCTAD for ICTs. However, the following HS four-digit subsectors are considered: 8470, 8471, 8472, 8473, 8517, 8518, 8519, 8521, 8522, 8523, 8525, 8527, 8528, 8529, 8531, 8534, 8540, 8541, 8542, 9013 and 9504.
31. A product is said to have a comparative advantage if its revealed comparative advantage (RCA) is greater than one. The RCA is determined by calculating the ratio of the value added or export of an industry or product to the total value added or export in a state, over the average contribution of that industry or product in Mexico's total value added or exports. This indicator of a location's competitive strengths is based on Ricardian trade theory, which claims that patterns of production or trade among regions are defined by their relative differences in productivity.
32. ICT goods and services include 94 codes at the six-digit level in the HS 2017 classification, covering five categories: computers and peripheral equipment, communication equipment, consumer electronic equipment, electronic components, and miscellaneous. The analysis of international import trends is based the UNCTAD classification for ICT goods and services. However, because UNCTAD does not provide a global aggregate for imports of ICT services, a global "proxy" was added by using available data on the value of ICT services imports for each country. This data was then used to calculate the value of Mexico's ICT services imports as a percentage of the total global proxy. For more details about this approach, see UNCTAD (2018).
33. This level of disaggregated data is not available for the ICT services imports.
34. The analysis also included Quintana Roo, a state where firms like AT&T and Microsoft have shown interest (for more information about the analysis, see appendix H).
35. The figure mentioned was calculated using UNCTAD data. Following UNCTAD's methodology, each of the three ICT goods categories was further broken down into 49 individual products. Data from UN Comtrade was then used to estimate the value of imports for each product. The analysis in this section used data from UN Comtrade, while the data analyzed in in the imports-substitution analysis is from UNCTAD. As a result, there may be a few discrepancies in the total value of imports.
36. To prioritize these products, an economic complexity analysis was conducted based on INEGI's (2019) value-added datafrom the 2019 Economic Census was made. The prioritization was determined by assigning weights to the normalized values of distance to the product (D), product complexity (PC), and opportunity gain (OG). Each product in Yucatán's ICT sector was ranked based on a "Short Jumps" Index, which assigned a weight of 50 percent to D and 25 percent each to PC and OG.
37. There are 17 rare-earth elements: cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, promethium, samarium, scandium, terbium, thulium, ytterbium, and yttrium. These elements are often found in minerals with thorium, and less commonly uranium.
38. Lucas, Sands, and Wolfe (2009).
39. These institutions is dependent on the government of Yucatán or other federal-level institutions such as the Instituto Politécnico Nacional and Universidad Nacional Autónoma de México, with only one of these instituitions receiving private funding.
40. Based on data from Mexico's Sistema Nacional de Investigadores (National System of Researchers) and projections from the Consejo Nacional de Población (National Population Council of Mexico), there are 795 researchers registered in Yucatán, ranking 14th highest in the country as of 2021.
41. In 2021, based on data from the Instituto Mexicano de la Propiedad Industrial (Mexican Institute of Industrial Property) and projections from the Consejo Nacional de Población (National Population Council of Mexico), 63 registers for inventions were filed in Yucatán (11th highest in the country), out of which 16 were for patents (15th), 35 for industrial designs (8th), and 12 for utility models (9th).
42. The states comprising this region include Campeche, Chiapas, Guerrero, Oaxaca, Puebla, Quintana Roo, Tabasco, Veracruz, and Yucatán.
43. The COVID-19 pandemic has increased the reliance on digital services accross various sectors. Even after the pandemic subsides, it is expected that this trend will continue.
44. That is, instead of focusing on country- or state-level economic growth, the focus on investment and growth for the specific industry in the state.
45. The analysis is carried out following a methodology implemented by Barrios and others (2018a; 2018b), using data from the Encuesta Nacional de Ocupación y Empleo (National Survey of Occupation and Employment) and the Sistema Nacional de Clasificación de Ocupaciones (National Classification System for Occupations). The deviation between the share of occupations existing at the national and state levels were calculated, using the symmetric mean absolute percentage error as a measure of the availability of workers for required occupations. In addition, the labor cost for each state is calculated and compared to the national level to measure the relative availability or scarcity of qualified human capital. This involves a weighted average of the hourly wage, using the occupation proportions at national level as the weights. In cases where a state has no workers in a particular occupation, the highest salary among the states for that occupation is assigned to reflect the scarcity of workers in that activity.
46. To identify infrastructure-related constraints hindering the development of the sector, the assessment of coverage and quality of infrastructure services are combined with measures of usage intensity of key inputs. For a detailed analysis of the coverage and quality of infrastructure services, see appendix C and for a detailed analysis of their usage intensity, see appendix D.
47. The analysis approach and assumptions are similar to that used by Barrios and others (2018a; 2018b) and includes all industry groups NAICS sector 31–33 at the four-digit level (manufacturing), except classified ones, according to INEGI's Economic Census for 2014 and 2019.
48. The analysis is conducted based on information regarding the typical installations for industries of both sectors included in SHCP's (2017) Dictamen de la Zona Económica Especial de Progreso. The measurement used the annual electricity consumption, expressed in megawatt hours, by a firm in those sectors.
49. The analysis is conducted based on information regarding the typical installations for industries of both sectors included in SHCP's (2017) Dictamen de la Zona Económica Especial de Progres. The measurement used the annual water consumption, expressed in cubic meters, by a firm in those sectors.
50. The analysis is conducted based on information regarding the typical installations for industries of both sectors included in SHCP's (2017) Dictamen de la Zona Económica Especial de Progreso. According to the information, ICT services do not have energy consumption considered in the analysis.
51. The project aims to develop approximately 1,500 kilometers of railway infrastructure, including approximately 1,000 kilometers of new tracks, that would connect 190 sites across the Mayan Peninsula. Its primary focus is to not only incentivize tourism in the southern states of Campeche, Chiapas, Tabasco, Quintana Roo, and Yucatán, but also potentially facilitate the transportation of freight.
52. According to the cost benefit analysis for the Mayan Train by Mexico's National Fund for Tourism Development (Fonatur), once completed, up to 41 percent of the freight that the railway mobilizes will come from electronic products (for more details see, https://www.trenomaya.gob.mx/repositorio-de-documentos-oficiales/).
53. According to the 2015–20 Development Master Plan for the Port of Progreso, the port has established routes for freight to various countries including China, Cuba, Jamaica, Republic of Korea, and the United States, and the port receives freight from various countries including Argentina, Brazil, Canada, China, and the United States.
54. The port has a draft of 10.4 meters, terminals for agriculture and mineral bulk, cruise-ships, shipyard, and private containers terminal The private container terminal was recently equipped with a gantry crane to enhance the efficiency of container handing from post-Panamax ships by 30 percent. The U.S. state of Florida has shown interest in establishing a maritime coastal route within several of its ports and Mexico's, including the port of Progreso (ASIPONA Progreso 2019).
55. The analysis is based on information regarding the typical installations for industries of both sectors included in SHCP's (2107) Dictamen de la Zona Económica Especial de Progreso. The measurement used the data transmission speed, expressed in megabits per second, utilized in a year by each sector.
56. The methodology used by INEGI to calculate the ICT index for 2015 and 2017 differs between each period. For 2015, see Ruiz (2015). For 2017, see Micheli and Valle (2018).
57. Flores, Ceballos, and Bojórquez (2016).
58. Domínguez, Brown, and Carrera (2017).
59. FCCyT (2013).
60. Financial access points refer to bank, sociedades cooperativas de ahorro y crédito popular (savings and credit cooperative societies)

and sociedades financieras populares (popular financial companies) branches, as well as bank agents, and automated teller machines.

61. Data is from CNBV's Bases de Datos de Inclusión Financiera (Financial Inclusion Dataset) for December 2021.

62. In Mexico, five out 10 jobs in the ICT sector are located in the states of Jalisco, Mexico City, Nuevo León, and the State of México. Quintana Roo has been the subject of interest for many relevant firms in the ICT sector. Yucatán performs better than the State of México in this metric.

63. Although data on interest rates at the state level are not available, data on firms' access to external finance are available at the state level and disaggregated by economic activity.

64. Because of the heterogeneity between the manufacturing and services components of the ICT sector, the two are analyzed separately.

65. The World Economic Forum's Network Readiness Index uses 53 indicators to measure a country's readiness to leverage ICTs for economic and social development.

66. This assessment, published by INEGI, is based on an ICT Development Index similar to the one created by the International Telecommunication Union (ITU). For more information, see Ruiz (2015); Micheli and Valle (2018).

67. Henry-Nickie, Kwadwo Frimpong, and Hao Sun (2019).

68. Henry-Nickie, Kwadwo Frimpong, and Hao Sun (2019).

69. Porter (2008).

70. Based on INEGI's ENDUTIH database.

71. IMCO (2018).

72. El Financiero (2019); Espejo (2021).

73. The Yucatán Times (2021); Ruiz (2021).

74. For example, transforming Mérida into the first smart city in southern Mexico could accelerate 5G adoption, showcasing the state's advanced ICT capabilities. In addition, launching periodic hackathons focused on addressing challenges faced by the public and private sectors using ICTs could further highlight the state's commitment to ICT development.

75. The "startup catalyst" model, established by the International Finance Corporation in 2016, can serve as a good model for supporting early-stage startups and fostering entrepreneurship in Yucatán. The initiative focuses on providing preseed and seed capital for equity or quasi-equity investments to commercially oriented incubators, accelerators, seed funds, and other similar vehicles or structures known as seed stage funding mechanisms, across emerging markets. For further details, see https://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Venture+Capital/Special+initiatives/Startup+Catalyst/.

76. Altán Redes (2021).

77. There are there are 31 data centers in the Mexico: 12 in Mexico City, seven in Querétaro, three in the State of México, two each in Jalisco and Nuevo León, one each in Aguascalientes, Baja California, Chihuahua, Coahuila, and Colima. Guatemala also has one data center.

78. One effort in this direction was the launch of the "Maritime Highway System's" first component by the Secretariat of Communications and Transportation in 2021. This initiative will connect the ports of Tampico, Veracruz, and Progreso in Mexico and Santo Tomas de Casillas in Guatemala.

79. According to the Inter-American Development Bank (2016), smart cities are characterized as urban centers that prioritize citizen-centric development, incorporate ICT technologies applied to urban management across all public services, and an efficient government that promotes a collaborative and participatory planning. Key attributes of these cities include sustainability, inclusivity, and transparency.

80. Prior to 2019, the Consejo Nacional de Ciencia y Tecnología (now Consejo Nacional de Humanidades, Ciencias y Tecnologías) offered programs to enhance the development of technologies through its Fondo Mixto (or "Mixed Funds"). However, no new convocatorias (or calls) for this specific fund have been made available since 2018.

81. The "startup catalyst" model, established by the International Finance Corporation in 2016, can serve as a good model for supporting early-stage startups and fostering entrepreneurship in Yucatán. The initiative focuses on providing preseed and seed capital for equity or quasi-equity investments to commercially oriented incubators, accelerators, seed funds, and other similar vehicles or structures known as seed stage funding mechanisms, across emerging markets. For further details, see https://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/Venture+Capital/Special+initiatives/Startup+Catalyst/.

82. Barrios and others (2018a; 2018b).

83. The comparison involves a weighted average of the hourly wage, using the occupation proportions at the national level as the weights. In cases where a state has no workers in a particular occupation, the highest salary among the states for that occupation is assigned to reflect the scarcity of workers in that activity.

84. The approach and assumptions in this appendix are similar to that used by Barrios and others (2018a).

85. The project aims to develop approximately 1,500 kilometers of railway infrastructure including approximately 1,000 kilometers of new tracks that would connect 190 sites across the Mayan Peninsula. Its primary focus is to not only incentivize tourism in the southern states of Campeche, Chiapas, Tabasco, Quintana Roo, and Yucatán, but also potentially facilitate the transportation of freight.

86. Yucatán has another airport in Tizimín, but currently it has no operations.

87. There is an existing government program called RuralSAT (Rural Satellite Telephony), offered by the state-owned company Telecomm. The program provides fixed-telephony services in towns with population from 60 to 499 people (Financiera para el Bienestar 2023).

88. 5G technologies are considered to be possible to install in Mexico (UER 2019). América Móvil and AT&T will be implementing 5G technologies that is expected to be completed in 2025 (Selectra n.d.).

89. Includes all industry groups NAICS sector 31–33 at the four-digit level (manufacturing), except classified ones, according to INEGI's Economic Census for 2014 and 2019.

90. The analysis is conducted based on information regarding the typical installations for industries of both sectors included in SHCP's (2017) Dictamen de la Zona Económica Especial de Progreso. The measurement used the annual electricity consumption, expressed in megawatt hours, by a firm of those sectors.

91. The analysis is conducted based on information regarding the typical installations for industries of both sectors included in SHCP's (2017) Dictamen de la Zona Económica Especial de Progres. The measurement used the annual water consumption, expressed in cubic meters, by a firm in those sectors.

92. The analysis is conducted based on information regarding the typical installations for industries of both sectors included in SHCP's (2017) Dictamen de la Zona Económica Especial de Progreso. According to the information, ICT services do not have energy consumption considered in the analysis.

93. García and Martner (2018).

94. The project aims to develop approximately 1,500 kilometers of railway infrastructure including approximately 1,000 kilometers of new tracks that would connect 190 sites across the Mayan Peninsula. Its primary focus is to not only incentivize tourism in the southern states of Campeche, Chiapas, Tabasco, Quintana Roo, and Yucatán, but also potentially facilitate the transportation of freight.

95. According to the cost benefit analysis for the Mayan Train by Mexico's National Fund for Tourism Development (Fonatur), once completed, up to 41 percent of the freight that the railway mobilizes will come from electronic products (for more details see, https://www.trenomaya.gob.mx/repositorio-de-documentos-oficiales/).

96. Proyectos México (2023).

97. The analysis is based on information regarding the typical installations for industries of both sectors included in SHCP's (2107) Dictamen de la Zona Económica Especial de Progreso. The measurement used the data transmission speed, expressed in megabits per second, utilized in a year by each sector.

98. The methodology used by INEGI to calculate the ICT index for 2015 and 2017 differs between each period. For 2015, see Ruiz (2015). For 2017, see Micheli and Valle (2018).

99. Financial access points refer to bank, sociedades cooperativas de ahorro y crédito popular (savings and credit cooperative societies) and sociedades financieras populares (popular financial companies) branches, as well as bank agents, and automated teller machines.

100. In Mexico, five out 10 jobs in the ICT sector are located in the states of Jalisco, Mexico City, Nuevo León, and the State of México. Quintana Roo has been the subject of interest for many relevant firms in the ICT sector. Yucatán performs better than the State of México in this metric.

101. Yucatán has a higher population concentration in urban areas (84 percent) compared to the national average (78 percent). Furthermore, 55 percent of the state's population is concentrated in five cities: Mérida, Motul, Progreso, Tizimín, and Valladolid.

102. Yucatán's governor, Mauricio Vila Dosal, has publicly announced his intentions of completing the project on at least two occasions. However, as of now, there has been no official announcement from the federal government regarding this project (EF Península and Tzec 2019; Novedades Yucatán 2019; EF Península and Durazzo 2019).

103. To develop an ICT cluster in the location, the state needs to complete the administrative process to reclaim the land donated to the federal government for the SEZ development.

104. These firms were identified by the Federal Authority for the Development of Special Economic Zones in 2017 (SHCP 2017).

105. Fernando (2020).

106. Most of these companies are interested in establishing operations in Guadajalara, Jalisco (Popescu 2016).

107. For example, Mita Ventures, a venture capital fund that focuses on providing funding and strategic mentorship to early-stage startups in Mexico and Silicon Valley companies seeking to expand their operations in Mexico (for more information, see https://mitaventures.com/en/home/).

108. El Financiero (2019); Espejo (2021).

109. Yucatán Times (2021); Ruiz (2021).

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