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Digital Inequality & Infrastructure Clustering in the Network Society: A Snapshot of Oaxaca's Internet Connectivity Landscape in 2020

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“All these you will go on to portray as historical incidents.
(Even what is happening here, at this moment, with us, is something you
Can regard as a picture in this way …).”

—Bertolt Brecht

“Speech to Danish Working-Class Actors on the Art of Observation”

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Abstract

This master's thesis researches the disproportionate clustering of digital infrastructure around certain municipalities in Oaxaca. Through a sociological and correlational quantitative analysis of the Internet connectivity landscape of the Mexican state, based on a dual-layer snapshot of the Oaxacan social space and the digital infrastructure's spatial form in 2020, a relationship is established between some socio-demographic, socio-economic, and socio-spatial characteristics of its inhabitants and the development of digital infrastructure quantity and quality.

The research found strong correlations between digital infrastructure clustering and the amount of population, the degree of urbanization, and the mean household income of the Oaxacan municipalities. The findings suggest that Internet service providers prioritize urban, wealthier areas for infrastructure development, driven by market economy goals, while rural and Indigenous communities are often left with limited or no digital infrastructure for Internet connectivity. This prioritization results in a form of technical digital inequality based on spatial infrastructure clusters and gaps across space reflecting other forms of inequality also present in Oaxaca.

A historical perspective structures the analysis in this research, as it is set to study a snapshot of the fast-paced development of digital infrastructure in Oaxaca amidst an ongoing historical process. The 2020 snapshot of the Internet connectivity landscape depicts, in consequence, Oaxaca's stage of incorporation into the information age. This incorporation is found to be mediated by the socio-technical politics of the network society, evident in its promotion of a hierarchy of social attributes, where digital infrastructure development is historically intertwined with capitalist expansion in the 21st century and Internet access is conditioned on the basis of market economy participation.

Keywords:
digital infrastructure, digital inequality, infrastructure clustering, Internet connectivity, Internet service providers, network society, digital revolution, information age

Glossary

AGEB: Basic Geo-Statistical Areas (*Áreas Geoestadísticas Básicas*)

ARPA: Advanced Research Projects Agency

ARPANET: Advanced Research Projects Agency Network

AMX: América Móvil

BIT: Information Bank on Telecommunications (*Banco de Información de Telecomunicaciones*)

BITNET: Because It's Time Network

CCPV: Population and Housing Census (*Censo de Población y Vivienda*)

CDN: Content Delivery Networks

CEM: Mexican Elevation Continuum (*Continuo de Elevaciones Mexicano*)

CFE: Federal Commision of Electricity (*Comisión Federal de Electricidad*)

CIAO: Critical Infrastructure Assurance Office

COFETEL: Federal Commission of Telecommunications (*Comisión Federal de Telecomunicaciones*)

CONEVAL: National Council for Social Development Policies Evaluation (*Consejo Nacional de Evaluación de la Política de Desarrollo Social*)

CSNET: Computer Science Network

DSL: Digital Subscriber Lines

ENDUTIH: National Survey on Availability and Use of Information Technology in Households (*Encuesta Nacional sobre Disponibilidad y Uso de Tecnologías de la Información en los Hogares*)

ENIGH: National Survey on Household Income and Spending (*Encuesta Nacional de Ingresos y Gastos de los Hogares*)

HEPNet: High Energy Physics Network

ICMM: Current Income for Mexican Municipalities (*Ingreso Corriente para los Municipios de México*)

ICT: Information and Communication Technology

ICT4D: Information and Communication Technology for Development

IFT: Federal Institute of Telecommunications (*Instituto Federal de Telecomunicaciones*)

INEGI: National Institute of Geography and Statistics (*Instituto Nacional de Geografía y Estadística*)

IP: Internet Protocol

IRS: Social Lag Index (*Índice de Rezago Social*)

ISP: Internet Service Provider

IT: Information Technology

IXP: Internet Exchange Point

ITESM: Monterrey Institute of Technology and Higher Studies (*Instituto Tecnológico y de Estudios Superiores de Monterrey*)

MFENet: Magnetic Fusion Energy Network

MODUTIH: Module on Availability and Use of Information Technology in Households (*Módulo sobre Disponibilidad y Uso de Tecnologías de la Información en los Hogares)*

NASA: National Aeronautics and Space Administration

NCP: Network Control Protocol

NICP: National Infrastructure Protection Center

NSF: National Science Foundation

NTIA: National Telecommunications and Information Administration

OECD: Organization for Economic Co-operation and Development

OTT: Over-The-Top Media Services

PCCIP: President's Commission on Critical Infrastructure Protection

PROFECO: Federal Attorney's Office for Consumers (*Procuraduría Federal del Consumidor*)

SCOT: Social Construction of Technology

SCT: Secretariat of Communications and Transportation (*Secretaría de Comunicaciones y Transportes*)

SBAF: Fixed Broadband Internet Access Service (*Servicio de Acceso a Internet de Banda Ancha*)

SPAN: Space Physics Analysis Network

STAR: TV and Radio Restricted Service (*Servicio de Televisión y Audio Restringido*)

SRI: Stanford Research Institute

TCP: Transmission Control Protocol

UCLA: University of California Los Angeles

UNAM: Autonomous National University of Mexico (*Universidad Nacional Autónoma de México*)

USENET: Users Network

Chapter 1: Introduction

1.1 Setting

Over the first couple of decades in the 21st century, Internet connectivity has steadily and quickly risen across the world. In 2005, the earliest date the Organization for Economic Co-operation and Development (OECD) collected data on this matter, 45.7% of the households in its 38 member countries had, on average, dial-up, ADSL, or cable broadband Internet access through a personal computer device. By the end of 2023, Internet connectivity in these American, European, and Asian-Pacific households went from less than half to almost all of them, rising to 91.55% on average.[1]

This increase in Internet access across the OECD population signals not only the increasing popularity and normality of digital technology as a dominant form of telecommunications but also the dawn of a new age in history where information has gained a central role. Seminal sociologist Manuel Castells noted that information technology has become so pervasive, penetrating all domains of human activity, that it is triggering socio-economic and political changes comparable to those triggered by steam, electrical, and fossil fuel energy sources, which resulted in the first and second industrial revolutions in the 18th and 19th centuries.[2] This information technology revolution is, in turn, producing its own historical period: the information age.[3]

Even spatially, Castells identified the emergence of a social trend towards new forms of isolation despite proximity. In a process he called splintering urbanism, infrastructural developments in telecommunications and transport have been selectively connecting certain urban areas while bypassing others. This selective connectivity results in reinforced disparities that lead to deeper dynamics of segregation within urban contexts: it influences the built environment by producing a divided urban landscape where integrated and globally connected regions are geographically located near fragmented, isolated ones.[4]

The dawn of the information age has shared its time in history with two global processes that have both influenced it and been influenced by it. On the one hand, the post-Cold War global restructuring of capitalism extended beyond the Western bloc and integrated most of the world under a single economic system, whose manifestations in each country resulted in multiple varieties of capitalism but where neoliberal forms of political

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[1] OECD. "Internet Access."
[2] Castells, Manuel. *The Rise of the Network Society*.
[3] Kranzberg, Melvin. "Technology and History: 'Kranzberg's Laws'".
[4] Castells, Manuel. *The Rise of the Network Society*.

economy became prevalent in the late 20th century and early 21st century.[5] Information technology has played a key role in this process: the synergy between informational and capitalist change has now resulted in a new stage of post-industrial capitalism (also referred to as informationalism by Manuel Castells).[6]

On the other hand, the fall of the Soviet bloc and the end of the Cold War in the wake of the 1990s kicked off wider and more intensive international flows of people, goods, services, capital, information, and data than ever before.[7] From a historical perspective, this is the most recent phase of the present globalization process: a phenomenon of worldwide integration based on production, transportation, and communication interconnectedness that, while it could be traced back to the Spanish and Portuguese colonial empires of the 16th century, consensus points its genesis towards at least the first industrial revolution, around 1750.[8]

Post-bipolar political multilateralism and interdependency, economic global integration, digitally induced interconnectedness, and intensification and expansion of international migration, trade, and finance have marked the last three decades.[9] This interplay of information technology revolution, capitalist reconfiguration, and escalation of globalization has produced, according to Manuel Castells, a historically contingent form of society whose basic structure follows a networking logic around these flows of people, goods, services, capital, information, and data: the network society.[10]

1.2 Problem Statement

While data on average Internet access among OECD households seems to paint a landscape of deep worldwide digital connectivity, unequal access is revealed once these countries are examined on an individual basis. While the average household Internet connectivity access in developed countries such as the Netherlands is 98.6%, in the United Kingdom 97.3%, and in Sweden 94.87%, all three of them above the OECD average, only 68.5% of Mexican households were connected to the Internet by 2022.[11] Moreover, none of the least developed countries and most of the developing countries in the world are part of its 38 members of the OECD.

[5] Hall, Peter A., and David Soskice. *Varieties of Capitalism*; Harvey, David. A *Brief History of Neoliberalism*; Ferguson, James. "The Uses of Neoliberalism".
[6] Bell, Daniel. *The Coming of Post-Industrial Society*; Castells, Manuel. *The Rise of the Network Society*.
[7] Seong, Jeongmin et al. "Global Flows: The Ties That Bind in an Interconnected World".
[8] Osterhammel, Jürgen, and Niels P. Petersson. *Globalization: A Short History*. P. 28.
[9] Osterhammel, Jürgen, and Niels P. Petersson. *Globalization: A Short History*. P. 144-145.
[10] Castells, Manuel. *The Rise of the Network Society*.
[11] OECD. "Internet Access."

Internet access inequality is even more evident when the scope shifts from the national to the regional level. A 2013 analysis of residential broadband subscribership and speeds in the United States showed the existence of uneven geographical deployment of digital infrastructure for Internet access between urban and suburban areas: not only were DSL copper cable, coaxial cable, and optic fiber cable speeds considerably higher where more than a single provider was competing, but prices were also lower.[12] Additionally, low population density and challenging topography in rural areas in the United States were found to be linked with areas where broadband speed offer was lower and, in some cases, not even available at all.[13] These findings signal a trend toward regional Internet access infrastructure and high-quality service clustering.

In Mexico, while 68.5% of households have Internet connectivity, in cities the average rises to 76.2% while in rural areas only 42.6% of Mexican homes have access to the Internet. Disparities are also evident across the country: Mexico City, the capital, has the highest average household Internet connectivity at 86%, closely followed by some of the states near the border with the United States such as Baja California (home of the most densely populated municipality in Mexico: Tijuana) at 83.1% and Nuevo León (home of the second most populated metropolitan area after the capital: Monterrey) at 81%. In contrast, the two Mexican state entities with the lowest Internet access, with less than half of its households having access to the Internet, are the southern states of Oaxaca and Chiapas, whose average is 47.4% and 38.4% respectively.[14]

As computer-mediated communication continues integrating the world in what Manuel Castells calls global networks of instrumentality, not simply connecting people and places through intercommunication but reshaping and reorganizing politics, economies, and cultural experiences around the logic of networks, societies become integrated into the larger network society.[15] The network morphology, however, simultaneously articulates flows with no distance between interconnected nodes and infinite distance between disconnected nodes: Internet connectivity, in other words, marks inclusion and participation in the economic and power dynamics of this historical period worldwide, while lack of access results in exclusion from the flows and processes of the network society.[16]

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[12] Wallsten, Scott, and Colleen Mallahan. "Residential Broadband Competition in the United States."
[13] Stenberg, Peter L. et al. "Broadband Internet's Value for Rural America"; Prieger, James E. "The Broadband Digital Divide and the Economic Benefits of Mobile Broadband for Rural Areas."
[14] INEGI. "ENDUTIH".
[15] Castells, Manuel. *The Rise of the Network Society*. P. 21.
[16] Castells, Manuel. *The Rise of the Network Society*. P. 501-502.

1.3 Case Study

The present research focuses on digital inequality, particularly on unequal access to the Internet as a subset of the information and communications technology (ICT) development in the 21st century. This phenomenon appears particularly prominent in developing countries and regions, as evident in the interplay between uneven deployment of digital infrastructure and high-speed Internet service across space, which tends toward clustering, and the statistically delayed adoption of Internet use among its population in comparison with national and international averages.

To explore this phenomenon, the scope of the study is placed on Oaxaca, one of the least digitally connected states in Mexico.[17] Its socio-demographic and geographic diversity, as well as its history of social inequality, suggest a landscape of high social contrasts. Its digital infrastructure spatial extension, as a built environment and an expression of the society that builds and uses it, could be expected to follow a similar pattern to its social structure.

Oaxaca has 4,132,148 inhabitants and 1,125,892 inhabited households, according to the latest census held in 2020.[18] This represents 3.3% of the Mexican population and 3.5% of total Mexican households. Its labor force as the population in the age of work amounts to 3,172,770, with an average income of 14,447.66 MXN in 2022 (approximately 741.27 EUR as of July 2024), 31.95% below the national average income, with a Gini index of 0.424.[19]

The geography of Oaxaca is one of its key characteristics, as 79.82% of the territory is crossed by the Sierra Madre del Sur, a mountain range covering most of southern Mexico.[20] This mountain relief fragments the state into regions based on their location along the mountains and valleys, with some of its places reaching over 3,720 kilometers over sea level while others, at the Pacific coast, are directly at sea level.[21]

Finally, at least a quarter of its population, 1,193,229 people, speak one of its 18 most prominent Indigenous languages; the most spoken of which are chinanteco, mixe, mixteco, mazateco, and zapoteco. Additionally, 194,474 inhabitants of Oaxaca are Afro-Mexicans: 4.71% of its population, the highest rate of Afro-descendants in a Mexican state.[22] 417 of its 570 municipalities are self-governed under Indigenous normative systems and populated by its 18 Indigenous nations.[23]

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[17] IFT. "Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos".
[18] INEGI. "Censo Población y Vivienda (CCPV) 2020".
[19] INEGI. "Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH) 2022".
[20] INEGI. "Topografía".
[21] INEGI. "Relieve. Oaxaca".
[22] INEGI. "Censo Población y Vivienda (CCPV) 2020".
[23] IEEPCO. "Dictámenes de Métodos de Elección de Concejalías a los Ayuntamientos que se Rigen por Sistemas Normativos Indígenas".

In contrast, Mexico's Secretariat of Tourism actively promotes 6 destinations in Oaxaca for international tourism, and 3 of those destinations have international airports to support the flow of tourists: Oaxaca de Juárez, capital of the state, as well as Huatulco and San Pedro Mixtepec, municipalities with tropical bays whose beaches are regularly visited by Mexican and foreign travelers.[24]

Section 1.4 Research Question

The primary objective of this study is to explore the sociological reasons behind the spatial dispersion of digital infrastructure in the state of Oaxaca, Mexico, in 2020. Its clustering in certain areas and its absence in others, as documented by the latest report from the Federal Institute of Telecommunications, should not be arbitrary. A sociological analysis of the places and intensity in which digital infrastructure is present or absent, its Internet connectivity landscape, can offer insights into the social dynamics of the Oaxacan society; even its inequality.

In other words, a look into infrastructure dispersion as the material expression of digital inequality can reveal insights into the inequality of the social structure that is built and makes use of it. This perspective considers the relationship between infrastructure and society not as causal but as co-constitutive: in the characteristics where correlations are found, the form of one suggests the form of the other.

By performing a quantitative comparative analysis of Oaxacan municipalities with a sociological and spatial interpretation, for which its 570 municipalities represent a large and varied statistical sample, this research looks into social patterns aligned with its digital infrastructure clusters and gaps. In consequence, a sociological snapshot of the Oaxacan society in 2020 should result from this research.

To pursue this objective in the present study, the research question structuring this thesis is as follows:

> Why was the quantity and quality of digital infrastructure in Oaxaca disproportionally clustered around certain municipalities in 2020?

Three research sub-questions were designed to support the analysis in this study in addressing the research question. Each of these sub-questions and its answer, in turn, structure the

[24] Secretaría de Turismo. "Visit Mexico: Oaxaca".

following chapters to achieve a final answer toward the final chapters of this thesis. The research sub-questions are as follows:

1. What is considered as digital infrastructure in Oaxaca, Mexico, for this research?
2. How is digital infrastructure dispersed across the Oaxacan space?
3. How are the spatial dispersion of digital infrastructure and the Oaxacan society related?

Section 1.5 Significance of the Study

This study places its focus on Oaxaca, a region with complex demographic, social, economic, and geographical characteristics in a developing nation, whose adoption of Internet access has been fast for the last couple of decades yet remains significantly below average in comparison with other OECD nations and disproportionately distributed across its territory.

Additionally, this research builds on the foundational work on digital infrastructure clustering in Mexico reported by the Directorate of Economic and Regulatory Analysis of the Federal Institute of Telecommunications in Mexico (IFT) in its Analysis on Fixed Telecommunications Services Infrastructure Competition.[25] By narrowing the scope to the case of Oaxaca, this thesis leverages the data and methodology of their analysis to explore material expressions of digital inequality in Mexico and the relationship they hold with its society.

While taking into consideration economic, historical, geographic, and socio-political factors for the analysis of digital inequality in Oaxaca, this research is not focused on the relationship between economic development and information and communications technology, typically addressed in the Information and Communication Technology for Development (ICT4D) literature. It is also not focused on demographic differences in Internet use and adoption, conventionally addressed by economics literature for market analysis. Finally, it does not dive into the effectiveness of public policies and institutional change to ensure Internet access as a citizen's right to communication, informing in turn further policies. Instead, these tangents serve as contextual support for the analysis of digital infrastructure from a sociological perspective, looking for insights into the relationship digital technology holds with societies and their spatial environment in the 21st century.

Internet studies, an academic discipline that studies the Internet from a social, cultural, political, and technical point of view, have become increasingly interdisciplinary in

[25] IFT. "Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos".

their research of the relationship between the Internet and societies over the past two decades. Their approach, however, has developed as an extension of media studies in the digital age. A material turn on Internet studies has been, while minor, a gap in the literature progressively addressed over the past decade and to which this thesis attempts to contribute through the sociological analysis of digital infrastructure spatial distribution in Mexico.

Finally, by considering the exploration of the broader social implications of digital infrastructure clustering in the 21st century, this research finds theoretical support in the network society theory by sociologist Manuel Castells. As information technology, particularly digital telecommunications, continues developing two decades into the new millennium, the ways in which it contributes to socio-spatial integration, exclusion, and segregation around the world continue to unfold.

Section 1.6 Structure of the Thesis

This first chapter has set the stage for the thesis by providing an overview of the setting, problem statement, case study, research question and sub-questions, and significance of the study. By introducing the pervasiveness of the Internet in the 21st century, the problem of unequal digital access and infrastructure clustering, and the unique context of Oaxaca in Mexico as a case study for Internet connectivity disparities in developing countries, it outlines the context for the following 4 chapters in this research.

Chapter 2 furthers the context by exploring the main technologies involved in Internet connectivity as managed by Internet service providers, following a literature review of the main scholarly approaches and debates on Internet connectivity and infrastructure, and finally providing historical context to the Internet and digital connectivity development in Mexico. This chapter addresses the question of what is considered digital infrastructure in the context of this research.

Chapter 3 presents Oaxaca as a social space in which Internet infrastructure is deployed, from the municipal structure that groups its 570 municipalities into 8 regions to the main geographic and demographic characteristics of each region. It then complements the notion of digital infrastructure's spatial form to construct a historical and socio-spatial snapshot of the Internet connectivity landscape in Oaxaca. The chapter also introduces the data sources for these insights, which will be used in the following chapter for a correlational analysis, thus addressing the question of how is digital infrastructure dispersed across the Oaxacan space.

Chapter 4 is devoted to the quantitative correlational analysis of municipalities, exploring patterns between socio-demographic, socio-economic, and socio-spatial variables and the varying degrees of digital infrastructure clustering in the Oaxacan municipalities. These correlations are explored in Oaxaca as a whole, as well as in each of the 8 regions in which Oaxaca is territorially divided, looking for nuances and variations in the significance and strength of the variables based on regional particularities. Through this analysis, the chapter addresses the question of how the spatial dispersion of digital infrastructure and the Oaxacan society are related.

Finally, Chapter 5 takes into account the discussions and findings of the three previous chapters to introduce a sociological and historical analysis of the Internet connectivity landscape, revealing an underlying snapshot of the social landscape of Oaxaca in 2020. Prior to this, the chapter summarizes the most relevant findings in Chapters 2, 3, and 4. These discussions address the question of why digital infrastructure in Oaxaca is clustered in some of its municipalities while disproportionally absent from others from a sociological perspective at this point of its historical incorporation into the information age. As closing remarks, the chapter lays out directions for future research based on the technical and scope limitations present in this master's thesis.

Chapter 2: On Digital Infrastructure

What is considered digital infrastructure in Oaxaca, Mexico, for the purpose of this research? To define the object of study that will articulate the following chapters, as well as the correlational and sociological analysis at the core of this study, it is necessary to first dive into the key concepts, dynamics, and technologies that constitute the present understanding of digital infrastructure. This chapter, in consequence, first introduces the reader to key concepts such as Internet service providers (ISPs), wireless and wireline technologies, and information and communication technology (ICT).

This introduction is followed by a review of the scholarly literature that has dealt with digital infrastructure over the years: from economics and development studies debate on the digital divide to Internet studies and the infrastructural turn of sociology during the past decade. Finally, a brief recount of the origins and evolution of the Internet in Mexico, from the first computer networks and the first connection to ARPANET to the present day, provides the context for the technologies and service providers articulating the infrastructure network for Internet access in Mexico in 2020.

2.1 Intro to Digital Infrastructure

The term information technology (IT) was originally coined by Harold J. Leavitt and Thomas L. Whisler in 1958. They required a unique term for a unique trend they foresaw in management 30 years ahead: the rapid development of technology that allowed for instant transmission of information would have a direct effect on management structures, causing middle management to shrink, top management to become more hands-on, and organizations to centralize as representatives would become less critical after the popularization of phone calls.[26]

The term expanded into information and communication technology (ICT) over the second half of the 20th century, as computer technology became too sophisticated to not have a nuanced distinction between tech-enhanced communication and information flows. Today, ICT refers to not only telecommunications, from telephone lines to wireless signals, but also computing hardware, enterprise software, and audio-visual systems all increasingly unified under these networked technologies.[27]

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[26] Porter , Michael E., and Victor E. Millar. "Information Technology and Tomorrow's Manager."
[27] Cheshmehzangi, Ali. *ICT, Cities, and Reaching Positive Peace*.

The widespread expansion of telegraph lines in the United States by the 1870s, and the later rise of the early telephone networks in the early 1900s, are milestones in the 150 years of history telecommunications has of transforming societies by making instant flows of information possible.[28] Computer networking, however, has overtaken the former as the main mode of telecommunications similar to the way in which video killed the radio star:[29] first, in the places around the world where sending and receiving information via this technology became available and affordable, and expanding elsewhere over the years as the effectiveness of its use allowed it to reach larger markets.

This pattern of technology diffusion, as well as the economic, political, and social transformations that have come with the pervasiveness of Internet use around the world, have been documented in detail by the OECD. Their 2019 report goes in-depth into mapping indicators, identifying trends, and documenting the state of these transformations up until the first two decades of the 21st century: from innovation, and education to productivity and added value. Additionally, the report draws policy roadmaps for enhancing access, increasing effectiveness in use, and strengthening trust in the digital tools and infrastructure.[30]

American economist Shane Greenstein described two types of Internet service providers (ISPs), whose privately owned connectivity technology deployment form what we know as Internet infrastructure networks. While the speed may vary depending on the Internet subscription of each household, each technology is able to grant its users different Internet speeds depending on its broader capability of simultaneous data transmission. Wireless providers, in this sense, have the slowest Internet service capacity and its technology also represents a low expense for the companies: it entails satellite transmission of data to and from any location, connected from geostationary orbit satellites to parabolic dish antennas in users' households. Wireline providers, in turn, may work with different technologies, which determine the speed and quality of the Internet service: digital subscriber lines (DSL) via copper cable provide the slowest range, coaxial cables, and modems are standard speed, and broadband optic fiber cables can achieve, to this day, the fastest Internet speed.[31]

Beyond these wireline and wireless networks, data transmission between Internet users and Internet content providers may require additional technologies and infrastructures depending on the complexity of the exchange. Typical data transmissions between two users who share the same ISP, such as a text message on WhatsApp, can occur within the same

[28] John, Richard R. "Telecommunications."
[29] The Buggles. "Video Killed The Radio Star."
[30] OECD. *Measuring the Digital Transformation*.
[31] Greenstein, Shane. "The Basic Economics of Internet Infrastructure." P. 195-196.

wireline network of the service provider. Data transmission with online platforms and streaming services, however, reroutes users from server to content delivery networks (CDN): networks of servers located relatively near users.[32] The proximity of users to their respective CDNs also impacts the Internet speed they can achieve.

Besides these two mechanisms, data transmission may also occur via private peering, internet exchange points (IXPs), and transit carriers. Private peering consists of a point of contact between two ISPs, which allows users from different service providers to communicate. Internet exchange points are places run by third parties where carriers interconnect to more efficiently exchange traffic from their users; ISPs are charged for this service as IXPs typically involve high investments to set up and maintain. Transit carriers are service providers who serve as carriers for data between two ISPs with no point of contact when IXPs are also not available to ensure such exchange.[33]

Because of the investment required by Internet service providers to set up and maintain their wireline networks, as well as the additional costs of data transmission via CDNs and IXPs, evidence shows that Internet infrastructure (also primarily named digital infrastructure in this research, for it connects digital devices and transmits digital data) tends to cluster geographically.[34] These clusters result in unequal Internet access for the population of a country or region, leading to high rates of Internet non-adoption.

Disconnected and under-connected populations, both within a regional space with clustered digital infrastructure and across countries, are not arbitrary. Economists Andrew Perrin and Sara Atske suggest, for instance, that demographic factors such as age and level of education could play a role in such disparities, at least in the United States, while gender, race, and ethnicity seem to show no correlation.[35] Internet researcher Emily A. Voguels, in turn, suggests spatial variables such as population density and rurality could offer some explanations for this phenomenon.[36] Most economists researching the matter, including Greenstein, also suggest user income plays a significant role in Internet connectedness; as well as the elevated costs with low return of investment for ISPs in geographically isolated areas.[37]

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32 Greenstein, Shane. "The Basic Economics of Internet Infrastructure." P. 197.
33 Greenstein, Shane. "The Basic Economics of Internet Infrastructure." P. 198.
34 Wallsten, Scott, and Colleen Mallahan. "Residential Broadband Competition in the United States."
35 Perrin, Andrew, and Sara Atske. "7% of Americans Don't Use the Internet. Who Are They?"
36 Vogels, Emily. "Some Digital Divides Persist between Rural, Urban and Suburban America."
37 Greenstein, Shane. "The Basic Economics of Internet Infrastructure." P. 210.

2.2 Digital Infrastructure Literature

Precisely because Internet adoption and digital technology have become drivers of worldwide transformations, supporting their adoption in developing countries and sub-national regions has been closely argued and promoted by economists, policymakers, and international development institutions.

A popular concept to address the issue of unequal access to computers and the Internet is the digital divide. Judith Sparrow and Anu Vedantham, both members of the National Telecommunications and Information Administration (NTIA) in the American Department of Commerce, noted in 1995 that disparities in ICT access existed between rich and poor people, as well as between suburban and inner-city residents.[38] The term, however, was coined by Sesame Street co-creator Lloyd Morrisett a year later.[39]

The term reached international popularity after February 2, 2000, when then-President Bill Clinton launched a proposal for bridging the digital divide by, among other actions, increasing public investments in Community Technology Centers.[40] That same year, the 189 member states of the United Nations agreed upon the Millennium Development Goals, with Goal 8 directly involving a global partnership for development to be achieved, in part, by making ICT available; some of the challenges to overcome were lack of mobile broadband infrastructure preventing poorer areas to be connected to the Internet.[41]

Research on the digital divide, particularly on the correlation between demographic characteristics and computer access, became popular among economists and business scholars looking to inform emerging policies. Donna L. Hoffman, Thomas P. Novak, and Ann Schlosser's analysis of the digital divide as seen in race, age, income, education, and gender across communities in the United States, as well as its impact on online advertising and electronic commerce, is a prime example of the literature from that period.[42]

It should be noted that the popularity of the digital divide in research and policies during the late 1990s and the year 2000 shared its timeframe with the Dot-Com financial bubble. Marked by a marketing and finance feedback loop that started in 1995 and ended bursting in 2000, the financial frenzy contributed to the popular perception of the social and economic transformations that would arrive along with the Internet.[43]

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[38] Sparrow, Judith, and Anu Vedantham. "Inner‑City Networking: Models and Opportunities."
[39] Katz, James, and Philip Aspden. "Motivations for and Barriers to Internet Usage: Results of a National Public Opinion Survey."
[40] The White House. "From Digital Divide to Digital Opportunity."
[41] United Nations. "The Millennium Development Goals Report."
[42] Hoffman, Donna L., Thomas P. Novak, and Ann Schlosser. "The Evolution of the Digital Divide".
[43] Crain, Matthew. "The Dot-Com Bubble."

Critiques of the notion of the digital divide followed these early studies in the early 2000s. Mark Warschauer, professor of education and informatics at the University of California, Irvine, noted that the digital divide had a reductionist and patronizing perspective on the population as Internet access haves and have-nots. In consequence, most policies aimed at simply reducing the digital divide by granting digital tools in an almost civilizing manner.[44] Infrastructure, on the other hand, hardly played a role in the analysis: it seemed to imply that Internet coverage would reach marginalized communities sooner or later, and all they needed was support in acquiring the tools to access it.

Warschauer also critiqued the causal relation implied between the lack of computers or access to the Internet and marginalization, lacking nuanced research on the complex sociological co-constitutive relationship society and technology have. Lastly, he argued that granting access to technology to promote development and social mobility did not take into account other factors that would render the access useful and meaningful in any way to those who are being intended to be supported.[45]

Economists Paul DiMaggio and Eszter Hargittai proposed, in this sense, a shift in the scholarly focus beyond discussions of the digital divide, of Internet haves and have-nots, and into digital inequality: inequality among people with various degrees of access to the Internet.[46] The nuance from this approach helped both explain and approach digital poverty, a parallel concept that emerged over the same decade to address this inequality from market-oriented development literature.[47] Hargittai has gone to deepen this perspective over the past two decades with several publications, including the Handbook of Digital Inequality she edited as Chair of the Internet Use and Society group in the Department of Communication and Media Research at the University of Zurich.[48]

DiMaggio and Hargittai proposed, back in 2001, 5 main variables influencing digital inequality: technical means (bandwidth inequality), autonomy (whether the time of access is limited or unlimited, supervised or unsupervised, privately or publicly granted), skill (knowledge required to make full advantageous use of the access), social support (existence of a network of more experienced users to help solve navigating issues), and purpose (ranging from work to educational and recreational).[49]

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[44] Warschauer, Mark. *Technology and Social Inclusion: Rethinking the Digital Divide*.
[45] Warschauer, Mark. *Technology and Social Inclusion: Rethinking the Digital Divide*.
[46] DiMaggio, Paul, and Eszter Hargittai. "From the 'Digital Divide' to 'Digital Inequality'".
[47] Galperin, Hernan, et al. *Digital Poverty*.
[48] Hargittai, Eszter. *Handbook of Digital Inequality*.
[49] DiMaggio, Paul, and Eszter Hargittai. "From the 'Digital Divide' to 'Digital Inequality'"; Hargittai, Eszter, and Yuli Patrick Hsieh. "Digital Inequality."

The promotion of digital technology as a tool for economic development continued to grow over the 21st century, both as policies and as policy-informing literature. This process gave birth to a subfield among development studies known as information and communication technology for development (ICT4D).[50]

On the other hand, Internet studies began its emergence over the last decades of the 20th century. Scholarly interest and literature publications on the Internet as a subject of study, as well as its social implications, could be traced at least to Murray Turoff and Roxanne Hiltz's The Network Nation, in 1978.[51] Canadian sociologist Barry Wellman identified it as an early first age of Internet studies, in a period mostly dominated by computer scientists focused on developing computer networking technology, which would serve as a stepping stone for an entire field of study.[52]

Wellman described three ages of Internet studies already clear in 2004. The first age, in the early to mid-1990s, was marked by optimism and speculation on the future of the Internet and societies based on the transformative potential of the former.[53] American cyberculture magazine Wired, whose first issue was published in March 1993 with a fast rise in popularity, could be considered an exemplary case of Internet literature from this age.[54] Similarly to the early literature on the digital divide, this period shared its timeframe with the Dot-Com bubble.

The second age, in contrast, took place around the year 2000 and the burst of the financial bubble, with systematic documentation on empirical observations on the social impacts of Internet use. This was the time of the Pew Research Center's Pew Internet & American Life Project and the UCLA Center for Communication Policy's World Internet Project, both founded in 1999.[55]

While Wellman identified the third age in the mid-2000s, the time in which he published his article on the ages of Internet studies. This age was marked by the maturity of the field, which moved from documentation to data and theoretically-driven analysis of the Internet and society; a scholarly transformation parallel to the Internet's evolution of groupware into social network software.[56]

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[50] Heeks, Richard. *Information and Communication Technology for Development (ICT4D).*
[51] Hiltz, Starr Roxanne, and Murray Turoff. *The Network Nation*.
[52] Wellman, Barry. "The Three Ages of Internet Studies: Ten, Five and Zero Years Ago."
[53] Wellman, Barry. "An Electronic Group Is Virtually a Social Network."
[54] WIRED. "WIRED Cover Browser 1993."; Keegan, Paul. "The Digerati!"
[55] Pew Research Center. "Our History"; World Internet Project. "About."
[56] Wellman, Barry. "The Three Ages of Internet Studies: Ten, Five and Zero Years Ago."

A fourth age, however, was arguably triggered in the 2010s as Internet studies became inherently interdisciplinary: integrating technology, economics, politics, history, and media studies to the former sociological and anthropological approaches to the Internet for a wider analysis of its political, economic, cultural, and other societal implications.[57]

Throughout the history of Internet studies, topics of materiality and space were typically approached through the notion of cyberspace, which originally emerged as a metaphorical space from cyberpunk science-fiction—particularly William Gibson's Neuromancer.[58] It evolved, however, into a complex notion of Internet spatiality whose polysemic nature was outlined by media studies professor Lance Strate through a three-level taxonomy. Cyberspace, in other words, is composed of three orders: an ontological space order, a virtual space order where physical and perceptual spaces meet, and a cybermedia space order born out of the user's communication and the aesthetics of computer-user interfaces.[59]

Physical cyberspace is a part of the virtual space order, according to Strate: it's one of the three building blocks that form it. Physicality is defined by the computer's hardware architecture, the site where users and computers are placed when connecting online, and the wires and cables that connect them to power sources and between one another.[60] Internet studies have focused, however, on the first two: the constantly new implications of ever-evolving computer devices, from large computers to mobile smartphones, and the geographically distant people and places connected by the Internet. Wired networks have been predominantly an afterthought in this field, a material condition for everything else to occur.

Digital infrastructure as material cyberspace has been typically addressed, instead, by security and cybersecurity studies. This approach dates back, again, to the American President's Commission on Critical Infrastructure Protection (PCCIP), in 1997, established by Bill Clinton in Executive Order 13010 to protect their energy, banking and finance, transportation, and telecommunications infrastructure from potential threats that would severely disturb their economy and security by incapacitating or destroying them.[61]

The PCCIP originally defined critical infrastructure in the United States as primarily private, but more than just a collection of companies offering services. Instead, they defined

[57] Dutton, William H. *The Oxford Handbook of Internet Studies*.
[58] Gibson, William. *Neuromancer*; Punday, Daniel. "The Narrative Construction of Cyberspace".
[59] Strate, Lance. "The Varieties of Cyberspace". P. 384-385.
[60] Strate, Lance. "The Varieties of Cyberspace". P. 384-385.
[61] President's Commission on Critical Infrastructure Protection. "Critical Foundations: Protecting America's Infrastructures".

them as “a network of independent, mostly privately-owned, man-made systems and processes that function collaboratively and synergistically to produce and distribute a continuous flow of essential goods and services”.[62] That network of systems and processes was composed, according to the PCCIP, of not only information and telecommunications infrastructures but transportation, oil and gas production and storage, water supply, emergency services, government services, banking and finance, and electrical power infrastructures as well.

The potential threats concerning Clinton in 1997, which led him to establish the PCCIP, were cyberattacks: as the expansion and integration of telecommunications increased during the 1990s, they also began to interconnect infrastructures between one another, opening them for an entirely new kind of vulnerability.[63] This historical context positioned the early concept of critical infrastructure within the realm of cybersecurity, concerned with protecting all infrastructures against cyberattacks and digital infrastructure against attacks of any kind.[64]

A Critical Infrastructure Assurance Office (CIAO) was created a year after to coordinate the security of those infrastructures along with the National Infrastructure Protection Center (NIPC) in the FBI.[65] The scope of critical infrastructure, however, expanded into overall security studies in 2002: George W. Bush established the Department of Homeland Security and tasked it to adopt the responsibilities of the CIAO while including national monuments in their definition after the 9/11 attacks.[66]

While sociological approaches to Internet studies have rarely dived into the realm of digital infrastructure, there has been a turn in sociological studies toward infrastructure in the past decade. Two key theoretical precedents from the 1990s for this interest in infrastructures and their relationship with societies are Bruno Latour’s Actor-Network Theory*,* which emphasizes the interconnectedness of human and non-human actors and actants that equally contribute to the construction of complex networks, and Gilles Deleuze’s link between types of machines and types of societies, not in the form of causality but from a perspective in which they express the social forms that create and use them.[67]

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[62] President's Commission on Critical Infrastructure Protection. “Critical Foundations: Protecting America’s Infrastructures”.
[63] President's Commission on Critical Infrastructure Protection. “Critical Foundations: Protecting America’s Infrastructures”.
[64] O’Neil, William D. “Cyberspace and Infrastructure.”
[65] Moteff, J. D. “Critical Infrastructures”.
[66] Moteff, J. D. “Critical Infrastructures”.
[67] Latour, Bruno. *We Have Never Been Modern*; Deleuze, Gilles. “Postscript on the societies of control”; Latour, Bruno. *Reassembling the Social: An Introduction to Actor-Network-Theory*.

In his influential 2003 publication “Infrastructure and Modernity”, director of the Program in Science, Technology & Society at Stanford University Paul N. Edwards presented a sociological outlook for infrastructure as environment, as society, and as modernity. For the latter, he reframed American philosopher Langdon Winner’s reflection on the politics of artifacts to propose a notion in which infrastructures act as laws: they create opportunities and limits at the same time, they promote a particular set of interests in their design and development at the expense of others, they enable the people that inhabit them in modern societies and they constrain them as well.[68]

American anthropologist Brian Larkin furthered this approach in “The Politics and Poetics of Infrastructure”, where he defined infrastructure as physical forms that shape the nature, speed, and direction of movement of the flows that populate the networks for which they were built.[69] Infrastructures, in this sense, are built networks for the flow of goods, people, and information, allowing their exchange over space while, in doing so, providing the base of societies and the environment they inhabit.

Edwards and Larkin’s approach to infrastructure set the ground for several sociological research on various forms of infrastructure over the 2010s. Lisa Björkman, for instance, dived into the water crisis in Mumbai by analyzing pipe flow control and the network of actors involved in the lack of access to water.[70] Penny Harvey and Hannah Knox dived into the vial infrastructure of Peru to create an ethnography of the Peruvian state.[71] Michael Fisch, in turn, focused on the Tokyo subway system to explore the relationship between commuter train networks and Japanese suicides.[72]

For Lisa Parks, professor of Comparative Media Studies and Science, Technology, & Society at MIT, research on media infrastructure is a relatively new approach among critical media studies scholars who, when placing their focus on the offline, normally tend to study networks of digitally connected actors. Infrastructure research, in turn, is concerned with the material conditions for data and audiovisual content to be distributed throughout the world via broadcast, cable, satellite, Internet, and mobile telephony systems. Such a task usually requires an interdisciplinary approach to infrastructures that range from sociology, anthropology, history, and urban studies to architecture and technology studies.[73]

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[68] Edwards, Paul N. “Infrastructure and Modernity.”
[69] Larkin, Brian. “The Politics and Poetics of Infrastructure”.
[70] Björkman, Lisa. *Pipe Politics, Contested Waters*.
[71] Harvey, Penny, and Hannah Knox. *Roads: An Anthropology of Infrastructure and Expertise*.
[72] Fisch, Michael. “Tokyo’s Commuter Train Suicides and the Society of Emergence”.
[73] Parks, Lisa. “Infrastructure”; Parks, Lisa. “Stuff You Can Kick”.

2.3 History of Digital Infrastructure in Mexico

The Internet was born in the Department of Defense of the United States of America, out of its Advanced Research Projects Agency (ARPA). While its first glimpse of existence can be attributed to J. C. R. Licklider, who served as the first head of its computer research program, when he began pushing for the development of computer networking in 1962, the first computer wide-area network was achieved with Lawrence G. Roberts', director of ARPA's experimental network program, Network Control Protocol (NCP) in 1969.[74]

The first four sites networked were the University of California Los Angeles (UCLA), the Stanford Research Institute (SRI), the University of Utah, and the University of California Santa Barbara. This was the birth of the ARPANET, a computer network that by 1972 already consisted of 29 nodes and three cross-country lines connecting the east and west coasts of the United States.[75] Although the network was created for sharing resources among computer researchers, at the time the only computer users, that same year Ray Tomlinson used it to send the first electronic mail; this rapidly became the most popular application on the net, opening its use for telecommunications and people-to-people traffic.[76]

During the 1970s, in the United States, every research community began developing their own networks to link their computers and share resources across the country. The Department of Energy created the MFENet for its magnetic fusion energy researchers and the HEPNet for its high-energy physicists. NASA developed the SPAN for its space physicists. The general computer science community developed the CSNET, funded by the National Science Foundation.[77] Additionally, USENET and BITNET emerged as the first networks built with no purpose other than telecommunications among computer users in 1980 and 1981.[78]

All these independent networks, as well as the emerging wireless network SATNET, led ARPA to develop a network of networks that allowed different technologies, different networking infrastructures, and computers in larger geographies to interconnect. Thus, the Internetting Project was created in 1973, resulting in a Transmission Control Protocol (TCP) and an Internet Protocol (IP) published in 1975 and allowing for a seamless exchange of data across all networks. In the second half of the decade, TCP/IP increasingly substituted the

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74 Hafner, Katie, and Matthew Lyon. *Where Wizards Stay up Late the Origins of the Internet*. P. 42, 94.
75 Hafner, Katie, and Matthew Lyon. *Where Wizards Stay up Late the Origins of the Internet*. P. 140.
76 Hafner, Katie, and Matthew Lyon. *Where Wizards Stay up Late the Origins of the Internet*. P. 118.
77 Leiner, Barry M, Vinton G. Cerf, and David D. Clark. *A Brief History of the Internet.*
78 Lueg, Christopher, and Danyel Fisher. *From Usenet to CoWebs*.

NCP until ARPANET as a whole officially switched to TCP/IP on January 1, 1983: this was finally the dawn of the Internet.[79]

In Mexico, the first public data network was Telepac, introduced in 1980 and part of Telenet, an American commercial public data network established in the United States 5 years earlier.[80] Telepac, however, was directly operated by the Mexican federal government through its Communications and Transports Secretary since transmission of codified signals via public telecommunication networks was banned by law since 1940. In the 1980s, the network was composed of 7 nodes in some of the major cities across the country: Monterrey, Guadalajara, Hermosillo, Mazatlán, Puebla, Villahermosa, and the capital, Distrito Federal.[81]

The first connection established from Mexico to the ARPANET, via Telepac, was achieved in 1982 by Max Díaz, a Mexican Stanford graduate who developed the programs necessary to achieve remote access and data exchanges between the Applied Mathematics Research Institute in the Autonomous National University of Mexico (UNAM) and Stanford University.[82] To achieve the networking, Díaz used the first Mexican public data transfer network, Telepac, which was operated by the Mexican Federal Government's Secretariat of Communications and Transportation (SCT).

In 1987, the Monterrey Institute of Technology and Higher Studies (ITESM) became the first institution in Mexico to gain access to electronic mail by establishing a connection to BITNET. Two years later, both ITESM and UNAM, the two main universities in Mexico, established the first Mexican connection to the Internet via TCP/IP as a consequence of an agreement with the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF) of the United States to grant access to Mexican researchers to American scientific networks.[83]

As documented by the Federal Attorney's Office for Consumers (PROFECO) report on the evolution of telecommunication services in Mexico, Telmex, a state-owned enterprise that entered a process of privatization in 1991, was also the first company in Mexico the SCT granted permission to become a provider of packet-switching services.[84]

In 1996, Avantel became the second Internet service provider as a modification in its concession granted it permission to provide optic fiber and telephone services. Over the last years of the 1990s several ISPs entered the market, with a predominance of cable television

[79] Hafner, Katie, and Matthew Lyon. *Where Wizards Stay up Late the Origins of the Internet*. P. 141.
[80] Moschovitis, Christos J. P. *History of the Internet: A Chronology, 1843 to the Present*. P. 79-80.
[81] Koenigsberger, Gloria. *Los Inicios de Internet en Mexico*. P. 89.
[82] Koenigsberger, Gloria. *Los Inicios de Internet en Mexico*. P. 132, 235.
[83] Koenigsberger, Gloria. *Los Inicios de Internet en Mexico*. P. 235.
[84] PROFECO. "Evolución y Cambio de Oferta de Servicios de Telecomunicaciones". P. 46.

providers since those wireline networks also allowed them to provide Internet access: Megacable, for instance, one of the main cable TV providers in Mexico, became the first high-speed Internet provider in Mexico in 1997.[85]

Mexican President Ernesto Zedillo presented a Federal Law on Telecommunications through which he created the Federal Commission of Telecommunications (Cofetel), also in 1996, as an autonomous administrative organism within the SCT and granted it technical, operative, and financial freedom to perform its daily operations.[86] The goal was to count on a public entity exclusively tasked with overseeing, promoting, and regulating the increasing development of telecommunications coverage across Mexico.

In 2000, the digital infrastructure network in Mexico was mainly composed of two technologies: 92.1% of Internet access was provided via DSL, utilizing existing copper cables previously installed as telephone lines and 7.8% via coaxial cables.[87] Wireless satellite Internet access was first introduced in 2003 as StarGo entered the Mexican market as an ISP targeting companies in mining, oil, fishing, farming, banking, and government facilities with operations in remote locations.[88]

A decade later, the proportion of Internet users with higher speed access via coaxial cable in Mexico increased to 20.6% and DSL-provided users reduced to 74.8%. Additionally, 2.3% of users were using wireless fixed access and 1.6% had broadband optic fiber access.[89] The universe of Mexican Internet users also highly increased over the first 10 years of the 21st century, from 9% in 2005, the first year statistics on households with Internet access were recorded in Mexico, to 22.2% in 2010.[90]

Widespread broadband Internet access was suddenly introduced into the Mexican market in 2010, as a result of a 2006 policy for digital infrastructure development promoted by the SCT four years prior to that date. The Secretariat of Telecommunications and Transportation commissioned the Federal Commision of Electricity (CFE) to install, operate, and exploit a 17,845 kilometer-long network of optic fiber cables across Mexico.[91] The goal was to increase competition across ISPs by offering them infrastructure services that allowed them to provide faster Internet connection to Mexican users, thus lowering Internet service prices, without relying on their investment and development.

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85 PROFECO. “Evolución y Cambio de Oferta de Servicios de Telecomunicaciones”. P. 46.
86 Diario Oficial de la Federación. *Ley Federal de Telecomunicaciones*. June 7, 1995.
87 PROFECO. “Evolución y Cambio de Oferta de Servicios de Telecomunicaciones”. P. 47.
88 PROFECO. “Evolución y Cambio de Oferta de Servicios de Telecomunicaciones”. P. 47.
89 PROFECO. “Evolución y Cambio de Oferta de Servicios de Telecomunicaciones”. P. 49.
90 OECD. “Internet Access”.
91 Registro Público de Concesiones. *FET003667CO-101510*. 2006.

Three major competitors gained access to the optic fiber cable network in 2010: Megacable, Telefónica Movistar, and Grupo Televisa.[92] Two of them were already major TV service providers and the other was a major telephone service provider. The major ISP competitor in the Mexican market, Telmex, did not participate in the concession as it already owned an extensive optic fiber cable network previously public, yet privatized along with the state-owned enterprise in 1991. However, its service supply was limited to a few corporate and residential clients by 2009.[93] Axtel, on the other hand, introduced WiMAX222 dish antennas to the Mexican market in 2009, which allowed wireless broadband Internet connection.[94]

A Federal Telecommunications Reform in 2013 reshaped the institutional framework behind digital infrastructure in Mexico. Among the many transformations brought by the reform, it turned ICT access, including Internet broadband access, into a constitutional right, while also substituting Cofetel with the Federal Institute of Telecommunications (IFT):[95] a non-departmental public body with increased autonomy, particularly from government party politics, which allows it to plan and develop long-term strategies beyond presidential terms. IFT was tasked with continuing with Cofetel's responsibilities, plus breaking telecommunications monopolies to ensure fair competition and mediating controversies among providers.

In the following years, the IFT pushed for major policies aimed at increasing and improving the Mexican digital infrastructure. Firstly, it created a new public concession to increase even more CFE's optical fiber cable network. The ownership of these extended optical fiber cable lines would belong to Telecomm, instead of CFE, another Mexican non-departmental public body within the SCT.[96]

In 2014, 6 Mexican ISPs founded the first-ever Internet exchange point in Mexico. Prior to this development of digital infrastructure, Mexico was the only OECD member state without an IXP within their own country, having larger data transmissions beyond CDN bandwidth traveling to IXPs in the United States. The benefits of this piece of infrastructure within Mexican territory go from reduced operating costs for ISPs and increased availability of Mexican online content for Mexican Internet users to smoother adoption of enhanced protocols such as IPv6.[97]

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[92] Registro Público de Concesiones. *FET006047CO-100596*. 2016.
[93] Telmex. "Informe Anual 2009".
[94] Axtel. "Informe Anual 2009".
[95] Diario Oficial de la Federación. *Reforma de Telecomunicaciones*. June 11, 2013.
[96] PROFECO. "Evolución y Cambio de Oferta de Servicios de Telecomunicaciones".
[97] Consorcio para el Intercambio de Tráfico de Internet. "Antecedentes".

IFT's attribution for public concessions increased competition with lower costs of entry, resulting in higher amounts of local and regional ISPs across Mexico enhancing Internet connectivity. Telecomunicaciones Indígenas Comunitarias, a non-profit association of 16 Indigenous rural communities in Oaxaca, as well as a small technical support team, gained the first Indigenous public concession for telecommunications in Mexican history, in 2016, to develop and manage mobile phone networks and radio broadcasts for locations historically bypassed by market service providers.[98]

By 2020, coaxial cable networks and modems finally surpassed DSL copper cable networks as the most common technology used for Internet access in Mexico, with 39% of all Internet access being through this technology. In contrast, 36% of Internet connections were achieved via DSL. Optic fiber broadband access increasingly bridged the gap over the decade, amounting to 24% of all Internet connections among Mexicans.[99] More than half of all households achieved access to the Internet by 2020: the percentage was also almost three times higher than it was in 2010, reaching 59.9%.[100]

The number of Internet service providers in Mexico by 2020, on the other hand, amounts to 544 in total. The 4 main ISPs, competing across the entire country and concentrating the most Internet users, are América Móvil (AMX, the multinational corporation built around Telmex after its privatization and acquisition by Mexican conglomerate Grupo Carso), Televisa, Megacable, and Total Play. The remaining 540 ISPs operate in a range between 1 and 77 municipalities in different regions around Mexico.[101]

The most recent data, corresponding to 2023, shows the trend toward rapid adoption of technology for high-speed broadband access continued with substantial results by the first years of the 2020s. Mexican households with Internet access via optic fiber cable networks are, on average, 62.3% of all digitally connected households. 22.57% of households accessed the Internet through coaxial cable networks, and the remaining 10.51% did so via DSL copper cables, showing a fast drop in low-speed Internet access technology by ISPs. Wireless satellite Internet access amounted to only 0.72% of all connections.[102]

The digital infrastructure landscape in Mexico showed an accelerated development 10 years after the Federal Telecommunications Reform of 2013, and Internet adoption among

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98 Tic-Ac. "Telecomunicaciones Indígenas Comunitarias".
99 IFT. "Banco de Información de Telecomunicaciones", own calculations.
100 OECD. "Internet Access".
101 IFT. "Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos".
102 IFT. "Banco de Información de Telecomunicaciones", own calculations.

the Mexican population continued to increase in response. By this point, over 68.5% of Mexican households had achieved Internet access.[103]

2.4 Defining Digital Infrastructure

Taking into consideration the topics discussed in the three previous sections of Chapter 2, digital infrastructure must be understood as a subset of both information and telecommunication technology (ICT) and media infrastructure, which provide users of digital devices with Internet access via material networks of computer networking technologies for data transmission. These technologies allow users to establish digital telecommunications between one another and access media posted online by users, groups, organizations, and companies all over the world, via TCP/IP protocols.

While digital infrastructure can be composed of wireline and wireless networks, with varying data transfer speeds depending on the technology employed for the Internet connection, satellite wireless Internet services have been reduced to a minor and are currently less than 1% of the digital infrastructure in Mexico. The speed of the Internet connectivity granted by technology, in turn supplied by an ISP, is an indicator of varying degrees of Internet access quality and contributes to the form of the digital infrastructure network.

Digital infrastructure is mostly supplied to users by private Internet service providers, which introduce the technologies into the national market in their pursuit of competitive advantage. The investment into and development of digital infrastructure, however, may be public: such is the case of the optic fiber network operated by most ISPs after the Mexican government created it to enhance Internet services in Mexico. Two other elements of the digital infrastructure are the digital devices owned and used by Mexicans across the country and the Internet exchange point developed in Mexico City in 2016.

Digital infrastructure, as any infrastructure from a sociological approach, is also a built environment whose form is an expression of the society that built and uses it. In this case, the form of digital infrastructure refers to the spatial extension of its networks of copper, coaxial, and optic fiber cable: the geographical location of its nodes, which grant access to the communities inhabiting those places, as well as the voids left from its absence in places inhabited by disconnected communities and the degrees of intensity in its nodes as a result of its clustering.

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[103] OECD. "Internet Access".

In conclusion, digital infrastructure is a large system of fixed wireline (and wireless) networks of digital data transfer technologies for computer networking dispersed across the Mexican territory. Those technologies are limited in this research to copper cables used for digital subscriber lines (DSL), which relies on existing telephone lines for digital data transmission, coaxial cables used to provide fixed Internet services to modems and personal computers in households via Ethernet connection, and fiber optic cables for fixed high-speed, long-distance broadband Internet connection.

CDNs, IXPs, and digital devices such as personal computers and smartphones, while highly relevant for the broader picture of the Internet connectivity network, will not be discussed in the following chapters when referring to digital infrastructure. However, the Internet service providers (ISPs) will be grouped into two main categories, following the terminology used in Mexican law and in the Directorate of Economic and Regulatory Analysis of the IFT depending on the technologies they supply: fixed broadband Internet access service (SBAF) providers, all of which use coaxial cables although in some areas they also use optical fiber cables, and fixed TV and radio restricted service (STAR) providers, which mainly use their existing DSL copper cables for Internet service provision.

Chapter 3: Into the Internet Connectivity Landscape

How is digital infrastructure dispersed across the Oaxacan space? As discussed in Chapter 2, digital infrastructure has been in constant development and deployment since the technology for computer networking was introduced to Mexican territory in 1982 and Internet service providers began supplying packet-switching services in 1991. Its constant evolution, both due to the pursuit of new users previously disconnected and to the introduction of newer data transmission technologies, requires any description of digital infrastructure dispersion across space to be considered only as a snapshot of an ongoing historical process.

The answer to this sub-question, therefore, entails a snapshot of the Internet connectivity landscape of Oaxaca in 2020. Such a landscape, in turn, is here discussed as two overlapping sceneries—similar to the color layers of a risograph print, the full picture only emerges from the juxtaposition of the two. One layer is the space occupied by the digital infrastructure: the networks of copper, coaxial, and optic fiber cables used to provide Internet services as a large technical system extended throughout Oaxaca. The other layer is the space occupied by the inhabitants of Oaxaca and the social relations held by them as social systems. Both their spatial coincidence and divergence and the relations the former establish with the latter at this point in time, result in the full picture of their Internet connectivity landscape.

3.1 Oaxaca as Social Space

The social layer of the Internet connectivity landscape is understood in this research through the lens of Henri Lefebvre's notion of social space.[104] The Oaxacan space is not composed of lifeless things (ground, rivers, mountains, beaches, valleys, streets, and buildings) but of past, present, and future social relations: it is both the result of past actions and the platform over which coming actions occur. Its configuration, for this reason, enables or inhibits future actions based on the form it acquired from those actions passed. Space is, in other words, a non-neutral socially produced order that lays over material geographies.

The Oaxacan social space, following this perspective, is discussed through some of its main socio-demographic and geographical characteristics. By tracing an overview of Oaxaca, focusing particularly on the differences among its regions and districts, context emerges on the social meaning behind the uneven deployment of digital infrastructure throughout these

[104] Lefebvre, Henri. *The Production of Space*.

areas to inform the following analysis on digital inequality and infrastructure clustering in Chapters 4 and 5.

3.1.1 Demographic & Geographic Data Sources

To trace the socio-demographic and geographical characteristics behind the Oaxacan social space in 2020, this research is supported by public data sourced from the National Institute of Geography and Statistics (INEGI) in Mexico: a non-departmental public body tasked with collecting and publishing information about the Mexican territory, population, economy, and resources. INEGI was formed in 1983 by grouping together four Mexican public bodies: the Directorate General of Statistics, operating since 1882, the Directorate General of Geography, in operations since 1968, the Directorate General of Informatics Policy, and the Directorate General of Information Integration and Analysis.[105]

Most of the socio-demographic information provided by INEGI for this research comes from its Population and Housing Census (CCPV) of 2020: the latest and 14th consecutive edition the Mexican government conducts of its national census, which has taken place every 10 years since 1900 after the pilot census of 1892 and the first General Census of the Mexican Republic in 1895.[106] The statistical information from the 2020 census is further broken down by INEGI into 7 geographical levels: the national, state, municipal, local, neighborhood (defined as basic geostatistical areas, or AGEB, composed of several urban or rural blocks), and urban block level.

Among the socio-demographic indicators covered in the Population and Housing Census of 2020 for each geographical level are data on the Mexican population, including the total amount of population, the percentage of men and women, mean age, and population density. It additionally provides information on the level of education, literacy, and languages spoken by the Mexican population, as well as their ethnicity (including Indigenous and Afro-descendant ethnicities), and their economic activity status.

While the Population and Housing Census of 2020 also documents the information and communication technology (ICT) devices available in Mexican households, along with their access to electricity, water, and sewers, their household appliances, and the vehicles they own for transportation, this research is also supported in the data provided by the National Survey on Availability and Use of Information Technology in Households (ENDUTIH)

105 INEGI. “Quiénes somos”.
106 INEGI. “Censo Población y Vivienda (CCPV) 2020”.

conducted by INEGI in 2022.[107] This type of data was first recorded by INEGI in 2001, and surveyed yearly on a state level for its Module on Availability and Use of Information Technology in Households (MODUTIH) until 2014.[108] The ENDUTIH was introduced in 2015 to continue these efforts with larger geographical scope and deeper insights into household ICT adoption on a yearly basis.

A key aspect of the Oaxacan social space that can not be sourced from the Population and Housing Census is the economic data on Mexican incomes and spending. This data is instead sourced from the National Survey on Household Income and Spending (ENIGH), which is conducted every two years by INEGI, and the Current Income for Mexican Municipalities (ICMM), which was first introduced in 2020.[109] These surveys record households' amount, source, and distribution of spending and income, as well as the economic activity and sociodemographic characteristics of their inhabitants, the ENIGH typically breaks the data down into income percentiles as well as geographically, into the national and state level. While the ENIGH does not provide information per municipality, the ICMM does, complementing the economic data of the former.[110] These surveys also define settlements with a population of over 2.5 thousand inhabitants as cities and rural localities as those with less than 2,500 people.

Although the CCPV does collect data on literacy, school desertion, and access to healthcare among the Mexican population, as well as data on household flooring, access to water, sewers, electricity, fridges, and washing machines, the Mexican National Council for Social Development Policies Evaluation (CONEVAL) takes this data to calculate a social lag index (IRS), as part of its poverty measurements. The results of this index calculation have been published every 5 years since the year 2000, with the latest version being that of 2020, providing insights for every state and every municipality, as well as Mexico as a whole.[111] While the IRS is typically used for measuring areas lagging on access to education, healthcare, and quality housing development, in order for social policies to address them, it also plays a role in this research's description of the Oaxacan social space.

The socio-demographic and economic data sourced from the INEGI's CCPV 2020, ENDUTIH 2022, ENIGH 2022, and ICMM 2020, as well as the CONEVAL's IRS 2020, will

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107 INEGI. "Encuesta Nacional Sobre Disponibilidad y Uso de Tecnologías de la Información en los Hogares (ENDUTIH) 2022".
108 INEGI. "Módulo sobre Disponibilidad y Uso de Tecnologías de la Información en los Hogares (MODUTIH) 2014".
109 INEGI. "Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH) 2022".
110 INEGI. "Ingreso Corriente para los Municipios de México (ICMM) 2020".
111 CONEVAL. "Índice de Rezago Social 2020".

be used in this research not only in this chapter, to discuss Oaxaca's Internet connectivity landscape, but on Chapter 4 and 5 as well. In Chapter 4, these datasets will inform the socio-demographic, socio-economic, and socio-spatial variables with which correlations with digital infrastructure will be explored as part of a quantitative municipal comparative analysis. In Chapter 5, as a conclusive analysis for this master's thesis, insights from Chapters 2, 3, and 4 will be readdressed to answer the main research question, including the data from these sources.

3.1.2 Municipal Structure of Oaxaca

The complex political division of the Oaxacan territory as a state of the Mexican Republic is a result of the political history of this region, which can be traced back to the earliest colonial territorialization by the Spanish Empire. Its capital, the city of Oaxaca, was founded on September 14, 1526, under the name of Antequera by Spanish settlers.[112] The region around this early colonial settlement was widely populated by Indigenous communities, including the zapoteco and mixe resistance groups that rejected colonial occupation. As the colony was further territorialized over the following couple of decades, towards 1548, Oaxaca became one of the first provinces within the Spanish Viceroyalty of Nueva España.[113]

As of 2020, the 8 regions of Oaxaca are Sierra de Flores Magón, Costa, Papaloapan, Valles Centrales, Istmo, Mixteca, Sierra de Juárez, and Sierra Sur. Each of these regions is composed of two to seven districts, into which all 570 Oaxacan municipalities are arranged. The regions and districts serve as broader categories in this research to discuss the Oaxacan social space beyond the individual characteristics of each municipality, as well as for municipal comparative analysis to identify patterns in the Internet connectivity landscape of Oaxaca. The general composition of each region is detailed in Table 1, while INEGI's map of the municipal division of Oaxaca in Figure 1 provides a visual representation of the spatial arrangement of these municipalities.

Table 1: *Municipal Structure of Oaxaca by Regions, Districts & Population*

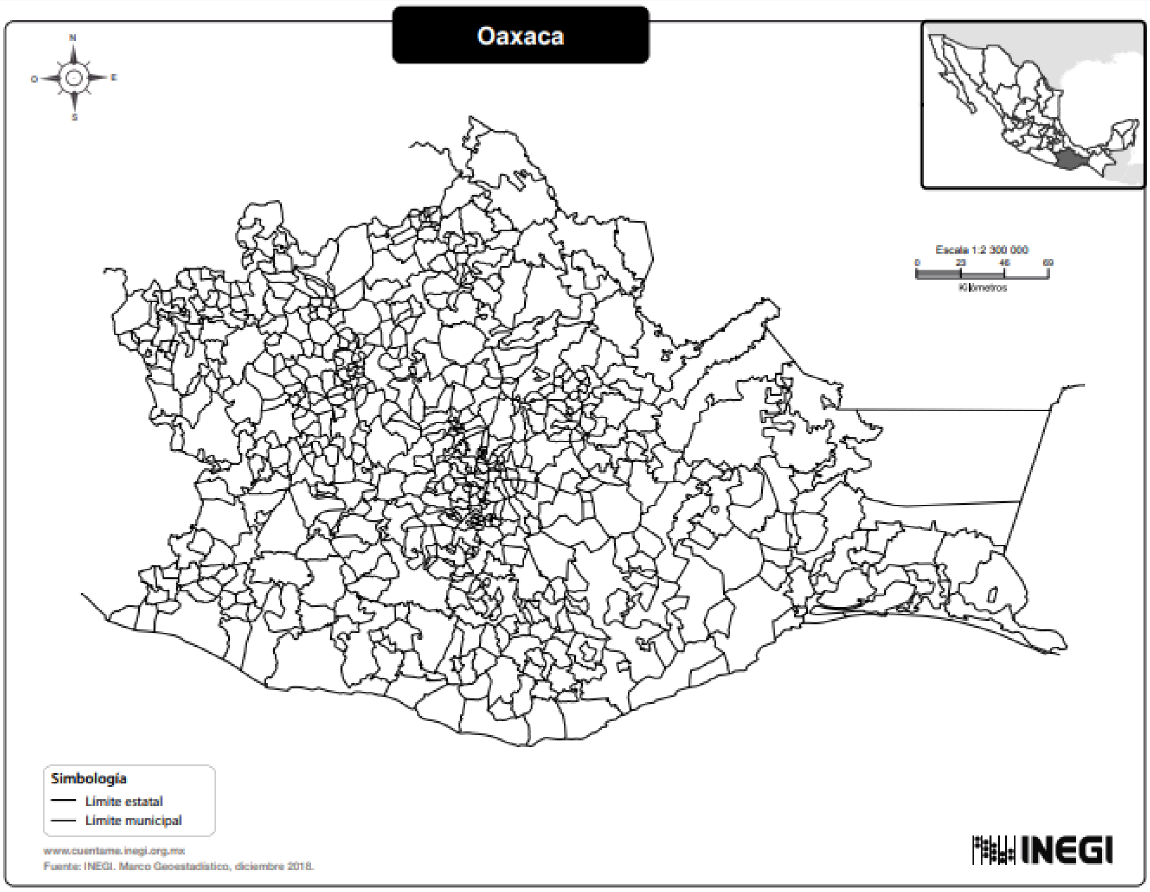
Region	**Districts**	**Municipalities**	**Population**
Sierra de Flores Magón	Teotitlán	25	158,990
	Cuicatlán	20	58,554

[112] INEGI. "Síntesis Geográfica del Estado de Oaxaca".
[113] Ordóñez, María de Jesús. "El Territorio del Estado de Oaxaca: Una Revisión Histórica."

Costa	Jamiltepec	24	200,290
	Juquila	12	163,580
	Pochutla	14	216,795
Papaloapan	Tuxtepec	14	416,824
	Choapan	6	48,368
Valles Centrales	Tlacolula	25	127,209
	Ocotlán	20	79,270
	Centro	21	607,704
	Zaachila	6	52,677
	Zimatlán	13	61,183
	Etla	23	147,599
	Ejutla	13	48,148
Istmo	Juchitán	22	387,117
	Tehuantepec	19	260,096
Mixteca	Nochixtlán	32	67,506
	Tlaxiaco	35	124,741
	Juxtlahuaca	7	79,467
	Huajuapan	28	153,107
	Teposcolula	21	34,929
	Silacayopam	19	35,654
	Coixtlahuaca	13	10,458
Sierra de Juárez	Ixtlán	26	41,036
	Villa Alta	25	34,344
	Mixe	17	116,457
Sierra Sur	Putla	10	98,289
	Sola de Vega	16	86,179
	Miahuatlán	32	138,515
	Yautepec	12	36,609

Source: Gobierno del Estado de Oaxaca, Government of the State of Oaxaca, “Municipios” (April 21, 2024), and INEGI, National Institute of Geography and Statistics, “CCPV 2020”, own calculations.

Figure 1: *Map of Oaxacan Municipalities*



Source: INEGI, National Institute of Geography and Statistics, "División Municipal de Oaxaca", 2018.

3.1.3 Demographic and Geographic Characteristics of Oaxaca

One of the southernmost states in Mexico, Oaxaca is distinguished by its historical, ethnic, and socio-political complexity, with a lineage that traces back to pre-colonial times. Covering 93,757.60 square kilometers, Oaxaca constitutes 4.75% of Mexico's total land area, with a population of 4,132,148 as of 2020 which accounts for 3.28% of the national population. The state's topography is dominated by the Sierra Madre del Sur mountain range, which fragments the territory and the population within it. This geographical feature significantly influences the population density, which stands at 44.1 inhabitants per square kilometer, making Oaxaca 31.4% less densely populated than the Mexican average.[114]

The demographic profile of Oaxaca reveals a mean age of 28 years, with a gender composition of 52.28% female and 47.72% male.[115] The state's economic indicators highlight

[114] INEGI. "Censo Población y Vivienda (CCPV) 2020"; Percentages are own calculations based on data sourced from CCPV 2020.
[115] INEGI. "Censo Población y Vivienda (CCPV) 2020"; Percentages are own calculations based on data sourced from CCPV 2020.

an average municipal income 27.91% below the national average and makes Oaxaca a considerably poorer state in the Mexican context.[116] The Gini index stands at 0.424, indicating that Oaxaca has 5.47% higher income inequality compared to the national average.[117]

The social lag index, reflecting the lack of access to education, healthcare, and quality housing in Mexican households, is notably high in Oaxaca: at 2.59089, it makes this state the second-highest in Mexico. Educational attainment is low, with an average of 8.1 years of schooling; the average population of Oaxaca in 2020 did not graduate from high school. Additionally, 11.8% of the population over 15 years old is illiterate, which is 151% higher than the national average. A significant 90.5% of the population lives in towns with fewer than 5,000 inhabitants, it is almost entirely rural. Its Indigenous population also constitutes 65.73% of the total while 4.71% identify as Afro-descendant, both figures notably higher than the national averages: 205.7% and 130.8% higher respectively.

The Valles Centrales region, as its name suggests, is located in the central valleys of Oaxaca, it's surrounded by mountain ranges and is home to the state capital, Oaxaca de Juárez. This region, with an area of 9,335.9 square kilometers, encompasses 121 municipalities: 21.23% of the state's total municipalities. In Valles Centrales live 1,193,897 people, making up 28.89% of Oaxaca's total population. The region's population density is significantly higher than the state average at 392.54 inhabitants per square kilometer.

The demographic profile of Valles Centrales includes a mean age of 29.92 years, with 47.55% of the population being male. Only 10.10% of the population over 15 years old is illiterate, the lowest in Oaxaca. Economically, the region's average municipal income is 67.5% higher than the state average. 69.23% of its population is old enough to work, and the average years of schooling among those over 15 is 7.29, the highest in Oaxaca. While slightly less rural than the state's average, 80.67% of the population live in towns with fewer than 5,000 inhabitants. Indigenous people constitute 62.93% of its population, the lowest rate in Oaxaca but still significant, and only 2.63% identify as Afro-descendant. These valleys' social lag index is 0.27628, reflecting a medium, almost low level of social lag, the second lowest in Oaxaca.

Costa is the coastal region of Oaxaca, bordering the Pacific Ocean and renowned for its tropical beaches in Santa María Huatulco and San Pedro Mixtepec, which are prominent

[116] INEGI. "Ingreso Corriente para los Municipios de México (ICMM) 2020"; Percentages are own calculations based on data sourced from ICMM 2020.
[117] INEGI. "Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH) 2022"; Percentages are own calculations based on data sourced from ENIGH 2020.

national and international tourist destinations. Covering 11,568.9 square kilometers, this region includes 50 municipalities, 8.77% of the state's total while the population of Costa is 593,034, making up 14.35% of Oaxaca's total population. The coastal population density is 52.2164 inhabitants per square kilometer, about half the state average.

The demographic composition of Costa shows a mean age of 25.94 years, with 48.25% male. The illiteracy rate is 17.91%, the second highest in Oaxaca. 66.6% of its population is between 12 and 65 years old; considered by INEGI, therefore, its occupied and unoccupied labor force. The average level of education is 7.29 years. Rural settlements dominate, with 85.47% of the population living in towns with fewer than 5,000 inhabitants. Indigenous people make up 67.27% of the population, while 21.92% are Afro-descendant: by far the highest percentage in the state. The social lag index is 0.93379, indicating a medium to high level of social lag.

Istmo de Tehuantepec is the narrowest strip of land between the Pacific Ocean and the Gulf of Mexico, notable for its international port and oil refinery in Salina de la Santa Cruz. The homonymous region in Oaxaca covers nearly half of it, making it the largest of all 8 Oaxacan regions: it consists of 20,619.1 square kilometers and includes 41 municipalities, 7.19% of all municipalities in the state. The population in Istmo is 642,220, making up 15.54% of Oaxaca's total population, with a population density of 73.07 inhabitants per square kilometer.

Istmo's demographic profile includes a mean age of 31.8 years, with 48.84% being male. The illiteracy rate is 12.59%, the second lowest in Oaxaca. The average municipal income is the second highest in Oaxaca. The labor force participation rate is 68.69% while the average years of schooling are 7.2, also the second highest in the state. While 66.64% of the population lives in rural areas, Istmo is the most urbanized region in Oaxaca. Indigenous people constitute 76.6% of the population, while 2.21% are Afro.descendant. The social lag index is 0.15879, also the lowest in the state.

Previously known as Cañada, Sierra de Flores Magón was renamed after the anarchist brothers Ricardo and Enrique Flores Magón: intellectual precursors of the Mexican revolution in the early 20th century and born in these mountains. This northern mountain region covers 4,473.5 square kilometers, making it the smallest region in Oaxaca, and includes 45 municipalities, 7.89% of the state's total. The population is 199,198, accounting for 4.82% of Oaxaca's total population; it is the second least populated region in Oaxaca. The population density is 78.32 inhabitants per square kilometer.

Demographically, the mean age is 30.02 years, with 47.98% being male. The illiteracy rate is 23.78%, the highest in Oaxaca, and the average years of schooling in Sierra de Flores Magón is 5.58, the lowest in Oaxaca: almost a quarter of its population can't read or write while its average population didn't get to finish elementary school. The average municipal income is also the lowest in the state, and the social lag index is 1.45829, making it the one with the highest lack of education, healthcare, and quality housing. Additionally, almost all of the population, 96.10%, lives in rural areas. Indigenous people constitute 86.58% of the population, while 3.69% are Afro-descendant.

Renamed after the 19th-century Mexican president Benito Juárez, considered the founding father of the Mexican Republic, Sierra de Juárez is located in the northern mountains of Oaxaca; hence its previous name, Sierra Norte. It covers 8,917.9 square kilometers and includes 68 municipalities, 11.92% of the state's total. A total of 175,226 people inhabit it, making it the least populated region in Oaxaca: only 4.24% of the state's total. The population density, on the other hand, is 36.82 inhabitants per square kilometer and it is 100% rural: there are no towns with over 5,000 inhabitants in it.

The mean age in Sierra de Juárez is 31.62 years, with 47.26% male. The illiteracy rate is 13.22%, 9% lower than the state's average, while the average income of the inhabitants of these northern mountains is the second lowest in Oaxaca. The labor force participation rate is 66.18%, and the average years of schooling are 6.37. Indigenous people make up 92.44% of the population, the highest in Oaxaca, while only 1.81% consider themselves Afro-Mexicans. While rural and impoverished, however, the social lag index is 0.58458, indicating a medium level of social lag.

Situated between Valles Centrales and Costa, Sierra Sur spans 14,964.8 square kilometers, comprising 70 municipalities, 12.28% of the state's municipalities belong to the southern mountain range of Oaxaca. The population is 360,421, accounting for 8.72% of Oaxaca's total population. The population density is 32.88 inhabitants per square kilometer: it is the second least densely populated Oaxacan region.

The mean age in Sierra Sur is 26.54 years, 47.93% being men. The illiteracy rate is 16.69%. The average municipal income is 32% below the state average and the second lowest income earning population in Oaxaca. The labor force participation rate is 65.89%, and the average level of education is 5.95 years, the second lowest in Oaxaca: the average Sierra Sur inhabitant also didn't manage to finish elementary school. Additionally, almost all of the population, 98.15%, lives in rural areas. Indigenous people make up 75.38% of the population, while 2.23% are Afro-descendant. The social lag index is 1.20177, on the other hand, indicating a high level of social lag: it is the second highest in Oaxaca.

Papaloapan, located along the Papaloapan River and neighboring the state of Veracruz, beyond the Sierra de Juárez mountains, is home to the second most populated Oaxacan city in San Juan Bautista Tuxtepec. This region covers 8,460.1 square kilometers and includes 20 municipalities, the fewest in all of Oaxaca. Up to 475,440 people inhabit this region, 11.5% of all of Oaxaca's total population. Its population density is 62.71 inhabitants per square kilometer, it is 47% less densely populated than the state's average.

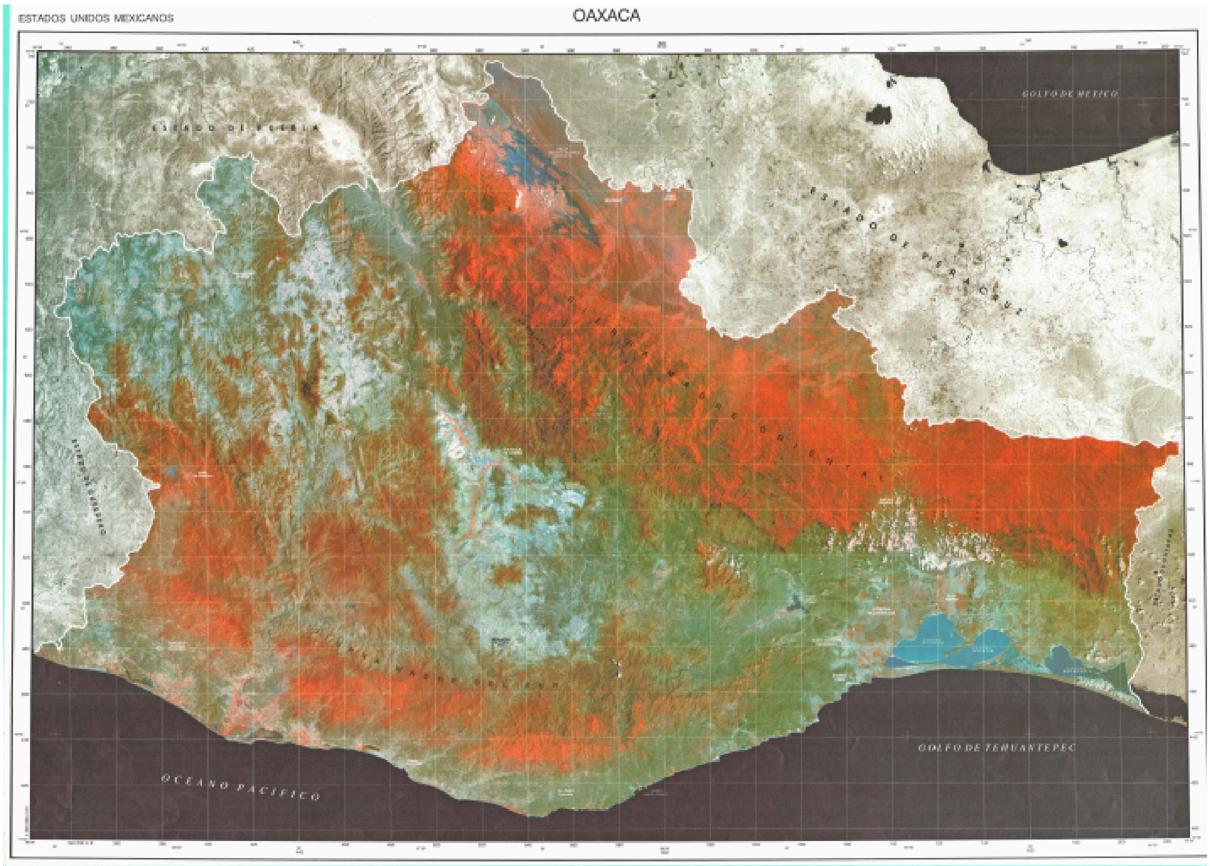
The demographic profile of Papaloapan shows a mean age of 27 years, with 51.86% being female. The average municipal income is 18% below the state average, and the social lag index is 1.07813, one of the highest in Oaxaca. The illiteracy rate is 16.92%, the average years of schooling are 6.18, and the labor force participation rate is 67.35% for the population inhabiting the areas along the Papaloapan River. Rural settlements account for 81.54% of the population, while ethnically 79.75% are Indigenous and only 1.82% identify as Afro-descendant.

Finally, located in the western corner of Oaxaca, the Mixteca region borders the states of Puebla and Guerrero and is home to one of the largest and most ancient Indigenous communities in Mexico, the Mixtec. This region covers 15,418.2 square kilometers and includes 155 municipalities, by far the largest number in Oaxaca at 27.19% of the state's total. The population is 473,997, accounting for 11.47% of Oaxaca's total population, while the population density is 27.54 inhabitants per square kilometer: it is the least densely populated region in Oaxaca.

The mean age among the Mixteca population is 32.61 years, with a gender composition of 47.38% male. 14% of its inhabitants cannot read or write, and the average municipal income is 26% below the state average. The labor force participation rate is 63.65%, and the average level of education is 6.38 years. Almost all of the population, 98.02%, lives in rural areas. Following a similar pattern to other highly Indigenous Oaxacan regions, in Mixteca Indigenous people make up 77.75% of the population, while 1.98% are Afro-descendant. The social lag index is 0.65229, indicating a medium level of social lag.

These descriptions emphasize that the Oaxacan society is not a monolith: far from being a unit with consistent features across the entire state, every region holds unique and differentiated social characteristics that make for its own constitution of Oaxaca as a social space. This regional social production of Oaxaca is, as previously described, not only arbitrarily laid over its territory but deeply tied to its unique mountainous topography. For this reason, the topographic map of Oaxaca in Figure 2 provides a visual representation of the spatial arrangement of these mountains, valleys, and coastline for a better understanding of each region’s location.

Figure 2: *Map of Oaxacan Topography*



Source: INEGI, National Institute of Geography and Statistics, “Espaciomapa Estatal: Oaxaca”, 1996.

3.2 The Internet Connectivity Landscape in Oaxaca

In order to discuss the digital infrastructure’s spatial form as a technological layer in the Internet connectivity landscape, Thomas Parke Hughes’ notion of the social construction of technology (SCOT) is particularly relevant. As a sociological and historical theory for understanding technology from a social constructivist perspective, it provides several key concepts to support the dual-layered notion of the Internet connectivity landscape proposed in this research. The concept of large technical systems, on the one hand, helps frame infrastructures as extensive systems composed of networked socially constructed artifacts: however large and however complex, infrastructures can be sociologically analyzed in a similar manner to which machines and devices have.[118] In Postscript on the Societies of Control, for instance, Gilles Deleuze proposed underlying politics in machine designs as they express the social forms that were capable of producing and using them.[119]

On the other hand, Thomas Parke Hughes also proposed a notion in which infrastructure networks are not only expressive artifacts but socially embedded systems. Large socio-technical systems require not only the material assemblage of its parts but also organizational forms to produce and operate them.[120] Digital infrastructure, for instance, relies not only on its coherent interaction with other technical systems, such as the electrical system in place but also on the managerial organization of Internet service providers to install and operate them. Digital infrastructure also relies on the social system of its users, naturally, as their demand and locations across Oaxaca inform ISPs of their spatial operation and expansion, thus giving the digital infrastructure its spatial form.

By placing its focus on the boundaries digital infrastructure holds with the social systems of Internet service providers and Oaxacan inhabitants, this research attempts to achieve insights that help better understand its form and its limit. This positions the research in between the two streams identified by Christian Sandvig on the study of Internet infrastructure: it draws from the relationist perspective by questioning to whom is digital infrastructure addressed and who in consequence is left out. Relationists have also studied five attributes of infrastructure, one of them being its standardization: the way in which it seamlessly interconnects with other systems and processes, both technical and social, resulting in its perceived normalcy and invisibility. This research also draws, however, from the new materialists who move from discussing infrastructure as a mere metaphor for intangible social or data structures and study, instead, the material objects composing the infrastructure itself.[121]

3.2.1 Indexes on Infrastructure Clustering

This research builds on the findings reported by the foundational Analysis on Fixed Telecommunications Services Infrastructure Competition published by the Directorate of Economic and Regulatory Analysis of the Federal Institute of Telecommunications in Mexico (IFT).[122] In particular, the research is based on the two indexes developed by the IFT in this

[118] Parke Hughes, Thomas. “The Evolution of Large Technological Systems.” P. 46.
[119] Deleuze, Gilles. “Postscript on the Societies of Control.” P. 3-7.
[120] Parke Hughes, Thomas. “The Evolution of Large Technological Systems.” P. 93, 100, 103.
[121] Sandvig, Christian. “The Internet as Infrastructure.”
[122] IFT. “Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos”.

report to measure the infrastructure clustering and digitalization development of all municipalities across Mexico.

The first index is the Municipal Competition Index (ICM). This index measures in every municipality not only the existence of fixed broadband Internet service providers but also the number of competitors that are operating per municipality and the likeness of a municipality to have these characteristics based on its proximity to another municipality with similar characteristics. This way, the ICM scores provide quantitative data on the quality and quantity of digital infrastructure present in a municipality, as well as its degree of clustering based on its spatial location and the ICM scores of its surroundings.

The ICM is calculated by the IFT by taking into account 8 variables, which were in turn sourced from its official Information Bank on Telecommunications (BIT). These variables are mainly focused on accounting for the spatial dispersion of fixed broadband Internet access service companies (SBAF) and wireline TV and radio restricted service companies (STAR), as these are the Internet service providers operating the copper, coaxial, and fiber optic cable networks. The 8 variables in the ICM are the number of SBAF large-scale operators, the number of SBAF large-scale operators using fiber optic cable networks, the number of wireline STAR large-scale operators, the market share of the main SBAF large-scale operator in the municipality, the market share of the main wireline STAR large-scale operator in the municipality, the SBAF and STAR Herfindahl-Hirschman Index results, and the number of small-scale operators supplying fixed wireline SBAF.[123]

The second index developed by the IFT is the Municipal Digital Development Index (IDDM). This index, while not measuring infrastructure clustering, provides quantitative data on digital infrastructure availability and also Internet demand and Internet adoption readiness in each municipality. The IDDM takes into account 10 variables, among which are coaxial and fiber optic SBAF and wireline STAR availability per municipality, but also personal computer and over-the-top (OTT) media services penetration among its population.[124]

3.2.2 A General Overview

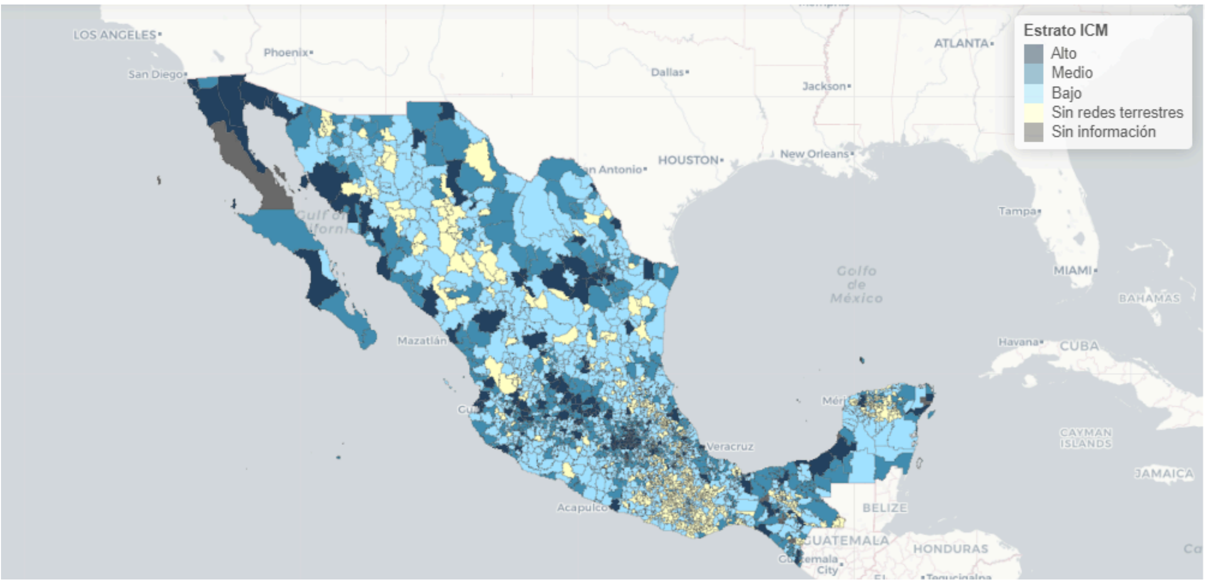
The map showcased in Figure 3 was extracted from the IFT's Directorate of Economic and Regulatory Analysis website reporting the ICM results from their analysis, and it spatially showcases the snapshot of Mexico's Internet connectivity landscape in 2020. The color codes represent the tiers of digital infrastructure quantity and quality present in every municipality,

[123] IFT. "Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos". P. 46.
[124] IFT. "Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos". P. 54.

as identified by the IFT, ranging from high in dark blue to low in light blue and total absence in white. A few municipalities are colored in grey, signaling no information was available to calculate an ICM score.

The IFT identified several clusters of digital infrastructure across Mexico. The most relevant is in Mexico City, where a high concentration of high-quality infrastructure is found across all of its municipalities, reporting an average ICM score of 70. The municipalities with the highest presence of digital infrastructure are Azcapotzalco, Gustavo A. Madero, and Iztacalco, scoring 85, 83, and 82 respectively, while the lowest is Tláhuac with a 42 ICM score. All of these are still considered high-tier scores, meaning that the entire Mexican capital is overall well connected considering the national average score is 12.

Figure 3: *Map of Mexican Digital Infrastructure's Spatial Form*



Source: IFT, Federal Institute of Telecommunications, "Indicadores de Infraestructura y Digitalización a Nivel Municipal" (May 12, 2024).

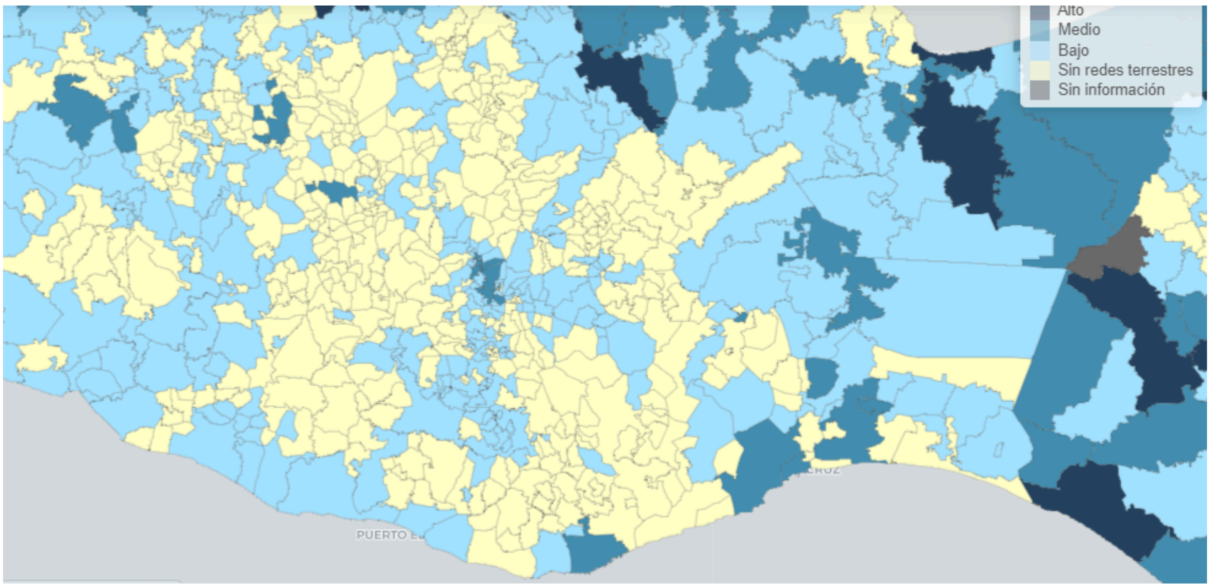
A common dismissal of choropleth maps that should be addressed in this discussion is that, when involving the intensity of human activities, they often primarily reflect population hotspots. In other words, maps depicting higher and lower amounts of human acts across a geographical map are often really population maps with few insights beyond that fact. While the amount of population inhabiting each municipality is expected to show a correlation with the amount of digital infrastructure quantity and quality present in them, as it will be furtherly explored in Chapter 4, these snapshots of the Internet connectivity landscape in Mexico cannot be reduced to matters of population.

Figure 3 and (upcoming) Figure 4 cannot be reduced to population maps because they deal with municipalities, which exist due to people inhabiting those areas, as well as digital infrastructure: not Internet users nor Internet traffic but the basis for any Internet connection to even exist. Such a reductionism would not explain, for instance, the existance of digital infrastructure gaps where ICM scores equal 0, as population is not 0 in those municipalities. Equating these two variables would ignore the relevance of analyzing social spaces where digital infrastructure is in a historically initial stage of development, where total coverage has not been reached, as well as those with evidence of disproportionate clustering, which Oaxaca was chosen for showcasing.

3.2.3 A Snapshot of Oaxaca

Oaxaca's Internet connectivity landscape in 2020 is, as already established in this research, a dual-layered snapshot featuring the spatial form of Oaxaca's digital infrastructure as well as the Oaxacan social space. A table with both ICM scores and demographic data on each of Oaxaca's regions and districts, featuring own calculations, is attached to this document in Appendix 1 for a quick quantitative overview of these two layers. Additionally, the map in Figure 4 was also extracted from the IFT's website, and it spatially showcases the snapshot. These two assets structure this last section, which provides an answer to the sub-question articulating this chapter: How is digital infrastructure dispersed across the Oaxacan space?

Figure 4: *Map of Oaxacan Digital Infrastructure's Spatial Form*



Source: IFT, Federal Institute of Telecommunications, "Indicadores de Infraestructura y Digitalización a Nivel Municipal" (May 12, 2024).

According to the ICM scores reported by the IFT, the Oaxacan Internet connectivity landscape presents three main digital infrastructure clusters. The first cluster is in the Valles Centrales region, at the center of Oaxaca, primarily within the Centro district where the capital city of Oaxaca is located. This cluster extends to the neighboring Etla district: the former presenting an average ICM score of 9.14 and the latter one of 5.13. Oaxaca de Juárez and San Pablo Etla have the highest ICM scores in the region, 36 and 27 respectively, while the regional average falls at 3.49.[125]

The second cluster is located in the Istmo region, at the lower right corner of the state's map, which hosts Oaxaca's international port and oil refinery. Its two discrits, Juchitán and Tehuantepec, showed an average ICM score of 7.5 and 4.11. However, the municipalities of Juchitán de Zaragoza, Ciudad Ixtepec, Matías Romero Avendaño, and Unión Hidalgo in Juchitán presented ICM scores of 35, 33, 22, and 19, respectively, while Salina Cruz and Santo Domingo Tehuantepec in Tehuantepec scored 33 and 21. These municipalities are all concentrated around the Tehuantepec Gulf. The regional average ICM score, on the other hand, is 5.93.[126]

In order to discuss the third digital infrastructure cluster in Oaxaca, it should be noted that although all ICM scores previously mentioned have been relatively high in the context of Oaxaca, they fall within what the IFT considers the middle tier of Mexican Internet connectivity: they are not high on a national standard, Oaxaca is an overall poorly connected state even in its clusters. The only municipality with a national high-tier ICM score in Oaxaca is San Juan Bautista Tuxtepec, the second most populated Oaxacan city located in the Papaloapan region, beyond the mountain range and neighboring the state of Veracruz. The second highly digitally connected municipality in the region is Loma Bonita, reporting an ICM score of 39 while San Juan Bautista Tuxtepec shows a score of 41. Paradoxically, Papaloapan is a very digitally unequal region, as these two municipalities belong to the Tuxtepec districts, with an average 9.07 ICM score, the highest in an Oaxacan district, while none of the municipalities in its second district, Choápam, show any trace of digital infrastructure.[127]

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[125] Own calculations based on data sourced from IFT's Analysis on Fixed Telecommunications Services Infrastructure Competition.
[126] Own calculations based on data sourced from IFT's Analysis on Fixed Telecommunications Services Infrastructure Competition.
[127] Own calculations based on data sourced from IFT's Analysis on Fixed Telecommunications Services Infrastructure Competition.

In the Costa region, while on a smaller scale than the three aforementioned clusters, the municipality with a noticeably higher digital infrastructure presence is Santa María Huatulco, an attractive tourist hotspot for national and international visitors for which the international airport Bahías de Huatulco is even in place. Tourists typically require a wide range of accommodations and have the purchasing power to back these demands, which in addition to their large numbers can explain why increased Internet connectivity can be found in these locations.[128] Santa María Huatulco shows a 36 ICM score while the regional average falls at 2.12. The mean household income in this municipality is, in consequence, 168.11% higher than the regional average, only closely matched by the neighboring touristic municipality of San Pedro Mixtepec.[129]

Beyond these clusters, most of Oaxaca has little to no digital infrastructure. The Choápam district of Papaloapan shows an average ICM score of 0, reflecting the most significant digital gap. Similar gaps are observed in the Sierra de Juárez, Sierra de Flores Magón, Mixteca, and Sierra Sur regions, with average ICM scores of 0.32, 0.57, 0.81, and 0.97, respectively. These mountainous regions are characterized by low mean incomes, high social lag scores, and historically Indigenous communities predating the Mexican state.[130]

The spatial dispersion of infrastructure observed in the Internet connectivity landscape, in conclusion, is marked by few clusters and wide gaps across Oaxaca. This unequal Internet access for the population is here understood as a material form of digital inequality. In particular, digital infrastructure clustering should be understood here as an acute form of bandwidth inequality, one of the five variables of digital inequality originally proposed by economists DiMaggio and Hargittai in 2001.[131]

[128] Camilleri, M. A. “The Tourism Industry: An Overview.”
[129] Own calculations based on data sourced from IFT’s Analysis on Fixed Telecommunications Services Infrastructure Competition.
[130] Own calculations based on data sourced from IFT’s Analysis on Fixed Telecommunications Services Infrastructure Competition.
[131] DiMaggio, Paul, and Eszter Hargittai. “From the ‘Digital Divide’ to ‘Digital Inequality’”.

Chapter 4: A Correlational Analysis of Municipalities

Chapter 3 discusses the Internet connectivity landscape of Oaxaca by presenting two overlapping sceneries: the social space, composed of the Oaxacan society and its particular demographic and economic characteristics along its 8 regions, and the technological space, composed of the uneven distribution of copper, coaxial, and fiber optic cables across its municipalities. While some patterns can be inferred by the descriptive comparison of these two layers, Chapter 4 further explores the existing dynamic between them. How are the spatial dispersion of digital infrastructure and the Oaxacan society related?

To answer this question, this research conducts a quantitative correlational analysis of the 570 municipalities in Oaxaca, looking for meaningful correlations between the presence of higher amounts of digital infrastructure and of better quality and some of the socio-demographic and economic characteristics of the Oaxacan social space. These correlations are calculated on a state level, across all of Oaxaca, and on a regional level to look for higher correlations in variables uniquely prominent in particular regions.

4.1 Quantitative Methodology

This research builds on the foundational work on digital infrastructure clustering in Mexico released in 2023 by the Directorate of Economic and Regulatory Analysis of the Federal Institute of Telecommunications (IFT), in its Analysis on Fixed Telecommunications Services Infrastructure Competition.[132] The IFT report introduced two indexes already discussed in Chapter 3: the Municipal Competition Index (ICM) and the Municipal Digital Development Index (IDDM). These indexes provide quantitative data for measuring digital infrastructure deployment via the presence of Internet service providers per Mexican municipality and the technology employed by them to offer their services.

While the IDDM enhances the ICM scores by adding Internet adoption readiness variables, such as computer availability in Mexican households, this research will primarily calculate variable correlations with the Oaxacan ICM results. By focusing on infrastructure development and the Internet service providers (ISPs) supply across Oaxacan municipalities, the study dives into the sociological factors influencing digital infrastructure spatial dispersion, as well as its relationship with the various socio-economic and socio-demographic variables within the unique context of Oaxaca.

[132] IFT. “Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos”.

4.1.1 Oaxacan Social Space Variables

A total of 12 variables were chosen to calculate their correlation with the quantity and quality of digital infrastructure across the 570 municipalities in Oaxaca, which were then grouped into three broader categories: socio-demographic, socio-economic, and socio-spatial. These variables are sourced from the datasets described in Chapter 3, in particular from the Population and Housing Census 2020 (CCPV 2020), the Current Income for Mexican Municipalities 2020 (ICMM), and the Social Lag Index 2020 (IRS 2020).

The socio-demographic variables include population, age, gender, Indigenous ethnicity, and Afro-Mexican ethnicity. The population variable measures the total number of inhabitants in each municipality, age is represented by the mean age of the population in each municipality, and gender measures the proportion of men in the total population of each municipality; all three of them derived sourced from INEGI's Population and Housing Census 2020.[133]

Indigenous ethnicity captures the proportion of Indigenous people in each municipality's total population, reflecting the cultural and ethnic diversity within Oaxaca. This dataset in particular was calculated by the Federal Institute of Technology (IFT) based on INEGI's CCPV 2015 report on the total Indigenous population of every municipality, and the scores for each municipality were included in the dataset published along with the report.[134] Similarly, the Afro-Mexican ethnicity variable measures the proportion of people who self-identify as of African descent in each municipality, providing insight into the racial composition of the region; the IFT report did not account for this variable and it is sourced directly from INEGI's CCPV 2020.[135]

The socio-economic variables include income, labor force, social lag, education, and literacy. Income is measured by the mean household income in each municipality, sourced from INEGI's National Survey on Household Income and Spending 2020 (ICMM 2020).[136] The labor force variable captures the proportion of the population aged between 12 and 65, considered by INEGI as suitable for economic activity, and is based on the IFT's calculations from INEGI's CCPV 2020 report on the Oaxacan total population per age range.[137]

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133 INEGI. "Censo Población y Vivienda (CCPV) 2020".
134 IFT. "Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos".
135 INEGI. "Censo Población y Vivienda (CCPV) 2020".
136 INEGI. "Ingreso Corriente para los Municipios de México (ICMM) 2020".
137 IFT. "Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos".

The social lag index is a comprehensive poverty measurement that, instead of assessing income or wealth, calculates the amount of lagging in access to education, healthcare, and quality housing relative to the Mexican national average for every municipality. This data is sourced from the National Council for Social Development Policies Evaluation's (CONEVAL) Social Lag Index 2020 (IRS 2020).[138] Additionally, the education variable measures the mean years of schooling among individuals older than 15 years in each municipality, and the literacy measures the proportion of people who cannot read or write in each municipality's population, both sourced from INEGI's CCPV 2020.[139]

The socio-spatial variables include rurality and population density. The urban-rural ratio measures the proportion of each municipality's population living in towns with 5,000 inhabitants or less, INEGI's definition of rural settlements. This data is based on IFT's calculations from INEGI's CCPV 2020, also published in the dataset.[140] Population density, on the other hand, is represented by the number of inhabitants per square kilometer in each municipality, providing a measure of how densely populated each area is, and it is also sourced from INEGI's CCPV 2020.[141]

The choice of these variables is informed by previous research, which has found correlations between these demographic and economic factors and the varying degrees of the population's broadband access. For instance, economic research conducted in the United States during the earlier years of the 21st century, a moment in time when digital infrastructure and Internet services were rapidly expanding across the country in a not-too-different stage to which Mexico is currently experiencing, showed significant correlations between broadband availability and variables such as income, age, gender, education, urbanization, and racial differences.

Hoffman, Novak, and Schlosser, at the time scholars in Vanderbilt University's Graduate Schools of Management and Marketing, explored these correlations in a research paper conducted in 2006.[142] Similarly, Stenberg, Morehart, Vogel, Cromartie, Breneman, and Brown, at the time members of the Economic Research Service of the United States Department of Agriculture, discussed the differences between rural and metropolitan areas in their 2009 report.[143] Additionally, Georgetown University economist Scott Wallsten, research with expertise in telecommunications, regulation, competition, technology policy, and the

[138] CONEVAL. "Índice de Rezago Social 2020".
[139] INEGI. "Censo Población y Vivienda (CCPV) 2020".
[140] IFT. "Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos".
[141] INEGI. "Censo Población y Vivienda (CCPV) 2020".
[142] Hoffman, Donna L., Thomas P. Novak, and Ann Schlosser. "The Evolution of the Digital Divide".
[143] Stenberg, Peter L. et al. "Broadband Internet's Value for Rural America".

economics of digitization, found in 2010 that regions with multiple Internet service providers tend to have better broadband access at lower prices.[144]

Furthermore, the Analysis on Fixed Telecommunications Services Infrastructure Competition by the Directorate of Economic and Regulatory Analysis of the Federal Institute of Telecommunications in Mexico (IFT) calculated correlations between their Municipal Competition Index (ICM) and Municipal Digital Development Index (IDDM) and 24 demographic variables on a national level. Some of the socio-demographic, socio-economic, and socio-spatial variables chosen for this study were also part of the IFT's analysis and were available per municipality; for this reason, although they could be sourced directly from INEGI's database they were sourced from the IFT analysis as they were readily available for in a downloadable spreadsheet.

It must be noted that the IFT's analysis did not calculate correlations on a state, regional, or district level, only on a national level using municipal data. All correlation coefficients and averages presented in this chapter are own calculations. Additionally, the analysis found higher correlations between digital infrastructure and variables related to income, population density, urbanization, education, labor force, age, and Indigenous ethnicity. It did not, however, consider correlations on Afro-Mexican ethnicity or social lag: these were sourced directly from INEGI and CONEVAL's database.

This present research aims to explore these potential correlations at a state and regional level within Oaxaca, in contrast to their national level approach, while also putting to test the IFT's findings by calculating the correlations on a more limited set of variables. By doing so, this study seeks to provide a nuanced analysis of the Internet connectivity landscape in Oaxaca and reach sociological insights the IFT did not attempt.

4.1.2 Analytical Techniques

The quantitative correlational analysis in this research consists of calculating the Pearson correlation coefficient (ρ for population, *r* for samples) of the ICM scores and each of the 12 socio-demographic, socio-economic, and socio-spatial variables. While ρ and *r* are also calculated for the ICM scores and variables correlations, these results are not primarily discussed in the analysis of Chapters 4 and 5. It should be noted that the calculation is conducted nine times per variable: first for ρ on a state level, for the 570 municipalities in Oaxaca that represent the statistic population, and then once per sample that compose each of

[144] Wallsten, Scott, and Colleen Mallahan. "Residential Broadband Competition in the United States."

the 8 regions of Oaxaca. A table with each ICM correlation result is attached to this document in Appendix 2 for a quick overview, as well as another with each IDDM correlation result in Appendix 3 for additional support on the relationship these variables hold with the larger Internet connectivity landscape in Oaxaca.

The significance level for these correlations is set at 95%. The confidence interval's upper and lower bounds naturally increase when calculating r on every variable, as the sample sizes range from 155 municipalities in Mixteca to as little as 20 in Papaloapan: these are the regions with the most and least amount of municipalities in Oaxaca. This is relevant for the following discussion of the Pearson correlation coefficients, as it explains how the variation in the degree of confidence in the regional correlations is not due to random chance but to varying sample sizes.

The Pearson correlation coefficient measures the strength and direction of the linear relationship between two variables. The results of these calculations range between -1 and 1. A result closer to 1 indicates a strong positive correlation, meaning as one variable increases, so does the other. A result closer to -1 indicates a strong negative correlation, meaning as one variable increases, the other decreases. A result closer to 0 suggests a weak or insignificant relationship between the two variables. For this research, correlations above 0.6 or below -0.6 are considered strong (or high); correlations between 0.59 and 0.4, as well as between -0.4 and -0.59, are considered moderate; correlations between 0.39 and 0.25, and between -0.25 and -0.39, are considered weak (or low); and correlations between -0.24 and 0.24 are considered negligible (or no correlation).

The Pearson correlation coefficient was chosen as a statistical method for this research, instead of alternatives such as Spearman's rank correlation coefficient, because the relationships to be found between digital infrastructure and the chosen variables are expected to have linear shapes. In fact, the stronger the correlation, the clearer the linearity is expected to be found. To consider a correlation significant in this research, however, the lower bound of the confidence intervals in positive correlations and the upper bound of the confidence intervals in negative correlations must remain within at least weak positive or negative ranges. This ensures that the correlations considered are not only statistically significant but also meaningful within the context of this research.

It also should be noted that for calculating the upper and lower bounds of these correlations' confidence intervals, each Pearson correlation coefficient (ρ and r) was converted into Fisher z. This decision was based on technical needs, as the calculations were conducted on Microsoft Excel software which does not include a function to calculate p-value. Instead, the critical z-score value was set at 1.959963986. These calculations are detailed per variable in Appendix 4 to 12, each featuring a table with every Pearson correlation coefficient calculated for the population and for each regional sample.

4.2 Socio-Demographic Correlations

4.2.1 Population

The Pearson correlation coefficient between the ICM scores and the total population in each of Oaxaca's 570 municipalities is 0.72, 95% CI [0.68, 0.76], indicating not only a strong positive correlation but the strongest in this research. This suggests that the amount of population in a municipality is highly correlated with the greater presence, amount, and quality of digital infrastructure.

Such a high correlation is consistent across all regions: in Istmo (*r*=0.83, 95% CI [0.70, 0.90]), Papaloapan (*r*=0.80, 95% CI [0.56, 0.92]), Mixteca (*r*=0.79, 95% CI [0.73, 0.85]), Costa (*r*=0.68, 95% CI [0.50, 0.81]), Valles Centrales (*r*=0.68, 95% CI [0.57, 0.76]), and Sierra Sur (*r*=0.66, 95% CI [0.51, 0.78]) strong positive correlations are also observed.

The only regions with moderate and weak correlations are Sierra de Juárez (*r*=0.55, 95% CI [0.35, 0.69]) and Sierra de Flores Magón (*r*=0.30, 95% CI [0.00, 0.54]), the latter having a confidence interval with a lower bound at effectively 0 and therefore being considered as negligible instead of weak. These two regions also happen to be the ones with the least amount of population and with the lowest average ICM scores (0.32 and 0.58 respectively), suggesting that areas with relatively fewer inhabitants may not be a priority for Internet service providers (ISPs) but, when they do approach them, the municipalities they choose to supply their services within them may not be chosen based on the amount of population they have.

4.2.2 Age

The correlation between the ICM scores and the mean age of the population across Oaxaca's municipalities is ρ=-0.01, 95% CI [-0.09, 0.07], indicating no significant correlation. This lack of correlation suggests that while age might still influence digital inequality in other contexts, the mean age of the Oaxacan population does not vary significantly among municipalities to impact digital infrastructure development (or lack thereof). None of the regions show significant correlations with mean age. Costa (*r*=0.12, 95% CI [-0.16, 0.39]), Sierra de Juárez (*r*=-0.14, 95% CI [-0.37, 0.10]), Mixteca (*r*=-0.10, 95% CI [-0.25, 0.06]) are the regions showing minor signs of spikes in their correlations.

The only exception is, however, Papaloapan (*r*=0.55, 95% CI [0.14, 0.80]), whose Pearson correlation coefficient shows a moderate positive correlation although its confidence interval lower limit falls too low at 0.14. It should be noted, however, that Papaloapan is the smallest sample with only 20 municipalities, which explains the radical variation in its CI. In this region, while the population's average age is 27 years old, in the two municipalities in which digital infrastructure seems to cluster, Loma Bonita and San Juan Bautista Tuxtepec, the average age sits at 30 and 32 respectively. The ICM scores in these municipalities are 39 and 41, while the region's average is 6.35. An older society, at least in Papaloapan, seems to be tied to higher access to better Internet connectivity.

4.2.3 Gender

For gender composition, the Pearson correlation coefficient is ρ=0.01, 95% CI [-0.07, 0.09], indicating no correlation with the ICM scores across Oaxaca's municipalities. This implies that the percentage of each municipality's population that is male does not significantly affect the spatial distribution of the digital infrastructure development within the state. Such a result can be explained by the fact that the average gender composition of the Oaxacan population does not vary much among municipalities.

Similar to the results of the correlation between digital infrastructure and mean age, the negligible correlation with gender composition remains negligible across almost all regions except for one. In Istmo, the municipalities with higher ICM scores, such as Ciudad Ixtepec, Heroica Ciudad de Juchitán de Zaragoza, Matías Romero Avendaño, Salina Cruz, and Santo Domingo Tehuantepec, seem to show a slightly smaller proportion of men as all of them remain under 49%. This trend in the industrial region of Oaxaca, however, may very well remain anecdotic: while Istmo (*r*=-0.46, 95% CI [-0.67, -0.18]) shows signs of a moderate negative correlation, its confidence interval upper bound falls too close to 0 to be considered statistically relevant.

4.2.4 Indigenous Ethnicity

The correlation between the ICM scores and the proportion of Indigenous people in Oaxacan municipalities is ρ=-0.34, 95% CI [-0.41, -0.26], indicating a weak negative correlation. This suggests that municipalities with higher Indigenous populations tend to have lower levels of digital infrastructure. Additionally, as consistently occurred in all weak Pearson correlation coefficients for ρ in this study due to the wide confidence intervals of *r*, results are too low and confidence interval upper bounds are too close to 0 to consider the correlations other than negligible in almost all regions.

There are, however, two exceptions: in Papaloapan (r=-0.68, 95% CI [-0.87, -0.35]) and Sierra de Flores Magón (r=-0.66, 95% CI [-0.80, -0.46]) there is evidence of a strong negative correlation between the two variables. In Sierra de Flores Magón, for example, three out of the only four municipalities with any presence of active digital infrastructure, San Juan Bautista Cuicatlán, Teotitlán de Flores Magón, and Santa María Tecomavaca, happen to be the only three in the region that are not inhabited almost exclusively by Indigenous population. These municipalities are not the ones with the highest mean income, degree of education, or amount of population; instead, there seem to be signs of an active exclusion of Indigenous communities by ISPs when initially developing their infrastructure in highly Indigenous areas.

4.2.5 Afro-Mexican Ethnicity

The correlation between the ICM scores and the proportion of Afro-Mexican populations is ρ=0.00, 95% CI [-0.08, 0.08], indicating no significant correlation across Oaxaca. Costa (r=-0.08, 95% CI [-0.35, 0.20]), despite being home to a large Afro-Mexican community and showing a much higher percentage of its population identifying as of African descent than any other region in Oaxaca, still shows no correlation with the digital infrastructure quantity and quality throughout its municipalities.

This result could be explained by the fact that, unlike the Indigenous ethnicity, the Afro-Mexican ethnicity is a self-assigned identity, and Internet service providers may not see these communities as significantly different than the dominant ethnic majority of Mestizo Mexicans, at least not in their consumption patterns; systemic exclusion from digital infrastructure seems to not target them in a way Indigenous ethnicity appears to be.

4.3 Socio-Economic Correlations

4.3.1 Mean Income

The Pearson correlation coefficient between the ICM scores and mean household income across Oaxaca is ρ=0.56, 95% CI [0.50, 0.61], indicating not only a moderate positive correlation but the third strongest correlations between digital infrastructure and a variable from the Oaxacan social space. As a consequence, mean income is also the strongest socio-economic correlation in this research. This result suggests that the higher income levels are across municipalities, the more and better digital infrastructure gets built within them.

This pattern is consistent across all of Oaxaca. Strong correlations are found in Papaloapan (r=0.77, 95% CI [0.50, 0.90]), Sierra de Flores Magón (r=0.68, 95% CI [0.49, 0.81]), Costa (r=0.67, 95% CI [0.48, 0.80]), and Valles Centrales (r=0.65, 95% CI [0.53, 0.74]). Additionally, moderate correlations are seen in Istmo (r=0.54, 95% CI [0.28, 0.73]), Sierra Sur (r=0.47, 95% CI [0.26, 0.63]), Mixteca (r=0.45, 95% CI [0.32, 0.57]), and Sierra de Juárez (r=0.46, 95% CI [0.25, 0.63]).

4.3.2 Labor Force

The correlation between the ICM scores and the proportion of the population that composes the (occupied and unoccupied) labor force is ρ=0.41, 95% CI [0.34, 0.48], indicating a moderate positive correlation. This suggests that municipalities with higher proportions of population between 12 and 65 years old, that is with a higher share of its population available for work, tend to have more digital infrastructure and of better quality. This could potentially link digital infrastructure development not only with higher purchase power, as suggested by its high correlation with mean household income but also with working necessities among the population.

Moderate correlations are observed in Istmo (r=0.58, 95% CI [0.34, 0.76]), Valles Centrales (r=0.57, 95% CI [0.44, 0.68]), Costa (r=0.55, 95% CI [0.32, 0.72]), and Papaloapan (r=0.49, 95% CI [0.07, 0.77]). No significant correlations, however, are found in Mixteca, Sierra de Flores Magón, Sierra de Juárez, and Sierra Sur. While mean age as a socio-demographic variable showed no correlation with the presence and quality of digital infrastructure, the labor force shows one of the highest correlations in this research. This could indicate that the labor force is also a variable relevant not for the initial development of digital infrastructure in a region but for its subsequent spatial clustering around certain municipalities within those regions.

4.3.3 Social Lag

The correlation between the ICM scores and the social lag index is ρ=-0.37, 95% CI [-0.44, -0.30], indicating a low negative correlation. This suggests that municipalities with higher social lag tend to have lower levels of digital infrastructure. In consequence, a regional moderate negative correlation is also found in Valles Centrales (r=-0.50, 95% CI [-0.63,

-0.36]), the region with the highest presence of digital infrastructure and home of the Oaxacan capital with an average ICM score of 3.49.

The confidence intervals are wide across regions and in most cases no upper bound remains within what is considered weakly correlated, such as in Costa (*r*=-0.38, 95% CI [-0.60, -0.12]), Istmo (*r*=-0.50, 95% CI [-0.70, -0.23]), Papaloapan (*r*=-0.59, 95% CI [-0.82, -0.20]), Sierra de Flores Magón (*r*=-0.41, 95% CI [-0.63, -0.13]), Sierra de Juárez (*r*=-0.12, 95% CI [-0.35, 0.12]), and Sierra Sur (*r*=-0.34, 95% CI [-0.53, -0.11]); they cannot be statistically considered other than negligible correlations. It is notable, however, that regions with higher ICM scores show signs of moderate correlations. This could indicate that social lag plays a role not in the initial development of digital infrastructure but in its spatial expansion within digital infrastructure clusters: as digital infrastructure increases, it tends to expand in municipalities with better access to education, healthcare, and housing, leaving more impoverished areas with poorer Internet access.

4.3.4 Education

The Pearson correlation coefficient between the ICM scores and the average years of schooling is ρ=0.47, 95% CI [0.41, 0.53]: there is a moderate positive correlation between the two. This suggests that municipalities with higher average levels of education are moderately associated with having better digital infrastructure developed within them.

This trend is particularly present in Papaloapan (*r*=0.64, 95% CI [0.28, 0.85]), Valles Centrales (*r*=0.60, 95% CI [0.48, 0.71]), Costa (*r*=0.57, 95% CI [0.34, 0.73]), and Istmo (*r*=0.55, 95% CI [0.30, 0.74]), regions with consistently higher performance across each of the socio-economic variables considered in this research. Sierra de Flores Magón (*r*=0.52, 95% CI [0.26, 0.70]) also shows a moderate correlation. This variable shows a significantly higher Pearson correlation coefficient than the illiteracy proportion variable; while both of them are in a way related to reading and writing skills, useful for Internet navigation, Internet service providers seem to follow an infrastructure developing pattern that prioritizes education over literacy.

4.3.5 Literacy

The correlation between the ICM scores and illiteracy rates is ρ=-0.27, 95% CI [-0.34, -0.19], indicating signs of a weak negative correlation but with a confidence interval upper bound so close to 0 that results in a statistically negligible correlation. The low correlation between digital infrastructure and literacy, however, is worth comparing to the moderate correlation it has with the average level of education. On the regional level, however, moderate negative correlations are found in Papaloapan (*r*=-0.55, 95% CI [-0.80, -0.14]), Istmo (*r*=-0.47, 95% CI [-0.68, -0.19]), Valles Centrales (*r*=-0.42, 95% CI [-0.56, -0.26]), and Costa (*r*=-0.41, 95% CI [-0.61, -0.14]).

While the confidence intervals are wide and in most cases, no upper bound remains within what is considered weakly correlated, it is notable that the regions with higher ICM scores are those showing moderate correlations. This suggests that literacy may not play a significant role in the initial development of digital infrastructure but becomes relevant in its spatial expansion within digital infrastructure clusters: once the quality and quantity of digital infrastructure increases in a region, it tends to avoid highly illiterate municipalities.

4.4 Socio-Spatial Correlations

4.4.1 Urban-Rural Ratio

The Pearson correlation coefficient between the ICM scores and the average degree of rurality is ρ=-0.61, 95% CI [-0.66, -0.56], indicating a strong negative correlation: in fact, the second strongest correlation in this research. This suggests that the more rural a municipality in Oaxaca is, the less digital infrastructure gets developed in them.

Three patterns are observable in this result. First, this variable is more strongly correlated in regions with lower ICM scores, meaning that the few areas in these mostly digitally disconnected regions with access to digital infrastructure are its few cities, such as in Sierra de Flores Magón (*r*=-0.78, 95% CI [-0.87, -0.62]) and Sierra Sur (*r*=-0.77, 95% CI [-0.85, -0.65]).

Second, this negative correlation between ICM scores and the municipal rural-urban ratio, however strong, is not the sole explanation for the presence or absence of digital infrastructure in a region: Sierra de Juárez, for instance, is a 100% rural region and it still has digital infrastructure in a few municipalities (Ixtlán de Juárez, San Juan Cotzocón, and Santa María Tlahuitoltepec, for example, are those with relatively higher ICM scores).

Third, this pattern shows regional variations where alternative variables seem to be playing a more influential role in the spatial development of digital infrastructure (or lack thereof). Costa shows the lowest correlation (*r*=-0.50, 95% CI [-0.68, -0.25]) despite it not being the most nor the least urbanized region. Whether its population lives in settlements with more than 5,000 inhabitants, while still moderately correlated, is not the strongest explanation for this region's digital infrastructure spatial form.

4.4.2 Population Density

The correlation between the ICM scores and population density is ρ=0.30, 95% CI [0.23, 0.38], indicating a weak positive correlation. Although this correlation suggests that more densely populated areas tend to have better digital infrastructure, the ρ is not only low but its confidence interval lower bound falls slightly below what this research considers a significant correlation.

It is worth noting, however, that this variable shows moderate correlation in the Mixteca (*r*=0.55, 95% CI [0.43, 0.65]) and Valles Centrales (*r*=0.47, 95% CI [0.32, 0.60]) regions. Istmo (*r*=0.49, 95% CI [0.21, 0.69]) and Papaloapan (*r*=0.48, 95% CI [0.04, 0.76]) show signs of potentially moderate correlations, although the lower bounds fall below 0.25, which in part can be attributed by the small size of their municipality sample.

These correlations imply that in urbanized regions, more densely populated cities are more likely to become clusters of digital infrastructure, while in rural areas the varying population densities play a less significant role: as long as there are cities, however small, that is where digital infrastructure tends to develop.

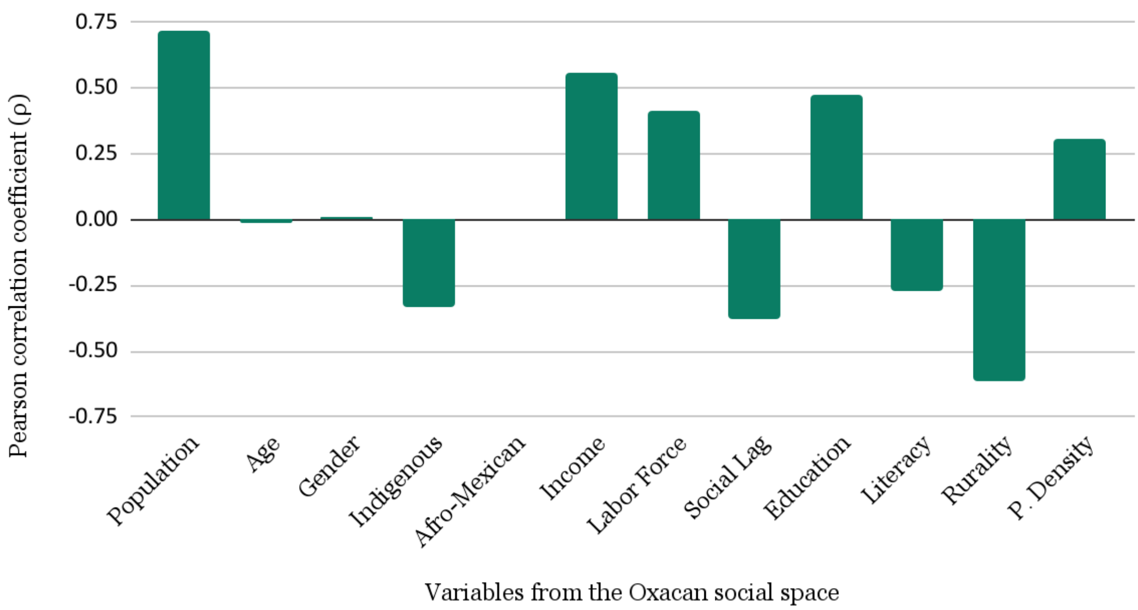
4.6 Findings on Digital Infrastructure Correlations

Based on the calculations conducted for this research, the strongest socio-demographic, socio-spatial, and socio-economic correlations with the quantity and quality of digital infrastructure present in a municipality across Oaxaca are its population (ρ=0.72, 95% CI [0.68, 0.76]), the proportion of its population living in urban settlements (ρ=-0.61, 95% CI [-0.66, -0.56]), and its average household income (ρ=0.56, 95% CI [0.50, 0.61]). These factors are, therefore, the ones that better explain the development and dispersion of digital infrastructure in Oaxaca as of 2020.

There seems to be in Oaxacan municipalities, however, a moderate correlation between their ICM scores and their population's average years of schooling (ρ=0.47, 95% CI [0.41, 0.53]) and the proportion of its inhabitants in working-age (ρ=0.41, 95% CI [0.34, 0.48]). Low correlations are also seen with their social lag index (ρ=-0.37, 95% CI [-0.44, -0.30]), the proportion of their population that is ethnically Indigenous (ρ=-0.34, 95% CI [-0.41, -0.26]), and the proportion that cannot read or write (ρ=-0.27, 95% CI [-0.34, -0.19]).

The average age (ρ=-0.01, 95% CI [-0.09, 0.07]) and gender composition (ρ=0.01, 95% CI [-0.07, 0.09]) of the municipalities, as well as the proportion of their population that self-identifies as Afro-descendant (ρ=0.00, 95% CI [-0.08, 0.08]), showed no correlation with the amount of digital infrastructure present in them. The Oaxacan social space variables with strong, moderate, weak, and negligible correlations with the Municipal Competition Index, as represented also in Figure 5, help answer the question that guides this chapter: How are the spatial dispersion of digital infrastructure and the Oaxacan society related?

Figure 5: *Pearson Correlation Coefficients (ρ) of ICM Scores with Each Variable*



Source: IFT, Federal Institute of Telecommunications, XLSX export from "Indicadores de Infraestructura y Digitalización a Nivel Municipal" (April 15, 2024), INEGI, National Institute of Geography and Statistics, "CCPV 2020", and CONEVAL, National Council for Social Development Policies Evaluation, "IRS 2020", own calculations.

At this point, however, it must be noted that while the aforementioned Pearson correlation coefficients show the strength and significance of correlations across Oaxaca, each of the eight regions showed unique strengths and significances in their correlations with these variables. This indicates the socio-demographic, socio-economic, and socio-spatial characteristics of each region uniquely influence the digital infrastructure development and the spatial distribution it had across them.

In the Valles Centrales municipalities, there is a strong correlation between digital infrastructure and their population (r=0.68, 95% CI [0.57, 0.76]), income (r=0.65, 95% CI [0.53, 0.74]), and education (r=0.60, 95% CI [0.48, 0.71]). Moderate correlations are found with their labor force (r=0.57, 95% CI [0.44, 0.68]), urban-rural ratio (r=-0.57, 95% CI [-0.68, -0.43]), social lag (r=-0.50, 95% CI [-0.63, -0.36]), population density (r=0.47, 95%

CI [0.32, 0.60]), and illiteracy rate (*r*=-0.42, 95% CI [-0.56, -0.26]). Indigenous ethnicity showed a low negative correlation (*r*=-0.38, 95% CI [-0.53, -0.22]).

In the Costa region, strong correlations with its municipalities' ICM scores are seen only with population (*r*=0.68, 95% CI [0.50, 0.81]) and income (*r*=0.67, 95% CI [0.48, 0.80]): digital infrastructure was most likely developed primarily following these two variables as criteria. Their labor force (*r*=0.55, 95% CI [0.32, 0.72]), level of education (*r*=0.57, 95% CI [0.34, 0.73]), and degree of rurality (*r*=-0.50, 95% CI [-0.68, -0.25]) were also moderately correlated with its digital infrastructure dispersion throughout the coastal region.

Istmo de Tehuantepec's digital infrastructure shows a very strong correlation with population (*r*=0.83, 95% CI [0.70, 0.90]). Additionally, moderate correlations are found with the degree of rurality (*r*=-0.59, 95% CI [-0.76, -0.35]), labor force proportion (*r*=0.58, 95% CI [0.34, 0.76]), and mean income (*r*=0.54, 95% CI [0.28, 0.73]) of its municipalities.

In Sierra de Flores Magón, the digital infrastructure's spatial form was strongly correlated with its municipalities' degree of rurality (*r*=-0.78, 95% CI [-0.87, -0.62]), mean income (*r*=0.68, 95% CI [0.49, 0.81]), and Indigenous population composition (*r*=-0.66, 95% CI [-0.80, -0.46]): this region is an example of a highly Indigenous region where the ethnicity of its population played a substantial role in whether or not digital infrastructure gets to be built in a municipality. Education also shows a moderate correlation (*r*=0.52, 95% CI [0.26, 0.70]), while population does not play a significant role in the digital infrastructure dispersion across these municipalities.

The municipalities in Sierra de Juárez only showed moderate correlations between their ICM scores and their amount of population (*r*=0.55, 95% CI [0.35, 0.69]) and mean income (*r*=0.46, 95% CI [0.25, 0.63]). The region's 100% rurality means urban settlement played no role in digital infrastructure dispersion across the region, as there are no cities in this part of the northern mountain range of Oaxaca.

Sierra Sur's ICM scores show strong correlations with its municipalities' urban-rural ratio (*r*=-0.77, 95% CI [-0.85, -0.65]) and population (*r*=0.66, 95% CI [0.51, 0.78]). Education shows a moderate correlation (*r*=0.44, 95% CI [0.22, 0.61]), but no other variable appeared to be significant in this region's development of digital infrastructure: a trend seemed to emerge in the least digitally connected regions, where not only fewer municipalities showed any presence of digital infrastructure but also the least amount of variables seemed to hold significance.

In Papaloapan, municipal ICM scores show very strong correlations with the amount of population (r=0.80, 95% CI [0.56, 0.92]), the average income (r=0.77, 95% CI [0.50, 0.90]), and the urban-rural ratio (r=-0.77, 95% CI [-0.90, -0.50]) of its municipalities. Indigenous ethnicity (r=-0.68, 95% CI [-0.87, -0.35]) and education (r=0.64, 95% CI [0.28, 0.85]) also showed strong correlations, while social lag shows a moderate correlation (r=-0.59, 95% CI [-0.82, -0.20]). The high number of strong correlations in the smallest region of Oaxaca makes for a potentially insightful study case in further research on Oaxaca's Internet connectivity landscape.

Finally, the municipalities in the Mixteca region show a very strong correlation between their levels of digital infrastructure and their amount of population (r=0.79, 95% CI [0.73, 0.85]). Moderate correlations are also found with their degrees of rurality (r=-0.57, 95% CI [-0.67, -0.46]), population density (r=0.55, 95% CI [0.43, 0.65]), and mean income (r=0.45, 95% CI [0.32, 0.57]). This region follows the same trend as Sierra de Flores Magón, Sierra de Juárez, and Sierra Sur: as the Oaxacan regions with the least amount of municipalities with digital infrastructure, and those with any presence of digital infrastructure having particularly low ICM scores, there could be a potential sign of which variables are relevant when digital infrastructure begins developing and spreading in a previously disconnected area.

In summary, not one variable is single-handedly responsible for the amount of digital infrastructure developed within the Oaxacan municipalities and the kind of technology used by Internet service providers to supply them with Internet connectivity. The Oaxacan society is diverse, and the social configurations of every region provide nuances on the spatial dispersion of digital infrastructure beyond the strongly correlated variables of population, urbanization, and income.

Chapter 5: A Second Snapshot of Oaxaca

Why was the quantity and quality of digital infrastructure in Oaxaca disproportionally clustered around certain municipalities in 2020? This question, which articulated the previous four chapters of this thesis, led the research through an in-depth discussion of a conceptual and historical definition of Mexican digital infrastructure, of the technical and social layers of the Internet connectivity landscape in Oaxaca, and of the way these two are interrelated in an ongoing historical process of which the year 2020 is but a snapshot of a larger sequence.

This fifth and conclusive chapter provides an answer to the research question by first diving into the main findings from each of the sub-questions posed in Chapters 2, 3, and 4. These answers provide a general overview of the qualitative and quantitative aspects behind Oaxaca's Internet connectivity landscape in 2020, from which an analytical approach to the main question follows.

By looking at the digital infrastructure's spatial form in Oaxaca from a sociological perspective, some insights can be drawn on the society that disproportionately built it around some municipalities while leaving others with limited or no Internet connectivity. This is presented within this research as a snapshot of Oaxaca's social landscape in the historical period of the information age, where digital infrastructure clustering is a material expression of digital inequality, underlying social dynamics help explain unequal infrastructure development, and Internet service providers as key agents of this development.

Finally, this chapter concludes the present thesis with a series of suggestions for future research on Oaxacan, Mexican, and developing countries' Internet connectivity landscape based on the limitations faced by this research.

5.1 Summary of Key Findings

Chapter 2 explored both the scholarly debates around infrastructure and the Internet to reach a working definition of digital infrastructure that could be applicable to the current state of Oaxaca, in Mexico, and that allowed this research to study its Internet connectivity landscape from a materialist perspective. For this purpose, the first sub-question posed was: What is considered digital infrastructure in Oaxaca, Mexico, for this research?

The answer to this sub-question proposed in this research is that digital infrastructure is a large system of fixed wireline (and wireless) networks of digital data transfer technologies for computer networking dispersed across the Mexican territory. Those technologies in particular refer to copper cables used for digital subscriber lines (DSL), which rely on existing telephone lines for digital data transmission, coaxial cables used to provide fixed Internet services to modems and personal computers in households via Ethernet connection, and fiber optic cables for fixed high-speed, long-distance broadband Internet connection.

The investment required by Internet service providers to set up and maintain their wireline networks, as well as the additional costs of data transmission via Content Delivery Networks and Internet Exchange Points, tends to result in digital infrastructure clustering geographically around the most profitable areas. This unequal Internet access for the population across space is, in this research, understood as a material form of digital inequality: a concept that attempts to go beyond Internet haves and have-nots, the central theme of the digital divide, by focusing on inequality among people with various degrees of access to the Internet. In particular, digital infrastructure clustering is framed here as one of the five variables of digital inequality originally proposed by economists DiMaggio and Hargittai in 2001: unequal access to technical means for Internet connectivity, resulting in bandwidth inequality.[145]

Furthermore, Chapter 3 dives into the Internet connectivity landscape of Oaxaca in 2020 by discussing it as a picture composed of two overlapping layers. The first layer is that of the Oaxacan social space, diving into the main demographic, economic, and topographic characteristics of the Mexican state, as well as its municipal structure of 570 municipalities and 8 regions, following Henri Lefebvre's notion of space as a non-neutral socially produced order that lays over material geographies.[146] The second layer is the digital infrastructure spatial form, understood as a particular dispersion of fixed wireline networks of digital data transfer technologies across space that shows presence intensities in the form of clusters as well as gaps where presence is minimal or non-existent.

The sub-question posed by the third chapter of this thesis is: How is digital infrastructure dispersed across the Oaxacan space? Its answer, in turn, relies on the Analysis on Fixed Telecommunications Services Infrastructure Competition published by the Directorate of Economic and Regulatory Analysis of the Federal Institute of Telecommunications in Mexico (IFT), which analyzes the quantity and quality of digital infrastructure present in every Mexican municipality by looking at the presence of Internet

[145] DiMaggio, Paul, and Eszter Hargittai. "From the 'Digital Divide' to 'Digital Inequality'".
[146] Lefebvre, Henri. *The Production of Space*.

service providers (ISPs) operating in them and the technology they are using to supply their services.[147]

The IFT's Analysis on Fixed Telecommunications Services Infrastructure Competition presented two indexes to measure the quantity and quality of digital infrastructure present in Mexican municipalities: the Municipal Competition Index (ICM), which quantifies infrastructure presence and clustering per municipality, and the Municipal Digital Development Index (IDDM), which measures digital development and readiness for Internet adoption by their inhabitants. This research based its analysis on the ICM results for the Oaxacan municipalities, in order to focus on infrastructure development and Internet service providers' (ISPs) supply across them.

According to the ICM results, the Oaxacan Internet connectivity landscape shows three main digital infrastructure clusters. The first cluster is located in the northern part of the Valles Centrales region, where the capital city of Oaxaca is located, mainly within the Centro and Etla districts. The second cluster can be found in the Istmo region, notable for its international port and oil refinery, in the municipalities within the Juchitán and Tehuantepec districts close to the Tehuantepec Gulf. The only municipality in Oaxaca with a high tier ICM score by national standards is San Juan Bautista Tuxtepec, the second most populated Oaxacan city and core of the third cluster in the Papaloapan region along with the neighboring San Juan Bautista Tuxtepec: these are located beyond the northern mountain range and neighboring the state of Veracruz.

The rest of Oaxaca, beyond these three clusters, ranges from little to no digital infrastructure presence. Besides the greatest digital infrastructure gap shown in the Choápam district of Papaloapan, with an average ICM score of 0, several Oaxacan regions show very similar results. The most notable gaps lie in the Sierra de Juárez, Sierra de Flores Magón, Mixteca, and Sierra Sur regions: the average ICM score in their municipalities is 0.32, 0.57, 0.81, and 0.97, respectively, while the state's average ICM score is two or three times greater.[148] These are all particularly mountainous regions marked by low mean incomes and high social lag scores, as well as historically being home to Indigenous communities that pre-date the Mexican state.

Finally, Chapter 4 explores the way in which the two layers that compose the Internet connectivity landscape of Oaxaca are interrelated. Such an exploration follows not only the

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[147] IFT. "Análisis de Competencia en Infraestructura para Servicios de Telecomunicaciones Fijos".
[148] Own calculations based on data sourced from IFT's Analysis on Fixed Telecommunications Services Infrastructure Competition.

trail left by previous studies, particularly in the United States, suggesting a correlation between several demographic characteristics of its population and the unequal access they had to the Internet in the early 2000s, but also the propositions of historian Thomas Parke Hughes on the social construction of technology: that it is human action what shapes technology and gives large socio-technical systems its form.[149]

The final sub-question presented in Chapter 4 was: How are the spatial dispersion of digital infrastructure and the Oaxacan society related? Its answer was found through a statistical correlational analysis, in which a total of 12 variables were chosen to calculate their Pearson correlation coefficient with the ICM scores across the 570 municipalities in Oaxaca. The socio-demographic, socio-spatial, and socio-economic variables with the strongest correlations in 2020 were its amount of population (ρ=0.72, 95% CI [0.68, 0.76]), the proportion of its population living in rural settlements (ρ=-0.61, 95% CI [-0.66, -0.56]), and its average household income (ρ=0.56, 95% CI [0.50, 0.61]).[150]

In addition to these strong correlations, Oaxacan municipalities also showed a moderate correlation between their ICM scores and their population's average years of schooling (ρ=0.47, 95% CI [0.41, 0.53]), as well as the proportion of its inhabitants in working-age (ρ=0.41, 95% CI [0.34, 0.48]). Plus, weak correlations were found with their social lag index, (ρ=-0.37, 95% CI [-0.44, -0.30]), which measures their access to education, healthcare, and quality housing, the proportion of their population that is ethnically Indigenous (ρ=-0.34, 95% CI [-0.41, -0.26]), and the proportion of their population that is illiterate (ρ=-0.27, 95% CI [-0.34, -0.19]).[151]

While the aforementioned Pearson correlation coefficients show the varying strength of the socio-demographic, socio-economic, and socio-spatial correlations with digital infrastructure across Oaxaca, each of the eight regions showed unique strengths and significances in their correlations with these variables. Regions with digital infrastructure clusters, such as Valles Centrales and Papaloapan, for instance, showed a larger amount of moderate correlations with the labor force, education, and social lag being common recurrences. The regions with wider digital infrastructure gaps, on the other hand, showed the least amount of significant correlations with income, urbanization, and population being consistently strong; the only exception to this was the socio-demographic variable of

[149] Parke Hughes, Thomas. "The Evolution of Large Technological Systems."
[150] Own calculations based on data sourced from IFT's Analysis on Fixed Telecommunications Services Infrastructure Competition.
[151] Own calculations based on data sourced from IFT's Analysis on Fixed Telecommunications Services Infrastructure Competition.

Indigenous ethnicity, which showed a strong correlation in regions with poor Internet connectivity and high digital inequality.

In summary, not one variable is single-handedly responsible for the amount of digital infrastructure developed within the Oaxacan municipalities and the kind of technology used by Internet service providers to supply them with Internet connectivity. The Oaxacan society is diverse, and the social configurations of every region provide nuances on the spatial dispersion of digital infrastructure beyond the strongly correlated variables of population, urbanization, and income.

5.2 A Snapshot of Oaxaca's Social Landscape

Naturally, correlation does not imply causation. However, while quantitative, this research is taking a social constructivist approach toward the development of digital infrastructure in Oaxaca instead of a conventional positivist approach. For this reason, the present correlational analysis is not particularly concerned with proving causation as it is not aiming at generating predictive insights; it is primarily focused on proving that a relation exists between the Oaxacan social space and the digital infrastructure's spatial form amidst the broader historical phenomenon of digital revolution in the information age.

The sociological interpretation of the aforementioned findings in this research, which primarily focused on understanding digital infrastructure clustering in Oaxaca as a form of digital inequality, is primarily informed by two theoretical bodies. On the one hand, it is a socio-spatial analysis inspired by Thomas Parke Hughes' social construction of technology and Gilles Deleuze's reflections on the link between types of machines and types of societies: causality is put aside in favor of a perspective in which infrastructure networks as large socio-technical systems express the (unequal) social forms that created and used them.[152] On the other hand, it is inspired by Manuel Castells' network society, in which information and communication technology development during the digital revolution is historically embedded with processes of capitalist reconfiguration and global integration; the role of Internet service providers in the Internet connectivity landscape of Oaxaca is key from this perspective.[153]

Following these perspectives, this research proposes two insights into why the quantity and quality of digital infrastructure in Oaxaca disproportionally clustered around

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[152] Parke Hughes, Thomas. "The Evolution of Large Technological Systems"; Deleuze, Gilles. "Postscript on the Societies of Control."

[153] Castells, Manuel. *The Rise of the Network Society*.

certain municipalities in 2020. First, from a socio-spatial point of view, a spatial overlap of inequalities in Oaxaca can help understand why is the clustering disproportional and why is it occurring around a few sets of municipalities. Then, discussing the hierarchy of social attributes that seems to be in play in the Mexican network society can reveal why are those the municipalities around which digital infrastructure clustering and not others. If Chapters 3 and 4 discussed the Internet connectivity landscape of Oaxaca, the goal of these conclusive reflections is aimed at revealing an underlying snapshot of the social landscape of Oaxaca in 2020, which built the spatial form of its digital infrastructure in its own social image.

5.2.1 A Spatial Overlap of Inequalities in Oaxaca

In the context of Mexico, Oaxaca is a poor and unequal society in many regards. Income inequality, for instance, can be perceived in both the mean household income and the Gini index score of Oaxaca, and in comparison with the national average. As of 2022, the state's mean monthly household income was 14,447.66 MXN (approximately 741.27 EUR as of July 2024); the average Oaxacan household earned 31.95% less than the Mexican average, which was reported at 21,231.66 MXN (approximately 1,096.27 EUR as of July 2024). The Oaxacan Gini index score in 2022 was 0.502 while the national Gini index score was 0.402: income inequality in Oaxaca 24.86% greater than in Mexico as a whole.[154]

Social inequality is another evidence of Oaxaca as an unequal society. The Social Lag Index (IRS) published by the National Council for Social Development Policies Evaluation (CONEVAL) reports how much are all Mexican areas lagging behind the national average access to education, healthcare, and quality housing development; it serves as a poverty measurement that deals with wellbeing instead of wealth or income. In 2020, Oaxaca showed the second-highest IRS score in Mexico, at 2.59089, just behind the neighboring state of Chiapas and only 2% lower in its social lagging.[155]

Digital inequality in Oaxaca seems to follow a similar pattern to income and social inequality: the digital infrastructure gaps shown in almost all of its territory result in Oaxaca having an average ICM score of 2, the lowest average score in a Mexican state and 5 times lower than the national average. It is a state where digital infrastructure, as well as income and social wellbeing, is particularly lacking in an overall unequal country but in which the little assets that exist are also spatially concentrated in very few, selected areas.

[154] Own calculations based on data sourced from INEGI's Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH) 2022.
[155] CONEVAL. "Índice de Rezago Social 2020".

As a result of this research, because significant correlations were found between many of the socio-demographic, socio-economic, and socio-spatial variables tested and digital infrastructure quantity and quality, it is possible to conclude that there is a spatial trend towards an overlapping of inequalities. This means that not only are wealth, social development, and digital infrastructure within Oaxaca, however few, spatially concentrated in few areas, but that these also tend to be the same areas. This statement is more accurate the stronger the Pearson correlation coefficient is per variable calculated.

A spatial overlap of inequalities helps explain why is the dispersion of digital infrastructure so disproportional across Oaxaca and why is Oaxaca a notorious gap in the Mexican Internet connectivity landscape: the more unequal a society is in variables highly correlated with digital infrastructure, the more unequal digital infrastructure is dispersed. As previously stated, strong correlations were found with population, urbanization, and income, while moderate and weak correlations were also found with education, labor force, social lag, Indigenous ethnicity, and illiteracy. This means that, in many cases, the more a populated area in Oaxaca gets urbanized and more people live in fewer settlements, and the higher wages and profitable local businesses gather in these growing cities, the more digital infrastructure gets built in them to supply those inhabitants with Internet services. Simultaneously, those who remain in the rural settlements see their communities and incomes stagnate, and Internet access reaches them later and scarcely, if ever at all.

Some of the municipalities with larger populations and where larger cities are located in Oaxaca also happen to be home to the digital infrastructure clusters of 2020: Oaxaca de Juárez in Valles Centrales, San Juan Bautista Tuxtepec in Papaloapan, and Juchitán de Zaragoza in the Istmo of Tehuantepec. In the Costa region, on the other hand, the municipality with a noticeably higher digital infrastructure presence may not be as populated as the three aforementioned, but it attracts and hosts national and international tourists whose large numbers and purchase power call for increased Internet connectivity: Santa María Huatulco shows a 36 ICM score while the regional average falls at 2.12.[156] Its mean household income, only closely matched by the neighboring touristic municipality of San Pedro Mixtepec, is also 168.11% higher than the regional average.[157]

[156] Own calculations based on data sourced from IFT's Analysis on Fixed Telecommunications Services Infrastructure Competition.

[157] Own calculations based on data sourced from INEGI's Ingreso Corriente para los Municipios de México (ICMM) 2020.

5.2.2 Socio-Technical Politics of the Network Society

Looking at digital infrastructure across Oaxaca, especially by making a snapshot of its dispersion by 2020 and analyzing it as a reflection of the society that built and uses it, holds anthropological value: it serves as material evidence of the otherwise intangible inequalities the Oaxacan society had in this point of its history. Its sociological relevance, however, must not be understated: its function as a material expression of the Oaxacan society is also an expression of the network society that assimilates Oaxacan communities through the introduction and expansion of digital infrastructure coverage. In other words, the ongoing and fast-paced development of digital infrastructure gives a snapshot of its form in 2020 historical value as it depicts Oaxaca's stage of incorporation into the information age.

Analyzing the digital infrastructure's spatial form in Oaxaca provides insights into the priorities and values of the network society, which can help explain why are those the municipalities around which digital infrastructure clusters and not others. Beyond stating the socio-demographic, socio-economic, and socio-spatial variables more strongly correlated with digital infrastructure, and beyond highlighting the spatial overlap of inequalities, there are also signs of a hierarchy of social attributes that the network society promotes and that private Internet service providers enforce when making decisions of who is worth connecting to the Internet (first). The correlated variables are not arbitrary.

Internet service providers are private companies in a market economy. Their decisions of in which municipalities to operate, either by developing new digital infrastructure or by making use of existing wireline networks but making their operations services readily available, are based on the capitalist goal of economic growth: increased revenue through high return on investments and market expansion. Identifying emerging markets in previously unoperated municipalities, either those close to already profitable municipalities or in new regions where no competitors are currently operating, is what leads to digital infrastructure clusters and gaps across Oaxaca.

The criteria behind these decisions seem to be clear from the correlational analysis conducted in this research: urban areas inhabited by relatively wealthier populations are seen as more profitable than rural and underpopulated areas. The higher the mean household income, the higher the purchasing power they have and the better suited they are as potential consumers. The higher the amount of population, the higher the chances of achieving a wide enough consumer base to obtain profit from their investment. The smaller the population in the municipality is scattered across rural settlements, the less investment is required to reach further away households with fixed broadband Internet access services. The more ISPs operate in a municipality, the more likely it is that the competition results in the use of better technology and lower prices. The communities, in conclusion, that fit this criteria sit atop of the hierarchy of social attributes driving the network society integration in Oaxaca; those that can't are placed at the bottom.

Decisions of where to develop digital infrastructure first in otherwise disconnected regions, in consequence, follow simple criteria with fewer variables, looking for potential emerging markets for their services. Decisions of where to develop further in already connected areas bring in turn more variables into question: by having several neighboring municipalities to the already profitable areas, ISPs may look for nuanced characteristics to identify ideal potential consumers, such as higher levels of education, a wider labor force that may potentially require Internet services for their economic activities, or lower degrees of social lag that would result in fewer basic necessities that need to be covered by the population before purchasing an Internet subscription.

The case of Indigenous communities with little to no digital infrastructure developed in their municipalities is a paradoxical case in this hierarchy of social attributes. Taking the Sierra de Flores Magón region as an example, it stands out that San Juan Bautista Cuicatlán, Teotitlán de Flores Magón, and Santa María Tecomavaca are almost all the municipalities in the region that show any presence of digital infrastructure. There are other municipalities in Sierra de Flores Magón with higher mean household income, higher amount of population, and with more average years of schooling that have no Internet services supplied in them, but these municipalities are almost entirely inhabited by Indigenous populations. It is possible that ISPs identify these alternative municipalities as Indigenous communities and, at the same time, do not see Indigenous communities as potentially profitable consumers.

Whether these Indigenous communities in Sierra de Flores Magón, and the inhabitantes of the widely disconnected Indigenous municipalities across Oaxaca, participate in the market economy cannot be concluded from the data used for this research, but the idea that they might not do so is potentially limiting the development of digital infrastructure in their territories. The attributes associated with being Indigenous seem to be placing the Indigenous ethnicity at the bottom of the hierarchy of social attributes of the network society in a way the Afro-Mexican ethnicity is not, resulting in an infrastructure bypassing Manuel Castells already alerted of under the concept of splintering urbanism.[158]

[158] Castells, Manuel. *The Rise of the Network Society*.

The bypassing of digital infrastructure networks over Indigenous communities also reveals the underlying socio-technical politics of the network society. On the one hand, there seems to be a racial discrimination in digital infrastructure supply based on preconceived social attributes of Indigenous ethnicities that are not favored in the network society. On the other hand, even if some Indigenous communities are not commodity and service consumption-oriented, capitalist expansion is so embedded in digital infrastructure development that to take part in the network society, to enter the information age at such an elementary level as accessing the Internet, it is a prerequisite to comply with the capitalist economic system. Otherwise, refusal to participate is met with technical isolation amidst a historical process of global integration.

6.3 Limitations & Future Research Directions

As a closing remark, this final section discusses some of the main limitations of the present research while also proposing an agenda for future research on the Internet connectivity landscape in Oaxaca. These limitations are discussed in two senses: technical limitations, for instance, refer to areas where lack of information or limited research time resulted in decisions constraining the analysis within the overall chosen research design. Scope limitations, in contrast, reflect on decisions regarding data sources, analytical techniques, and scholarly approaches that formed this research design, but which could provide relevant insights if explored in future research.

One technical limitation was the lack of a readily available dataset on the average elevation of municipalities in Oaxaca, as making one was not possible within the timeframe for this research. Elevation varies significantly across Mexico and on a national level a correlational analysis with digital infrastructure presence may not be as relevant, but a highly mountainous state like Oaxaca could present some insightful correlations since challenging topographies can elevate costs for infrastructure development. Data on elevation can be sourced from INEGI's Mexican Elevation Continuum (CEM) 3.0, originally collected in 2012 as a third version of the geographical continuum of elevations created in 2007 and 2010 on a 1:50,000 scale. Crafting such a dataset and calculating a Pearson correlation coefficient with the IFT's ICM values would expand this research's findings, particularly by enhancing the analysis of socio-spatial variables.

Another technical limitation lies in the suggested historical co-constitutivity of digital infrastructure and Indigenous ethnicity. It would be ideal to test it by exploring the evolution of Indigenous populations in every municipality of Oaxaca and comparing that evolution based on their different digital infrastructure Municipal Competition Index (ICM). The only available data for Indigenous populations, however, is from INEGI's Population and Housing Census from 2015, preventing an exploration of this variable over time. The number of people in each municipality that speak any and each Indigenous language exists, as it has been reported in the national census for decades, but it should be noted that the loss of Indigenous languages among Indigenous communities is a real and separate challenge that does not accurately reflect the presence or size of these Indigenous communities.

Similarly, the historical co-constitutivity of digital infrastructure and urbanization could not be explored due to data unavailability. The municipal urban-rural ratio dataset used for this research was built by the IFT using INEGI's CCPV 2020 data, and it is possible to build it for past periods using the Population and Housing Census information on population on the municipal and the local level: calculating a municipal proportion of the population living in localities of under 5,000 inhabitants. Future research could construct this dataset to analyze and compare their evolution over time to test these potentially looped dynamics.

A scope limitation, on the other hand, is reflected in the way that some socio-demographic variables, such as age and gender, did not show significant correlations with digital infrastructure in this study despite expectations. This does not mean that there is no correlation between age or gender and digital inequality: it means that it is not visible with the limited granularity provided by conducting the analysis on a municipal level. Future research could use more granular spatial analysis at the neighborhood, block, or household level to explore nuances in the potential correlation age and gender hold with digital inequality.

Additionally, this research is based on a quantitative analysis of the data provided by the Federal Institute of Telecommunications (IFT) and the National Institute of Geography and Statistics (INEGI). Future studies could instead approach the Internet connectivity landscape via qualitative methods, such as interviews and participatory observation, to research what Internet connectivity means for those with a relatively high amount of digital infrastructure and high-speed Internet connection compared to the rest of the territory; for those in municipalities with lower ICM near digital infrastructure clusters, where variables like high social lag or a majority of Indigenous population inhabiting it result in poorer Internet connectivity; and for those in widely disconnected regions where digital infrastructure has barely been developed in 2020.

Another scope limitation is the focus on Internet availability as a form of technical digital inequality, as it represents only one of the five forms of digital inequality proposed by economists Paul DiMaggio and Eszter Hargittai.[159] Looking instead at the Internet use across Oaxaca from a qualitative perspective could provide instead further insights into other types of digital inequality: from autonomy (whether the time of access users have is limited or unlimited, supervised or unsupervised, privately or publicly granted), skill (if users have the knowledge required to make full advantageous use of that access), and social support (whether a network of more experienced users exists to help solve navigating issues for others) to the very purpose it is being used for (from educational and recreational to productive).

It should not go unmentioned that this thesis exclusively deals with fixed broadband Internet infrastructure, which poses one of the main scope limitations in the research: it does not take into account mobile telephony, an increasingly relevant technology for Internet access without which no Internet connectivity landscape is complete. Mobile data plans were actively avoided when designing this research, mainly because they are not directly tied to spatial locations in a way household Internet plans are and because cell phone towers are not used exclusively for Internet connectivity, which would make the distinction between cellphone users and Internet users impossible without directly analyzing users' data traffic. Researching both the cell phone tower networks and mobile data plan subscribership is, for this reason, a key topic for future research.

Lastly, while this research takes a historical perspective for its understanding of both Oaxaca's Internet connectivity landscape and each of the sub-questions aimed at discussing the sociological patterns involved in its spatial form, the analysis is limited to a snapshot of the year 2020. Some of the challenges to an evolutionary analysis of the socio-demographic, socio-economic, and socio-spatial characteristics of the Oaxacan social space have already been discussed in the technical limitations of this study, but an evolutionary analysis of the Oaxacan digital infrastructure deployment over the years would also be valuable for studying the process of network society formation. Geographic Information System (GIS) mapping in particular is an ideal analytical method for this approach.

Despite these limitations, this research highlights the significant socio-demographic, socio-economic, and socio-spatial factors influencing digital infrastructure development across Oaxaca. The disproportionate clustering of digital infrastructure in one of Mexico's most digitally disconnected states is shown to serve as material evidence of not only digital inequality but also of an unequal and socially complex society reached by the digital

[159] Hargittai, Eszter. *Handbook of Digital Inequality*.

revolution in the year 2020. Hopefully, the spatial overlap of inequalities in Oaxaca and the socio-technical politics of the network society that seem to be in play behind this digital infrastructure's spatial form may serve as inspiration for more research on Mexico, on digital inequality, and on those who inhabit the information age. History is today, too.

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Appendix 1: District Comparisons Across Oaxaca

Region	District	ICM	IDDM	% Land Area	% Households	% Population	% Age	% Gender	% Indig.	% Afro	% Income	% Labor	% Education	% Illiteracy	IRS	% Rurality	P. Density
Costa	Jamiltepec	1.46	5.08	179.07	2218.67	8146.17	27.08	48.67	60.74	38.23	3445.88	66.22	6.41	17.79	0.78	87.41	50.01
Costa	Juquila	1.50	6.08	291.23	3817.42	14191.00	24.42	46.99	76.19	12.19	5332.66	66.92	5.92	20.03	0.84	75.26	54.19
Costa	Pochutla	3.79	7.57	269.75	4269.29	16231.00	25.29	48.61	70.82	2.30	5194.34	66.98	6.07	16.32	1.28	90.93	54.30
Istmo	Juchitán	7.50	15.23	428.77	5763.50	19900.36	31.95	48.81	76.66	2.03	6010.80	69.09	7.36	12.70	0.19	64.78	101.35
Istmo	Tehuantepec	4.11	11.53	588.75	3213.37	10758.53	31.63	48.86	76.53	2.42	5474.34	68.23	7.01	12.48	0.12	68.79	40.32
Mixteca	Coixtlahuaca	0.46	2.69	126.41	222.92	703.15	36.38	47.26	78.10	0.74	3027.55	63.03	6.58	8.20	0.03	100.00	6.88
Mixteca	Huajuapan	1.54	4.29	117.24	1434.61	5414.82	30.71	48.18	62.87	1.91	3770.28	64.23	6.27	13.35	0.15	97.44	38.81
Mixteca	Juxtlahuaca	2.14	5.57	222.56	2127.14	9848.00	28.57	46.02	86.59	0.59	2650.98	62.82	5.03	30.23	1.51	95.64	41.08
Mixteca	Nochixtlán	0.38	3.31	88.18	569.94	1917.47	34.09	47.35	83.17	1.91	2628.24	63.13	6.59	12.20	0.85	97.58	23.64
Mixteca	Silacayopám	0.68	2.63	98.47	468.89	1713.21	31.11	47.86	66.06	1.36	2642.79	60.36	5.27	22.16	0.48	100.00	22.80
Mixteca	Teposcolula	0.90	4.05	72.57	468.57	1648.57	35.62	47.36	75.95	4.65	3499.39	64.85	6.85	8.61	0.27	96.20	19.37
Mixteca	Tlaxiaco	0.51	2.94	77.65	926.09	3307.86	31.23	46.85	90.25	1.61	2561.33	65.14	6.80	13.92	1.24	98.65	34.54
Papaloapan	Choápam	0.00	1.33	489.18	2126.17	8323.83	24.67	48.43	90.58	0.38	1817.24	65.90	5.35	19.83	1.77	100.00	19.88
Papaloapan	Tuxtepec	9.07	12.36	394.64	8533.00	30392.64	28.00	48.03	75.12	2.44	3934.80	67.97	6.54	15.68	0.78	73.64	81.07
Flores Magón	Cuicatlán	0.70	2.75	116.54	1626.30	5769.30	29.25	48.11	87.12	2.67	2268.78	64.99	5.51	24.84	1.53	95.43	61.66
Flores Magón	Teotitlán	0.48	2.76	85.71	916.88	3352.48	30.64	47.88	86.16	4.51	2163.59	64.55	5.64	22.95	1.40	96.65	91.65
S. de Juárez	Ixtlán	0.35	3.85	108.85	400.96	1375.00	32.96	46.88	92.01	3.23	3484.59	66.48	7.00	7.98	0.00	100.00	27.42
S. de Juárez	Mixe	0.47	2.47	288.91	1740.53	6429.76	27.18	47.82	92.56	0.78	2999.21	66.93	5.69	23.72	1.66	100.00	35.69
S. de Juárez	Villa Alta	0.20	2.40	47.06	372.84	1206.80	33.28	47.28	92.81	1.05	2175.05	65.36	6.20	11.55	0.46	100.00	47.37
Sierra Sur	Miahuatlán	0.97	2.84	131.60	1198.09	4515.06	26.22	47.96	73.08	2.01	3257.83	66.09	5.76	18.17	1.34	98.19	42.19
Sierra Sur	Putla	2.40	5.40	259.60	2621.80	9571.10	25.80	47.09	73.33	5.87	2921.99	65.94	6.23	17.12	0.91	92.84	39.95
Sierra Sur	Sola de Vega	1.12	2.94	238.82	1450.76	6070.59	23.94	47.95	72.40	1.27	2249.36	65.77	5.87	17.37	1.42	97.95	28.09
Sierra Sur	Yautepec	0.25	2.08	383.20	771.33	2844.00	31.67	48.50	86.65	1.45	1923.53	65.46	6.37	11.47	0.71	100.00	9.05
V. Centrales	Centro	9.14	25.76	25.65	8446.19	30857.95	29.95	47.50	45.59	2.64	11424.66	73.80	9.39	3.50	-0.62	45.52	1553.40

V. Centrales	Ejutla	1.00	2.92	73.10	1011.54	3835.92	29.08	47.30	56.36	4.62	3123.86	65.38	5.64	18.41	0.98	96.29	68.55
V. Centrales	Etla	5.13	13.78	93.21	1779.43	6760.09	29.43	47.86	54.06	2.23	7997.89	70.52	8.24	5.43	-0.19	80.14	259.84
V. Centrales	Ocotlán	1.65	5.65	43.35	1060.05	4025.35	29.60	47.26	72.92	3.05	5677.21	68.11	6.66	12.85	0.89	91.71	172.93
V. Centrales	Tlacolula	1.64	7.32	131.09	1498.76	5503.20	32.32	47.39	81.26	1.31	5906.67	68.91	6.51	11.88	0.26	88.28	89.44
V. Centrales	Zaachila	0.83	3.83	95.37	2570.17	10120.83	26.00	47.63	73.32	1.53	4131.50	66.54	6.83	10.76	1.17	88.27	141.58
V. Centrales	Zimatlán	1.62	7.77	75.90	1269.23	4747.62	29.31	48.06	57.86	3.76	4667.15	66.99	6.60	12.84	0.52	87.67	112.67

Source: IFT, Federal Institute of Telecommunications, XLSX export from "Indicadores de Infraestructura y Digitalización a Nivel Municipal" (April 15, 2024), INEGI, National Institute of Geography and Statistics, "CCPV 2020", and CONEVAL, National Council for Social Development Policies Evaluation, "IRS 2020", own calculations.

Appendix 2: ICM Correlations with Chosen Variables

ICM Correlations	Population	Age	Gender	Indigenous	Afro	Income	Labor Force	Social Lag	Education	Literacy	Rurality	P. Density
Oaxaca (ρ)	0.72	-0.01	0.30	-0.34	0.00	0.56	0.41	-0.37	0.47	-0.27	-0.61	0.30
Costa (*r*)	0.68	0.12	0.37	-0.20	-0.08	0.67	0.55	-0.38	0.57	-0.41	-0.50	0.37
Istmo (*r*)	0.83	0.01	0.49	-0.37	0.12	0.54	0.58	-0.50	0.55	-0.47	-0.59	0.49
Mixteca (*r*)	0.79	-0.10	0.55	-0.12	0.05	0.45	0.19	-0.18	0.24	-0.10	-0.57	0.55
Papaloapan (*r*)	0.80	0.55	0.48	-0.68	0.34	0.77	0.49	-0.59	0.64	-0.55	-0.77	0.48
Flores Magón (*r*)	0.30	-0.02	-0.08	-0.66	0.09	0.68	0.34	-0.41	0.52	-0.38	-0.78	-0.08
S. de Juárez (*r*)	0.55	-0.14	0.16	-0.39	0.08	0.46	0.16	-0.12	0.27	-0.08	N/A	0.16
Sierra Sur (*r*)	0.66	0.02	0.38	-0.27	0.06	0.47	0.17	-0.34	0.44	-0.19	-0.77	0.38
V. Centrales (*r*)	0.68	0.05	0.47	-0.38	0.03	0.65	0.57	-0.50	0.60	-0.42	-0.57	0.47

Source: IFT, Federal Institute of Telecommunications, XLSX export from "Indicadores de Infraestructura y Digitalización a Nivel Municipal" (April 15, 2024), INEGI, National Institute of Geography and Statistics, "CCPV 2020", and CONEVAL, National Council for Social Development Policies Evaluation, "IRS 2020", own calculations.

Appendix 3: IDDM Correlations with Chosen Variables

IDDM Correlations	Population	Age	Gender	Indigenous	Afro	Income	Labor Force	Social Lag	Education	Literacy	Rurality	P. Density
Oaxaca (ρ)	0.65	0.03	-0.01	-0.41	0.01	0.75	0.54	-0.52	0.67	-0.39	-0.70	0.46
Costa (*r*)	0.81	0.17	0.13	-0.26	-0.07	0.80	0.58	-0.50	0.69	-0.51	-0.66	0.46
Istmo (*r*)	0.72	0.12	-0.49	-0.46	0.14	0.64	0.60	-0.62	0.68	-0.57	-0.64	0.49
Mixteca (*r*)	0.78	-0.11	-0.03	-0.14	0.16	0.63	0.29	-0.29	0.41	-0.20	-0.72	0.54
Papaloapan (*r*)	0.83	0.67	-0.04	-0.71	0.33	0.86	0.61	-0.72	0.78	-0.64	-0.79	0.47
Flores Magón (*r*)	0.28	-0.06	-0.01	-0.73	0.05	0.85	0.39	-0.52	0.69	-0.46	-0.86	-0.06
S. de Juárez (*r*)	0.17	0.05	-0.08	-0.38	0.30	0.83	0.24	-0.48	0.72	-0.30	N/A	0.28
Sierra Sur (*r*)	0.70	0.05	-0.20	-0.22	0.08	0.59	0.28	-0.39	0.52	-0.22	-0.78	0.36
V. Centrales (*r*)	0.56	0.15	-0.05	-0.47	0.02	0.79	0.69	-0.66	0.75	-0.54	-0.62	0.59

Source: IFT, Federal Institute of Telecommunications, XLSX export from "Indicadores de Infraestructura y Digitalización a Nivel Municipal" (April 15, 2024), INEGI, National Institute of Geography and Statistics, "CCPV 2020", and CONEVAL, National Council for Social Development Policies Evaluation, "IRS 2020", own calculations.

Appendix 4: Confidence Interval Calculations for Oaxaca

OAXACA	**Population**	**Age**	**Gender**	**Indigenous**	**Afro-Mexican**	**Income**	**Labor Force**	**Social Lag**	**Education**	**Literacy**	**Rurality**	**Population Density**
Pearson correlation coefficient (ρ)	**0.72259**	**-0.01189**	**0.01034**	**-0.33581**	**0.00246**	**0.55551**	**0.41059**	**-0.37431**	**0.47232**	**-0.26807**	**-0.61357**	**0.30462**
ρ into Fisher *z*	0.91304	-0.01189	0.01034	-0.34937	0.00246	0.62632	0.43632	-0.39342	0.51305	-0.27479	-0.71463	0.31461
Sample size (n)	570	570	570	570	570	570	570	570	570	570	570	570
Standard error (SE*z*)	**0.04200**	**0.04200**	**0.04200**	**0.04200**	**0.04200**	**0.04200**	**0.04200**	**0.04200**	**0.04200**	**0.04200**	**0.04200**	**0.04200**
Critical value (95%)	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996
Lower bound of *z* confidence interval	0.83073	-0.09420	-0.07197	-0.43168	-0.07985	0.54401	0.35401	-0.47573	0.43074	-0.35710	-0.79694	0.23230
Upper bound of *z* confidence interval	0.99535	0.07042	0.09265	-0.26706	0.08477	0.70863	0.51864	-0.31111	0.59536	-0.19248	-0.63231	0.39692
***r* confidence interval: lower bound (*z* into ρ)**	**0.68087**	**-0.09393**	**-0.07185**	**-0.40672**	**-0.07968**	**0.49601**	**0.33993**	**-0.44282**	**0.40594**	**-0.34266**	**-0.66232**	**0.22821**
***r* confidence interval: upper bound (*z* into ρ)**	**0.75964**	**0.07030**	**0.09239**	**-0.26088**	**0.08457**	**0.60982**	**0.47665**	**-0.30145**	**0.53374**	**-0.19013**	**-0.55964**	**0.37731**

Source: IFT, Federal Institute of Telecommunications, XLSX export from “Indicadores de Infraestructura y Digitalización a Nivel Municipal” (April 15, 2024), INEGI, National Institute of Geography and Statistics, “CCPV 2020”, and CONEVAL, National Council for Social Development Policies Evaluation, “IRS 2020”, own calculations.

Appendix 5: Confidence Interval Calculations for Costa

COSTA	Population	Age	Gender	Indigenous	Afro-Mexican	Income	Labor Force	Social Lag	Education	Literacy	Rurality	Population Density
Pearson correlation coefficient (*r*)	**0.67982**	**0.12301**	**0.12066**	**-0.20346**	**-0.08305**	**0.66538**	**0.55119**	**-0.38392**	**0.56638**	**-0.40540**	**-0.49796**	**0.36639**
r into Fisher *z*	0.82877	0.12364	0.12125	-0.20634	-0.08324	0.80240	0.62009	-0.40465	0.64217	-0.43009	-0.54658	0.38425
Sample size (n)	50	50	50	50	50	50	50	50	50	50	50	50
Standard error (SE*z*)	**0.14586**	**0.14586**	**0.14586**	**0.14586**	**0.14586**	**0.14586**	**0.14586**	**0.14586**	**0.14586**	**0.14586**	**0.14586**	**0.14586**
Critical value (95%)	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996
Lower bound of *z* confidence interval	0.54288	-0.16225	-0.16464	-0.49223	-0.36913	0.51651	0.33420	-0.69054	0.35628	-0.71598	-0.83247	0.09836
Upper bound of *z* confidence interval	1.11466	0.40953	0.40714	0.07955	0.20265	1.08829	0.90598	-0.11876	0.92806	-0.14420	-0.26069	0.67014
***r* confidence interval: lower bound (*z* into *r*)**	**0.49517**	**-0.16084**	**-0.16317**	**-0.45598**	**-0.35323**	**0.47500**	**0.32229**	**-0.59833**	**0.34194**	**-0.61442**	**-0.68180**	**0.09805**
***r* confidence interval: upper bound (*z* into *r*)**	**0.80570**	**0.38807**	**0.38604**	**0.07938**	**0.19992**	**0.79625**	**0.71920**	**-0.11821**	**0.72969**	**-0.14321**	**-0.25494**	**0.58507**

Source: IFT, Federal Institute of Telecommunications, XLSX export from “Indicadores de Infraestructura y Digitalización a Nivel Municipal” (April 15, 2024), INEGI, National Institute of Geography and Statistics, “CCPV 2020”, and CONEVAL, National Council for Social Development Policies Evaluation, “IRS 2020”, own calculations.

Appendix 6: Confidence Interval Calculations for Istmo

ISTMO	Population	Age	Gender	Indigenous	Afro-Mexican	Income	Labor Force	Social Lag	Education	Literacy	Rurality	Population Density
Pearson correlation coefficient (*r*)	**0.82640**	**0.00830**	**-0.45919**	**-0.36925**	**0.12169**	**0.54257**	**0.58464**	**-0.50390**	**0.55438**	**-0.46976**	**-0.59344**	**0.48615**
r into Fisher *z*	1.17667	0.00830	-0.49628	-0.38755	0.12230	0.60779	0.66949	-0.55452	0.62469	-0.50976	-0.68297	0.53100
Sample size (n)	41	41	41	41	41	41	41	41	41	41	41	41
Standard error (SE*z*)	**0.16222**	**0.16222**	**0.16222**	**0.16222**	**0.16222**	**0.16222**	**0.16222**	**0.16222**	**0.16222**	**0.16222**	**0.16222**	**0.16222**
Critical value (95%)	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996
Lower bound of *z* confidence interval	0.85872	-0.30965	-0.81423	-0.70550	-0.19565	0.28985	0.35154	-0.87247	0.30674	-0.82771	-1.00091	0.21305
Upper bound of *z* confidence interval	1.49462	0.32625	-0.17833	-0.06961	0.44024	0.92574	0.98743	-0.23658	0.94264	-0.19182	-0.36502	0.84895
***r* confidence interval: lower bound (*z* into *r*)**	**0.69560**	**-0.30012**	**-0.67192**	**-0.60785**	**-0.19319**	**0.28199**	**0.33774**	**-0.70263**	**0.29747**	**-0.67925**	**-0.76198**	**0.20989**
***r* confidence interval: upper bound (*z* into *r*)**	**0.90417**	**0.31515**	**-0.17646**	**-0.06949**	**0.41385**	**0.72860**	**0.75627**	**-0.23226**	**0.73643**	**-0.18950**	**-0.34963**	**0.69052**

Source: IFT, Federal Institute of Telecommunications, XLSX export from “Indicadores de Infraestructura y Digitalización a Nivel Municipal” (April 15, 2024), INEGI, National Institute of Geography and Statistics, “CCPV 2020”, and CONEVAL, National Council for Social Development Policies Evaluation, “IRS 2020”, own calculations.

Appendix 7: Confidence Interval Calculations for Mixteca

MIXTECA	Population	Age	Gender	Indigenous	Afro-Mexican	Income	Labor Force	Social Lag	Education	Literacy	Rurality	Population Density
Pearson correlation coefficient (*r*)	**0.79385**	**-0.10011**	**-0.01098**	**-0.11971**	**0.05011**	**0.45423**	**0.18950**	**-0.18288**	**0.24266**	**-0.10288**	**-0.57449**	**0.55435**
r into Fisher *z*	1.08176	-0.10044	-0.01098	-0.12028	0.05015	0.49002	0.19182	-0.18496	0.24760	-0.10324	-0.65420	0.62463
Sample size (n)	155	155	155	155	155	155	155	155	155	155	155	155
Standard error (SE*z*)	**0.08111**	**0.08111**	**0.08111**	**0.08111**	**0.08111**	**0.08111**	**0.08111**	**0.08111**	**0.08111**	**0.08111**	**0.08111**	**0.08111**
Critical value (95%)	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996
Lower bound of *z* confidence interval	0.92278	-0.25942	-0.16995	-0.27926	-0.10883	0.33104	0.03284	-0.34394	0.08862	-0.26222	-0.81318	0.46566
Upper bound of *z* confidence interval	1.24073	0.05853	0.14799	0.03869	0.20912	0.64899	0.35079	-0.02599	0.40657	0.05573	-0.49523	0.78361
***r* confidence interval: lower bound (*z* into *r*)**	**0.72721**	**-0.25375**	**-0.16834**	**-0.27222**	**-0.10840**	**0.31946**	**0.03283**	**-0.33099**	**0.08839**	**-0.25637**	**-0.67134**	**0.43469**
***r* confidence interval: upper bound (*z* into *r*)**	**0.84566**	**0.05846**	**0.14692**	**0.03867**	**0.20613**	**0.57099**	**0.33708**	**-0.02598**	**0.38556**	**0.05567**	**-0.45836**	**0.65477**

Source: IFT, Federal Institute of Telecommunications, XLSX export from "Indicadores de Infraestructura y Digitalización a Nivel Municipal" (April 15, 2024), INEGI, National Institute of Geography and Statistics, "CCPV 2020", and CONEVAL, National Council for Social Development Policies Evaluation, "IRS 2020", own calculations.

Appendix 8: Confidence Interval Calculations for Papaloapan

PAPALOAPAN	Population	Age	Gender	Indigenous	Afro-Mexican	Income	Labor Force	Social Lag	Education	Literacy	Rurality	Population Density
Pearson correlation coefficient (*r*)	**0.80212**	**0.54790**	**-0.00259**	**-0.68465**	**0.34418**	**0.77055**	**0.49492**	**-0.59137**	**0.64390**	**-0.54689**	**-0.76983**	**0.47648**
r into Fisher *z*	1.10453	0.61538	-0.00259	-0.83781	0.35882	1.02168	0.54256	-0.67977	0.76480	-0.61393	-1.01991	0.51842
Sample size (n)	20	20	20	20	20	20	20	20	20	20	20	20
Standard error (SE*z*)	**0.24254**	**0.24254**	**0.24254**	**0.24254**	**0.24254**	**0.24254**	**0.24254**	**0.24254**	**0.24254**	**0.24254**	**0.24254**	**0.24254**
Critical value (95%)	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996
Lower bound of *z* confidence interval	0.62917	0.14002	-0.47795	-1.31318	-0.11654	0.54632	0.06720	-1.15513	0.28944	-1.08929	-1.49527	0.04305
Upper bound of *z* confidence interval	1.57989	1.09074	0.47277	-0.36245	0.83418	1.49704	1.01792	-0.20441	1.24016	-0.13857	-0.54454	0.99378
***r* confidence interval: lower bound (*z* into *r*)**	**0.55748**	**0.13911**	**-0.44460**	**-0.86508**	**-0.11601**	**0.49775**	**0.06709**	**-0.81945**	**0.28162**	**-0.79662**	**-0.90429**	**0.04303**
***r* confidence interval: upper bound (*z* into *r*)**	**0.91858**	**0.79715**	**0.44043**	**-0.34737**	**0.68272**	**0.90461**	**0.76902**	**-0.20161**	**0.84550**	**-0.13769**	**-0.49642**	**0.75897**

Source: IFT, Federal Institute of Telecommunications, XLSX export from "Indicadores de Infraestructura y Digitalización a Nivel Municipal" (April 15, 2024), INEGI, National Institute of Geography and Statistics, "CCPV 2020", and CONEVAL, National Council for Social Development Policies Evaluation, "IRS 2020", own calculations.

Appendix 9: Confidence Interval Calculations for Sierra de Flores Magón

S. FLORES MAGÓN	Population	Age	Gender	Indigenous	Afro-Mexican	Income	Labor Force	Social Lag	Education	Literacy	Rurality	Population Density
Pearson correlation coefficient (*r*)	**0.29771**	**-0.02048**	**0.03104**	**-0.66202**	**0.08503**	**0.68374**	**0.33864**	**-0.40830**	**0.51734**	**-0.37630**	**-0.77605**	**-0.07676**
r into Fisher *z*	0.30700	-0.02048	0.03105	-0.79641	0.08524	0.83611	0.35256	-0.43357	0.57269	-0.39574	-1.03535	-0.07691
Sample size (n)	45	45	45	45	45	45	45	45	45	45	45	45
Standard error (SE*z*)	**0.15430**	**0.15430**	**0.15430**	**0.15430**	**0.15430**	**0.15430**	**0.15430**	**0.15430**	**0.15430**	**0.15430**	**0.15430**	**0.15430**
Critical value (95%)	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996
Lower bound of *z* confidence interval	0.00457	-0.32291	-0.27138	-1.09884	-0.21719	0.53368	0.05013	-0.73599	0.27027	-0.69817	-1.33778	-0.37934
Upper bound of *z* confidence interval	0.60943	0.28195	0.33348	-0.49398	0.38767	1.13854	0.65499	-0.13114	0.87512	-0.09331	-0.73292	0.22552
***r* confidence interval: lower bound (*z* into *r*)**	**0.00457**	**-0.31214**	**-0.26491**	**-0.80008**	**-0.21384**	**0.48819**	**0.05009**	**-0.62672**	**0.26387**	**-0.60320**	**-0.87114**	**-0.36214**
***r* confidence interval: upper bound (*z* into *r*)**	**0.54373**	**0.27471**	**0.32164**	**-0.45737**	**0.36935**	**0.81392**	**0.57502**	**-0.13039**	**0.70397**	**-0.09304**	**-0.62485**	**0.22177**

Source: IFT, Federal Institute of Telecommunications, XLSX export from “Indicadores de Infraestructura y Digitalización a Nivel Municipal” (April 15, 2024), INEGI, National Institute of Geography and Statistics, “CCPV 2020”, and CONEVAL, National Council for Social Development Policies Evaluation, “IRS 2020”, own calculations.

Appendix 10: Confidence Interval Calculations for Sierra de Juárez

S. DE JUÁREZ	**Population**	**Age**	**Gender**	**Indigenous**	**Afro-Mexican**	**Income**	**Labor Force**	**Social Lag**	**Education**	**Literacy**	**Rurality**	**Population Density**
Pearson correlation coefficient (*r*)	**0.54579**	**-0.14483**	**0.06329**	**-0.38876**	**0.07577**	**0.45912**	**0.15746**	**-0.11856**	**0.27242**	**-0.07711**	**N/A**	**0.16188**
r into Fisher *z*	0.61236	-0.14585	0.06338	-0.41034	0.07592	0.49619	0.15878	-0.11912	0.27947	-0.07726	N/A	0.16332
Sample size (n)	68	68	68	68	68	68	68	68	68	68	68	68
Standard error (SE*z*)	**0.12403**	**0.12403**	**0.12403**	**0.12403**	**0.12403**	**0.12403**	**0.12403**	**0.12403**	**0.12403**	**0.12403**	**0.12403**	**0.12403**
Critical value (95%)	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996
Lower bound of *z* confidence interval	0.36926	-0.38896	-0.17973	-0.65344	-0.16718	0.25309	-0.08433	-0.36223	0.03637	-0.32037	N/A	-0.07978
Upper bound of *z* confidence interval	0.85547	0.09725	0.30648	-0.16723	0.31902	0.73929	0.40188	0.12398	0.52258	0.16584	N/A	0.40642
***r* confidence interval: lower bound (*z* into *r*)**	**0.35334**	**-0.37046**	**-0.17782**	**-0.57398**	**-0.16564**	**0.24782**	**-0.08413**	**-0.34717**	**0.03635**	**-0.30984**	**N/A**	**-0.07961**
***r* confidence interval: upper bound (*z* into *r*)**	**0.69391**	**0.09694**	**0.29723**	**-0.16569**	**0.30862**	**0.62872**	**0.38156**	**0.12335**	**0.47968**	**0.16434**	**N/A**	**0.38543**

Source: IFT, Federal Institute of Telecommunications, XLSX export from “Indicadores de Infraestructura y Digitalización a Nivel Municipal” (April 15, 2024), INEGI, National Institute of Geography and Statistics, “CCPV 2020”, and CONEVAL, National Council for Social Development Policies Evaluation, “IRS 2020”, own calculations.

Appendix 11: Confidence Interval Calculations for Sierra Sur

SIERRA SUR	Population	Age	Gender	Indigenous	Afro-Mexican	Income	Labor Force	Social Lag	Education	Literacy	Rurality	Population Density
Pearson correlation coefficient (*r*)	**0.66182**	**0.02089**	**-0.17473**	**-0.27112**	**0.06288**	**0.46977**	**0.16771**	**-0.33940**	**0.43606**	**-0.19106**	**-0.76901**	**0.38469**
r into Fisher *z*	0.79605	0.02090	-0.17654	-0.27807	0.06296	0.50978	0.16931	-0.35341	0.46736	-0.19344	-1.01789	0.40556
Sample size (n)	70	70	70	70	70	70	70	70	70	70	70	70
Standard error (SE*z*)	**0.12217**	**0.12217**	**0.12217**	**0.12217**	**0.12217**	**0.12217**	**0.12217**	**0.12217**	**0.12217**	**0.12217**	**0.12217**	**0.12217**
Critical value (95%)	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996
Lower bound of *z* confidence interval	0.55660	-0.21855	-0.41599	-0.51752	-0.17648	0.27033	-0.07014	-0.59286	0.22791	-0.43289	-1.25734	0.16611
Upper bound of *z* confidence interval	1.03549	0.26035	0.06291	-0.03862	0.30241	0.74923	0.40876	-0.11396	0.70681	0.04601	-0.77845	0.64500
***r* confidence interval: lower bound (*z* into *r*)**	**0.50545**	**-0.21514**	**-0.39354**	**-0.47578**	**-0.17467**	**0.26393**	**-0.07002**	**-0.53195**	**0.22405**	**-0.40773**	**-0.85033**	**0.16460**
***r* confidence interval: upper bound (*z* into *r*)**	**0.77610**	**0.25462**	**0.06283**	**-0.03860**	**0.29352**	**0.63469**	**0.38742**	**-0.11347**	**0.60867**	**0.04597**	**-0.65181**	**0.56830**

Source: IFT, Federal Institute of Telecommunications, XLSX export from "Indicadores de Infraestructura y Digitalización a Nivel Municipal" (April 15, 2024), INEGI, National Institute of Geography and Statistics, "CCPV 2020", and CONEVAL, National Council for Social Development Policies Evaluation, "IRS 2020", own calculations.

Appendix 12: Confidence Interval Calculations for Valles Centrales

V. CENTRALES	Population	Age	Gender	Indigenous	Afro-Mexican	Income	Labor Force	Social Lag	Education	Literacy	Rurality	Population Density
Pearson correlation coefficient (*r*)	**0.67698**	**0.04525**	**-0.03094**	**-0.38358**	**0.02939**	**0.64588**	**0.57367**	**-0.50272**	**0.60370**	**-0.41994**	**-0.56788**	**0.47349**
r into Fisher *z*	0.82353	0.04528	-0.03095	-0.40425	0.02940	0.76820	0.65297	-0.55294	0.69895	-0.44762	-0.64438	0.51456
Sample size (n)	121	121	121	121	121	121	121	121	121	121	121	121
Standard error (SE*z*)	**0.09206**	**0.09206**	**0.09206**	**0.09206**	**0.09206**	**0.09206**	**0.09206**	**0.09206**	**0.09206**	**0.09206**	**0.09206**	**0.09206**
Critical value (95%)	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996	1.95996
Lower bound of *z* confidence interval	0.64310	-0.13514	-0.21138	-0.58468	-0.15103	0.58777	0.47254	-0.73337	0.51852	-0.62805	-0.82481	0.33413
Upper bound of *z* confidence interval	1.00395	0.22571	0.14948	-0.22382	0.20983	0.94863	0.83340	-0.37251	0.87938	-0.26719	-0.46396	0.69498
***r* confidence interval: lower bound (*z* into *r*)**	**0.56700**	**-0.13433**	**-0.20828**	**-0.52606**	**-0.14989**	**0.52829**	**0.44025**	**-0.62512**	**0.47656**	**-0.55671**	**-0.67768**	**0.32222**
***r* confidence interval: upper bound (*z* into *r*)**	**0.76325**	**0.22196**	**0.14838**	**-0.22015**	**0.20680**	**0.73916**	**0.68230**	**-0.35619**	**0.70611**	**-0.26101**	**-0.43330**	**0.60117**

Source: IFT, Federal Institute of Telecommunications, XLSX export from “Indicadores de Infraestructura y Digitalización a Nivel Municipal” (April 15, 2024), INEGI, National Institute of Geography and Statistics, “CCPV 2020”, and CONEVAL, National Council for Social Development Policies Evaluation, “IRS 2020”, own calculations.