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Digital divide and marginalization contexts in Mexico: A decade of evolution

Brecha digital y contextos de marginación en México: una década de evolución

Contextos de exclusão digital e marginalização no México: uma década de evolução

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ABSTRACT | The aim of this article is to analyze, in the context of socio-territorial marginalization of localities with more than 2,500 inhabitants in Mexico, the evolution of the unavailability of information and communication technologies (ICTs) between 2010 and 2020. The research is based on data from the 2020 population and housing census to provide a diachronic follow-up to a previous analysis conducted with the 2010 census information. Methodologically, descriptive exploratory statistics tools were used to generate marginalization magnitude profiles, which were compared with two factors of the digital divide: unavailability of the Internet and/or of interaction artifacts. The findings reveal a general decline in unavailability between 2010 and 2020 due to the positioning of the mobile phone at the center of the connectivity model, with its positive and negative aspects, for the beneficial appropriation of ICTs. In the context of this evolution, the population of the most marginalized localities has the weakest intercensal dynamics and lags the further behind. From this perspective, public action, with its chiaroscuro to mitigate the digital divide, is called upon to look for other strategies to deal with the extent of the lag.

KEYWORDS: digital divide; Internet-computer parity; urban localities; Mexico.

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RESUMEN | *El objetivo de este artículo es analizar, en el marco del contexto de marginación socioterritorial de las localidades de más de 2500 habitantes de México, la evolución de la indisponibilidad de las tecnologías de la información y de las comunicaciones (TIC) entre 2010 y 2020. La investigación se basa en datos provenientes del censo de población y vivienda de 2020 para dar seguimiento diacrónico a un análisis previo realizado con información censal de 2010. Metodológicamente, se emplearon herramientas de la estadística exploratoria descriptiva para generar perfiles de magnitud de marginación, los que fueron comparados con dos factores de la brecha digital: la indisponibilidad de Internet y/o de los artefactos de interacción. Los hallazgos revelan un retroceso general de la indisponibilidad entre 2010 y 2020 debido al posicionamiento del teléfono móvil al centro del modelo de conectividad, con sus aspectos positivos y negativos, para la apropiación provechosa de las TIC. En el marco de esta evolución, la población de las localidades de mayor marginación es la que registra la dinámica intercensal más endeble y es la más rezagada. Bajo esta perspectiva, la acción pública, con sus claroscuros para mitigar la brecha digital, es llamada a buscar otras estrategias para lidiar con la amplitud del rezago.*

PALABRAS CLAVE: *brecha digital; paridad Internet-computadora; localidades urbanas; México.*

RESUMO | O objetivo deste artigo é analisar, no contexto da marginalização socioterritorial de localidades com mais do que 2500 habitantes do México, a dinâmica evolutiva, entre 2010-2020, da indisponibilidade do TIC. Este estudo se baseia nos dados do censo populacional e habitacional de 2020 para dar seguimento diacrônico a uma análise prévia realizada com informações censitárias de 2010. Metodologicamente, a pesquisa foi abordada por meio de ferramentas de estatística exploratória descritiva que permitiram a geração de perfis magnitude da marginalização que se deparou com os fatores da exclusão digital em sua modalidade de indisponibilidade da Internet e/ou artefatos de interação. Os resultados revelam um declínio geral da indisponibilidade entre 2010-2020 com o posicionamento do telemóvel no centro do modelo de conectividade com os seus aspectos positivos e negativos para a apropriação rentável das TIC. No quadro desta mesma evolução, é a população das localidades mais marginalizadas que regista a dinâmica intercensal mais fraca e apresenta as maiores defasagens. Sob essa perspectiva, a ação pública com seu claro-escuro na mitigação da exclusão digital é chamada a buscar outras estratégias para lidar com a extensão da defasagem.

PALAVRAS-CHAVE: exclusão digital; paridade computador-internet; localizações urbanas; México.

INTRODUCTION

The appropriation of information and communication technologies (ICTs) has changed over time, leading to changes in the means and meanings of combating the digital divide. In Mexico, as in other emerging countries, monitoring the evolution of the digital divide is of interest due, among other factors, to the growing importance of ICTs in the public discourse on development and social inclusion. Socio-territorial marginalization is an ideal context for monitoring the social penetration of ICTs for several reasons, including their availability, as they are a costly and scarce resource in an area where there is no market (Ali et al., 2020; Graham & Marvin, 2001; Schleife, 2010; Toudert, 2013).

In Mexico, the unavailability of Internet service in households in localities with more than 2,500 inhabitants went from 78.11% in 2010 to 62.31% in 2020 (Instituto Nacional de Estadística e Informática, 2010, 2020). This average increase in social Internet penetration of about sixteen percentage points in the decade before the COVID-19 pandemic was accompanied by an average lack of computer availability, which increased from 69.30% in 2010 to 73.91% a decade later (Instituto Nacional de Estadística e Informática, 2010, 2020). This decline in computer penetration, which is relevant to access to digital content, was offset by a seventeen-percentage point increase in mobile phone penetration over the period. In the same period, the availability of the fixed telephone dropped by almost 21 percentage points in places with more than 2,500 inhabitants, consolidating a connectivity model centered on the mobile phone (Instituto Nacional de Estadística e Informática, 2010, 2020). Overall, these intercensal dynamics reveal chiaroscuros that can be the subject of a multifocal approach. In this study, this evolution is addressed exclusively in the context of the socio-territorial marginalization of localities with more than 2,500 inhabitants, considered by the public administration as urban agglomerations.

The inability of the market to provide access to ICTs for all social segments, regardless of their territorial location, explains the spread of the discourse of an exclusionary information society (Martínez Domínguez, 2020; Pick et al., 2014; Toudert, 2019). From this perspective, the availability of ICTs is essential to access the benefits of digitization and the sharing of networked content. Under these assumptions, socio-territorial inequalities are addressed - among other measures - by public policies of governments, which until recently were confined to their regulatory functions (Ali et al., 2020; Hilbert, 2011; Toudert, 2013).

This approach also takes on a pragmatic interest, considering that the integration of ICTs for the marginalized population has been the central motive of public policies and various civil society actions in the last decade (Martínez Domínguez, 2020; Toudert, 2015).

This study aims to carry out an exploratory analysis that allows comparing the evolution of the availability of the Internet, computers, landlines and mobile phones between 2010-2020 in households in Mexican places with more than 2500 inhabitants, as a contribution to enrich the research on the digital divide in the country and the Ibero-American region.

Digital divide: a multidimensional and evolving concept

The origin of the concept of the digital divide is uncertain; the National Telecommunications and Infrastructure Administration (NTIA) of the United States popularized it to characterize those who have and those who do not have the Internet and the devices that allow them to connect and interact with its content (Department of Commerce, 1999). Castells (2002) first used the term digital divide to refer to different situations, such as inequalities in access to ICTs. For Wilson (2006), it is a reference to the distribution and use of ICTs; Warf (2001) sees it as an indicator of differences inherent in the connection, such as bandwidth, while Noris (2001) relates it to inequalities within online communities. As the social appropriation of ICTs progressed, the digital divide acquired other meanings due to the constant evolution of technology, the intensification of its social penetration and, above all, the increasing sophistication of social and individual interaction with this type of innovation (Castells, 2000; Toudert, 2019).

The digital divide, as a binary approach to ICT availability, quickly evolved into other types of areas of interest, such as inequalities in skills and Internet use (Hargittai & Hinnant, 2008; van Deursen et al., 2015; Tirado-Morueta et al., 2017; Toudert, 2019). The use of the Internet and ICTs in general is seen by Carlson and Isaacs (2018) as a privileged access to a socio-technological capital that can determine directions thanks to the acquisition of economic and political advantages (Chen, 2013; Norris, 2001; Rogers, 2004). These approaches mainly stem from what has been characterized by Hargittai and Hinnant (2008) as a second-level digital divide for the development of skills that allow interacting with online and final content, or by van Deursen and colleagues (2015), who defined the ability to achieve a benefit that is not exclusively entertainment. However, these approaches rather characterize an epistemological pragmatism inherent to developed countries, where both availability and accessibility are currently marginal issues (International Telecommunication Union, 2019). On the contrary, in emerging countries such as Mexico, despite the fact that a significant portion of the population enjoys ICTs as in developed countries, another significant portion lacks these services and artifacts (Martínez Domínguez, 2020; Pick et al., 2014; Toudert, 2019). Although developed and emerging countries share the impact of demographic, gender, social, and educational constraints that affect the rate and quality of ICT adoption (Martínez Domínguez, 2020; van Deursen et al., 2015), the availability and access gap is still a reality in Mexico

(Martínez Domínguez, 2020; Toudert, 2015). In fact, if we talk about the levels of the digital divide and take up the scaling metaphor used by authors such as Hargittai (2002), they coexist close to each other in the same territorial context. Theoretically, all levels of digital divide can occur in a given space, from the material unavailability of ICTs to the lack of access to the beneficial use of the Internet (Toudert, 2019; van Deursen & van Dijk, 2015).

The territorial distribution of Internet availability obeys different factors that go beyond the desire of individuals to use the service and the devices that allow them to interact with the content of the network (Pick et al., 2015; Toudert, 2019). The Internet is a service that relies on significant infrastructure investments and is provided by companies that seek to expand their network of users in order to increase their dividends (Billón et al., 2008). From this perspective, the commercial logic reaches its limits of penetration in places with few inhabitants, where there is usually little market. In addition, localities with few inhabitants do not have, among other things, enough young people, students, ethnic minorities and highly skilled workers, who usually constitute the precursor groups in the use of ICT in their communities (Chen, 2013; Pick et al., 2015). Thus, the size of the agglomeration is relevant because of its influence on the diffusion of ICTs, on the decision to go online, and on the possibility of becoming a user of its services and artifacts (Agarwal et al., 2005; Billón et al., 2008; Schleife, 2010). Taken together, these aspects help to characterize different digital divides at different scales, which make it possible to define almost antagonistic spaces in terms of socio-territorial appropriation of ICTs. The urban-rural digital divide is probably the clearest case of this spatial antagonism, due to significant differences in the social penetration of the Internet and the use of ICT artifacts (Agarwal et al., 2005; Chen, 2013; Martínez Domínguez, 2020; Toudert, 2019). These spatial disparities are generally the product of the polarization in these areas of demographic, cultural, linguistic, educational, and socio-professional factors that are poorly conducive to ICT appropriation (Lembani et al., 2020; Martínez Domínguez, 2020). In fact, as mentioned by Schleife (2010), the fact that an area is rural does not necessarily imply a lower appropriation of ICTs in all contexts, although this statement is more accurate in the case of developed countries.

Some of the same factors that seem to be involved in the rural area also intervene in the center-periphery opposition, through the complementarity of functions that characterizes urban centers and their substitution dictated by distance in the peripheries (Billón et al., 2008; Pick et al., 2015; Schleife; 2010). However, regardless of the contributions of the different meanings of the digital divide, an analysis through the contexts of marginalization seems to offer a pragmatic approach to a multidimensional and evolving problem.

Digital divide and contexts of socio-territorial marginalization

In contexts characterized by inequalities in the appropriation of ICTs, the conceptualization of the digital divide through socio-territorial marginalization becomes an approach aimed at consolidating both reflection and action (Halford & Savage, 2010; Toudert, 2013, 2015). From a conceptual point of view, this approach starts from a determinism that has become very powerful in the dominant discourse on the capacity granted by ICTs to overcome the conditions of marginalization and poverty (Castells, 2002; Keniston & Kumar, 2004). In this perspective, the integration into the information (or knowledge) society, which is empowering in the discourses of ICT adoption, is seen as a factor of accessibility to different types of capital (technical, social, cultural, and so on), which allegedly promotes social mobility (Carlson & Isaacs, 2018; Chen, 2013; Halford & Savage, 2010). The same approach applies to the territorial dimension observed in development theories and its corollary: stigmatization of forgotten social space by ICT providers (Graham, 2008, Toudert, 2013). The causal interaction between the digital divide and socio-territorial marginalization reinforces the multidimensional, evolutionary and multistage nature of the problem faced, both in its conceptual definition and in its practical approach (Mecinas Montiel, 2016).

Different social contexts and geographical scales reflect the synchronicity of a cause-and-effect construct characterized by marginalization affecting the appropriation of ICTs and marginalized spaces. This can range, for example, from the manifestation of gender or age barriers to the adoption of ICTs within affluent social strata to fragmented urbanism, an expression of urban segregation due to the lack of telecommunications infrastructure in marginalized areas (Billón et al., 2008; Schleife; 2010; Graham & Marvin, 2001). From this perspective, offering alternative modalities to increase Internet accessibility (mainly mobile and satellite) seems to shift the terms of the initial contradiction towards other variables such as segregation by bandwidth and the cost of the online experience (Graham & Marvin, 2001; Graham, 2008; Toudert, 2013). The same seems to follow from the adoption of mobile phones and other types of devices as an alternative to the computer, which is still insufficient to profitably interact with school or work content (Pearse & Rice, 2013). Under this pragmatic approach, the socio-territorial availability of ICTs is rapidly shifting from a demand-supply business issue to a public policy issue (Ali et al., 2020; Hilbert, 2011; Toudert, 2013).

The State's insistence on becoming a provider of ICT solutions seems to mark a tentative return after the privatization that was carried out with the consent of the other actors, regardless of their positions and interests (Comisión Económica para América Latina y el Caribe, 2004). Indeed, the provision of Internet services in areas where there is no market has become a leitmotif of a collective obsession

with universal access to the information age. In Mexico, the State's most recent foray into this type of venture began in 2001 with the E-Mexico project, which sought to connect first the municipalities and then other marginalized localities (Cerisola & Weber, 2001). In the last six years, the failure of E-Mexico gave way to other types of initiatives, such as the alliance with the company Altán Redes, which is still responsible for Red Compartida, an advanced infrastructure to provide services to operators who want to enter marginalized areas without a market. The same initiative has been taken up by the current federal government, along with the creation of the company CFE Telecomunicaciones e Internet para Todos in 2019, a subsidiary of the Federal Electricity Commission (CFE, by its Spanish acronym) that aims to bring the Internet to marginalized localities with less than 5,000 inhabitants (Secretaría de Comunicaciones y Transportes, 2020). To achieve this type of governmental experience, in 2013 Article 6 of the Political Constitution was amended to establish the right of access to ICTs, which includes broadband and the Internet, obliging the state to create conditions for competition and the provision of these services. As part of this dynamic, various sectoral programs of the SCT have been launched, such as the recent Social Coverage Program 2021-2022, which aims to identify priority areas for action, including areas of high and very high marginalization. Along with these federal actions, local and municipal governments, generally in conjunction with the private sector, have proposed different types of programs, mostly aimed at strengthening digitization and material access to virtual content. So far, the balance of these recent actions, as indicated below, seems to be weakened, undermining the credibility of the State's ability to address the digital divide in marginalized areas.

Socio-territorial marginalization, as a concept turned into diagnosis and practice, gives the digital divide a semantic dynamic and logistical consistency that tends to generate public policies and budgets in deprived areas (Ali et al., 2020; Hilbert, 2011; Toudert, 2013). In Mexico, practical references to marginalized areas begin in the late 1970s with the General Coordination of the National Plan for Depressed Areas and Marginal Groups (1982). From the 1990s, this initiative was transferred to the National Population Commission (CONAPO, by its Spanish acronym) and the National Water Commission (CAN, by its Spanish acronym), and later to the Education, Health and Food Program (PROGRESA, by its Spanish acronym), remaining only in the hands of the National Population Council (CONAPO, by its Spanish acronym) since 2000 (Toudert, 2013). Within these activities, CONAPO produces, mainly for the institutional use of the federal government, the Marginalization Index, elaborated in the different scales allowed by the census data used to construct it (Consejo Nacional de Población, 2013). From this perspective, the marginalization indicator, as a synthetic and approximate measurement of a complex and multidimensional phenomenon, is transformed

by mathematical algorithms into profiles to which magnitudes are assigned on a marginalization scale to facilitate the design of public policies (Ranfla et al., 2001).

DATA AND METHODOLOGY

If we look at the literature on the socio-territorial appropriation of ICTs in marginalized contexts, in the Mexican case the important sector of the population affected by the digital divide in the last decade stands out. Given the wide margin of action for public policies, is a decade really a reasonable period of time to reduce the gap in the availability of ICTs, at least in the marginalized strata of society? From another perspective, it is also important to ask whether the quality of the increase in ICT availability is sufficient to stimulate beneficial use of the Internet among the newly included. To answer this type of question, it is first necessary to model social segmentation in order to highlight the different levels of marginalization that structure the population.

Thanks to the data from the 2020 Population and Housing Census of the National Institute of Statistics and Geography (Instituto Nacional de Estadística y Geografía, 2020), the only source of this type of information available for localities with more than 2,500 inhabitants, it was possible to draw up eight profiles of marginalization types for the year 2020. For 2020, the same variables and a statistical procedure similar to that developed for 2010 in Toudert (2013) were used.

Seventeen continuous variables related to five concepts: human development, occupation at work, housing characteristics, housing services and housing assets (table 1).

In order to obtain a 2010-2020 comparison in full conditions of statistical compatibility, we opted for the generation of eight profiles-types of localities, characterized by the nominal modalities derived from the continuous variables used in the study. Thus, each of the continuous variables was segmented into five ordinal modalities (very low, medium, high, high, very high), which allowed us to assign a degree of marginalization to each of the initially determined profile types.

The statistical procedure used to generate the type profiles is in line with previous contributions published in Ranfla and colleagues (2001) and Toudert (2013), which adopt techniques and tools of multidimensional exploratory statistics developed by Lebart and colleagues (2000). In general, a vertical processing chain is used, which allows to go from a large set of variables to a very few principal components.

Only the continuous variables in table 1 were used to obtain the principal components, and the components characterized by a greater contribution to the

total variance and an eigenvalue close to one were reserved for the following treatment. The reserved components were then classified using a hierarchical aggregation algorithm with moving centers to generate a hierarchy of partitions (Lebart et al., 2000). To achieve greater stability of the partitions (classes), we proceeded to an iterative segmentation of the hierarchical aggregation (tree), supported by successive iterations on moving centers that allow minimizing the intraclass variance and maximizing the interclass variance (Nakacha & Confais, 2004). The result was the consolidation of eight type profiles, achieved with a very low and almost constant interclass inertia at the end. This operation can be assimilated to a mixed-type cluster analysis; however, the algorithm as a whole allows the characterization of the profiles obtained by means of the modes of the variables involved in the study, thus facilitating an ordination by level of marginalization.

Concepts	Variables
Human development	Percentage of the population not entitled to health services.
	Percentage of the population 15 years of age and older who are illiterate.
	Percentage of the population between 6 and 14 years of age not attending school.
	Percentage of the population 15 years of age and older with incomplete secondary education.
Occupation	Percentage of the population that is unemployed.
Housing characteristics	Percentage of homes with only one room.
	Percentage of homes with dirt floors.
Housing services	Percentage of homes without piped water.
	Percentage of households without sewage.
	Percentage of households without electricity.
Possession of property in housing	Percentage of households without any goods.
	Percentage of households without a refrigerator.
	Percentage of households without a fixed telephone.
	Percentage of households without a mobile phone.
	Percentage of households without their own car or truck.
	Percentage of households without Internet.
	Percentage of households without a computer.

Table 1. Variables involved in the study

Source: Own elaboration.

To characterize the profile types obtained, we used data mining techniques based on transforming continuous variables into ordinal modalities of five classes (very low, medium, high, high, very high). In this way, the profile types were characterized by 85 modalities, which allowed us to assign semantic dimensions to them and, therefore, a thematic contextualization in the framework of the study. This procedure of assigning modalities to type profiles is based on the assumption that a modality j represents a type profile k if its expected presence in the population is significantly higher. This assumption is made with a modality j exclusive of a decreasing probability that favors its possible permutation with the Laplace-Gauss test value, transforming it into the number of standard deviations of a normal, centered and reduced distribution (Morineau, 1984; Lebart et al., 2000). Thus, at a 95% confidence level in this study, the test score becomes a robust indicator of the association of ordinal modalities with type profiles.

The association of significant modalities with type profiles also allows a degree of marginalization to be assigned to each of them by stratification and assignment of scores to the associated modalities. For example, profile types characterized by modalities reflecting strong deprivation will receive a high score corresponding to a high degree (level) of marginalization. Thus, the eight existing profile types in municipalities with more than 2500 inhabitants were stratified from the profile type with the lowest degree of marginalization (level 1) to the one with the highest degree of marginalization (level 8).

RESULTS AND DISCUSSION OF FINDINGS

Population dynamics and socio-territorial marginalization

Between 2010 and 2020, the population of localities with more than 2,500 inhabitants will grow by 14.76%; 33.5% of the intercensal balance will be accounted for by cities with between half a million and one million inhabitants, 13.13% by localities with 30 to 50 thousand inhabitants, and 11.78% by cities with 100 to 250 thousand inhabitants (Instituto Nacional de Estadística e Informática, 2010, 2020). Despite the fact that localities with more than 500 thousand inhabitants accounted for 42.25% of this intercensal balance, localities with 5 to 10 thousand inhabitants accounted for almost one percentage point more than cities with more than one million inhabitants. On the basis of these figures, it seems that the demographic dynamics are mainly aimed at strengthening the intermediate cities, which have a lower rank than the large cities. In 2020, cities with more than 100,000 inhabitants will concentrate 33% of the population of localities with more than 2,500 inhabitants in the lowest level (magnitude 1) of marginalization,

while 25% will be grouped in magnitude 2 (figure 1). In the case of level 3 of marginalization, the figure is 1.7%; 0.44% are in level 4 and 1.47% in level 5, to disappear completely in the following levels of marginalization. In fact, the highest levels of marginalization (6, 7 and 8) –which affect 6% of the population of localities with more than 2,500 inhabitants– reveal a phenomenon of intensification of marginalization that seems to be exclusive to localities with less than 50,000 inhabitants. This characteristic of polarization of the highest marginalization also seems to have an important characteristic of dispersion, since it is located in a series of localities with few inhabitants.

The distribution of the population by magnitude of marginalization between 2010 and 2020 is characterized by an increase in the number of localities with more than 2500 inhabitants, except for magnitudes 4, 7, 8 (figure 1). These last magnitudes, together with magnitudes 1 and 6, also show a decrease in population participation by magnitude in favor of an increase in magnitudes 2, 3 and 5, which represent 51.55% of the inhabitants of localities with more than 2,500 inhabitants in 2020. This intercensal dynamic, in a context of territorial dispersion, seems to indicate that the proportion of the population of very low, medium and high magnitudes is shifting towards medium-high and low magnitudes. In the context of relative participation, this translates into a shift of 11.33% of the population from the high, low and medium extremes to the 5, 3 and 2 levels of marginalization, respectively. These dynamics do not clearly show the reasons for the change in levels of marginalization, and therefore it may be clearer to analyze the results from an absolute perspective.

In absolute terms, the 2010-2020 dynamics show a reduction in the population affected by levels 4, 6, 7 and 8 to the benefit of the other levels of marginalization. This vertical movement of the population from the highest and middle levels indicates a significant improvement in the marginalization conditions captured by magnitudes 2 (39.70%), 5 (26.88%), 3 (23.35%) and 1 (10.05%). In this regard, the change occurred in a context of wide dispersion of localities for magnitudes 3 and 5, while for magnitudes 1 and 2, agglomeration conditions prevail more. With regard to the quantitative and qualitative dynamics in the structuring of socio-territorial marginalization, changes are expected in the material availability of ICTs, which will be analyzed below.

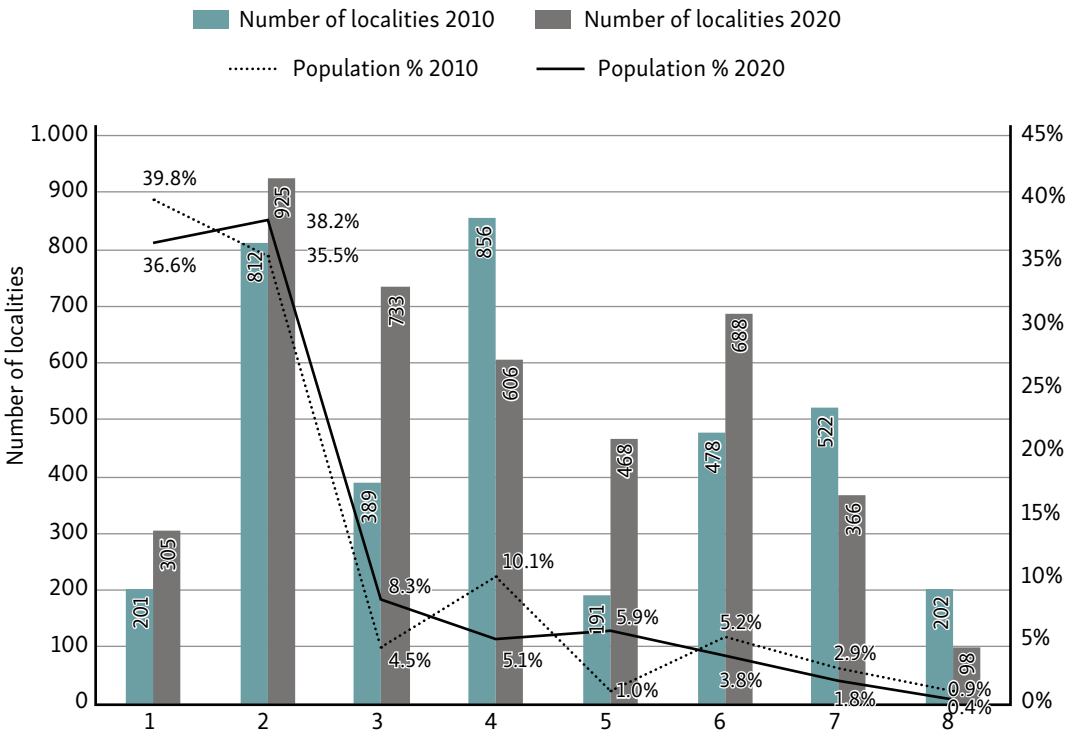

Figure 1. Population distribution dynamics between 2010 and 2020

Source: Own elaboration based on data from the National Institute of Statistics and Informatics (Instituto Nacional de Estadística e Informática, 2010, 2020).

Marginalization and evolution of the physical unavailability of ICTs

Between 2010 and 2020, the dynamics of the availability of devices and services that allow access to ICT show a difference that seems to be due to the technological evolution and the strengthening and diversification of the supply of services, accompanied by a potential demand that needs to be integrated. These aspects, which seem to determine the change in the availability of access to ICTs, are related to the changes in the conditions of marginalization and its territorial distribution, which were addressed in the previous paragraphs.

With regard to technological developments that allow users to choose new devices that include the services of previous devices, the decline in the social penetration of the fixed telephone compared to the mobile phone is mentioned (figure 2). In fact, the fixed phone went from an unavailability rate of 70.10% in 2010 to 78.44% in 2020, while in the case of the mobile phone, this rate decreased from 46.70% to 18.02% in the same period. In other words, the unavailability of the fixed telephone by level of marginalization increased in 2020 compared to 2010, with a rate ranging from 7.43% to 21.62% at all levels, except for level 3, where there was a marginal decrease of -0.21% (Instituto Nacional de Estadística e

Informática, 2010, 2020). In the same period, the unavailability of mobile phones by level of marginalization decreased at all levels, with a rate ranging from -76.50% to -43.33%. The difference in the rates of unavailability of these two devices indicates a 2010-2020 evolution that seems to follow a logic of substitution of fixed telephones by mobile telephones. In fact, with the increasing social penetration of cable and satellite television, about 48% of household Internet connections in 2019 were made with these devices, which significantly reduce the dependence on the telephone line (Instituto Nacional de Estadística e Informática, 2019). Autonomy and personalization, and above all the immediacy of use compared to the difficulties of contracting a fixed line in areas with poor coverage (Mariscal & Martínez Aguayo, 2014), play in favor of mobile telephony, driven by competitive and flexible plans. These advantages translate into a household availability of the order of 2.75 mobile phones per fixed telephone line in 2019 (Instituto Nacional de Estadística e Informática, 2019).

Faced with the increase in the availability of the telephone in its two modalities, the presence of the computer in inhabited dwellings showed a relatively low growth, going from an unavailability of 81.52% in 2010 to 75.82% in 2020 (Figure 2). In the context of this change, the decrease in the unavailability of computers, with rates ranging from -20.15% to -0.60%, shows a concentration mainly in the first five levels of marginalization, which had an average decrease of -12.22% compared to -1.66% in the three highest levels. In this perspective, the strongest unavailability regression between 2010-2020 occurred in the lowest level of marginalization (level 1), with -20.15%, while it remained almost unchanged in the three highest levels of marginalization. In this sense, the intercensal dynamics of computer unavailability shows a frank stagnation in the contexts of higher marginalization, which seems to polarize more than in other magnitudes the possible impacts of the scarcity of ICT artifacts.

The unavailability of the Internet service has practically the same structure of unavailability as that of the computer, but with a more significant rate of change. In fact, the unavailability of the Internet went from 88.64% of inhabited households in 2010 to 65.39% in 2020. This variation is observed in the first five levels of marginalization, which had an average rate of decline in unavailability of -39.07%, while in the last three levels the rate was only -10.14% (figure 2). Given these rates of change, the decline in Internet unavailability was outpaced by the social penetration of mobile phones, which grew at higher rates during the same period. However, this growth in Internet coverage was very slow in the highest levels of marginalization (6, 7 and 8), associated with localities of less than 50 thousand inhabitants in a context dominated by territorial dispersion. In these conditions, profitability seems to prevail in dispersed catchment areas with

low consumption conditions more than in other magnitudes of marginalization (Billón et al., 2008; Toudert, 2013). For example, in localities with less than 15 thousand inhabitants, 53% of households do not have Internet due to lack of economic resources, and in 16% of the other cases due to lack of interest in this technology (Instituto Nacional de Estadística e Informática, 2019). Of course, in localities with more than 100 thousand inhabitants, the reasons for non-availability in the household are not very different (economic resources: 52%; 30%, due to lack of interest); however, in this type of localities the population base is more than five times larger. The latter gives localities with more than 100 thousand inhabitants a greater attractiveness for Internet providers compared to smaller localities, which was also observed in 2010 for localities with more than 250 thousand inhabitants (Toudert, 2015).

Another aspect that seems to show attenuated dynamics when analyzing ICT artifacts and services from a pragmatic perspective is undoubtedly the parity of availability of network connections and computers in inhabited dwellings (Toudert, 2013). Indeed, the ratio (r) between the availability of Internet service and the presence of computers in inhabited dwellings shows a regression at all levels of marginalization, except for the highest one (figure 2). This ratio went from an average of 2.24 computers per Internet connection in 2010 to 1.78 in 2020, marking a clear regression in the appropriation of appropriate devices for content consultation. This regression between 2010 and 2020 increased almost linearly from a level of marginalization of 1 to a level of 4, reached its maximum at a level of 5, decreased again at a level of 6, and increased again at a level of 7. Within this regressive dynamic, a single positive growth is achieved at magnitude 8 of marginalization, almost the same size in absolute value as at magnitude 2. Along with these observations, it is important to mention that the coefficient of variation of the ratio (r), which indicates its variation in the different levels of marginalization, shows a slight increase, from 0.27 in 2010 to 0.29 in 2020. This increase shows a slight increase in inequality between different levels of marginalization in the distribution of parity between Internet and computer services. This inequality, measured by the coefficient of variation, is 5.5 times higher at the three levels of high marginalization. From this point of view, a decade of public policies does not seem to have succeeded in significantly reversing the observed lag between the levels of marginalization in terms of parity of service and the most efficient devices for the social appropriation of ICTs.

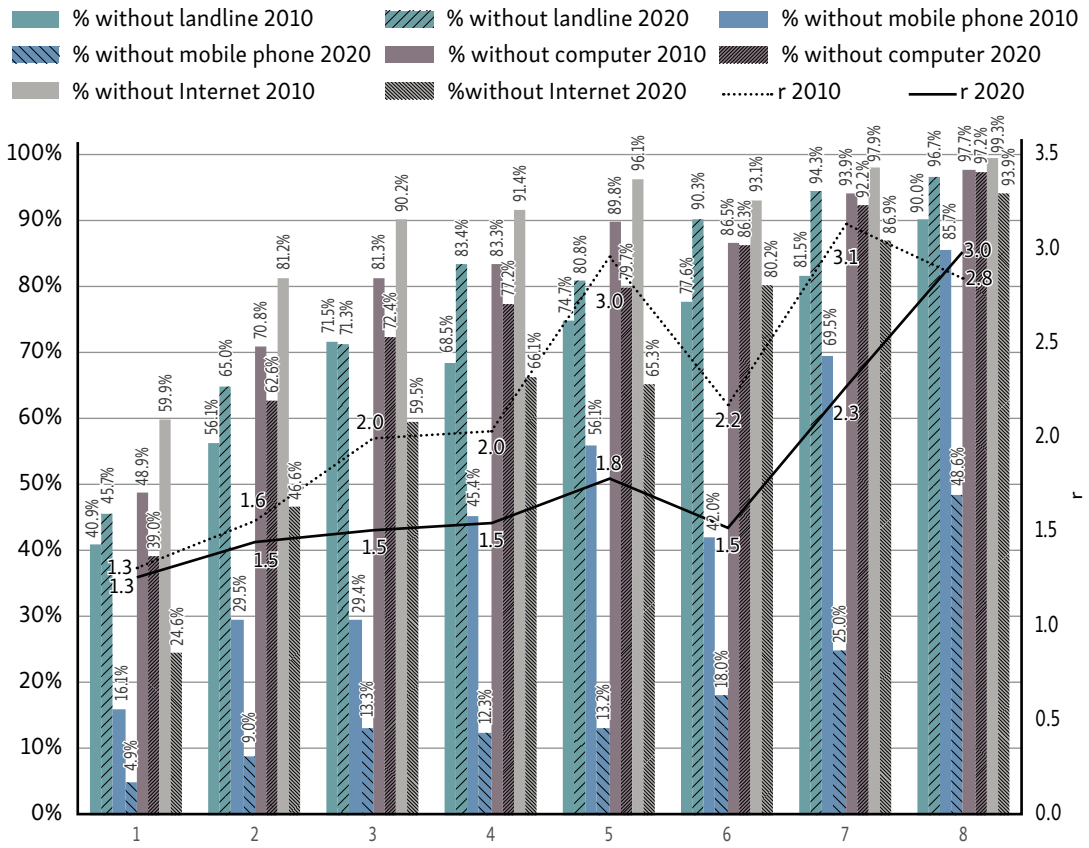

Figure 2. Marginalization and lack of ICT access devices and services from 2010-2020

Source: Own elaboration based on data from the National Institute of Statistics and Informatics (Instituto Nacional de Estadística e Informática, 2010, 2020).

CONCLUSIONS

Our findings on the availability of ICTs in marginalized contexts show that the areas lagging furthest behind are those with the lowest social penetration of ICTs, and are also those that have seen the greatest decline in the availability of landline telephones and computers over the decade under study. Over the same period, the parity between Internet access and computers has fallen most sharply in the medium and high levels of marginalization. This dynamic highlights, especially in the most marginalized areas, a shift towards a model centered on the mobile phone, with its advantages for connectivity and its limitations for use. The intercensal differences in the material availability of ICTs show the existence of a structural relationship with the levels of socio-territorial marginalization. The mere provision of services is not enough to reverse the observed trends. In fact, the polarization of ICTs, the inequality of their distribution and the spatial dispersion of their unavailability are transcendental elements that must be taken into account in any effort to consolidate the socio-territorial appropriation of these tools.

With regard to the discourse of public policies to increase access to ICTs in general and the Internet in particular, the results of this study reveal initiatives that address diverse and complex appropriation contexts. Although the government's discourse is repetitive, with its desire to bring the network to the entire population through projects such as Red Compartida, in practice the means do not seem to be sufficient to achieve this. Nor do private companies seem enthusiastic about entering areas where there is no market. Under these conditions, it is most likely that the growth of the social penetration of the Internet will continue in areas of low and medium socio-territorial marginalization. In the absence of supportive policies for the acquisition of more efficient devices such as computers, access will be preferred through mobile phones, which currently do not seem to be conducive to doing school homework, for example. With regard to highly marginalized areas, the public policies recently implemented to promote availability do not seem sufficiently robust to reduce the vulnerability of the less favored strata in the face of the increasing digitalization of economic and social activities. These shortcomings have been demonstrated by a connectivity model based on mobile telephony, which did not allow, among other things, to generate inclusive schooling during the COVID-19 crisis.

REFERENCES

Agarwal, R., Animesh, A., & Prasad, K. (2005). Research Note – Social Interactions and the 'Digital Divide': Explaining Regional Variations in Internet Use. *Information Systems Research*, *20*(2). https://doi.org/10.1287/isre.1080.0194

Ali, M. A., Alam, K., & Taylor, B. (2020). Do social exclusion and remoteness explain the digital divide in Australia? Evidence from a panel data estimation approach. *Economics of Innovation and New Technology*, *29*(6), 643-659. https://doi.org/10.1080/10438599.2019.1664708

Billón, M., Ezcurra, R., & Lera-López, F. (2008). The Spatial Distribution of the Internet in the European Union: Does Geographical Proximity Matter? *European Planning Studies*, *16*(1), 119-142. https://doi.org/10.1080/09654310701748009

Carlson, A. & Isaacs, A. M. (2018). Technological capital: an alternative to the digital divide. *Journal of Applied Communication Research*, *46*(2), 243-265. https://doi.org/10.1080/00909882.2018.1437279

Castells, M. (2000). *The Rise of the Network Society.* Blackwell.

Castells, M. (2002). The Internet Galaxy. Oxford University Press.

Cerisola y Weber, P. (2001, October 29-31). *El rumbo de las telecomunicaciones en México* (The direction of telecommunications in Mexico) (Conference Presentation). Expo Comm México 2001, Mexico City, Mexico.

Chen, W. (2013). The Implications of Social Capital for the Digital Divides in America. *The Information Society*, *29*(1), 13-25. https://doi.org/10.1080/01972243.2012.739265

Comisión Económica para América Latina y el Caribe. (2004). *Estrategias, programas y experiencias de superación de la brecha digital y universalización del acceso a las nuevas TIC. Un panorama regional* (Strategies, programs, and experiences to overcome the digital divide and universalization of access to new ICTs. A regional overview). Cepal. https://www.cepal.org/es/publicaciones/6094-estrategias-programas-experiencias-superacion-la-brecha-digital-universalizacion

Consejo Nacional de Población. (2013). *Índice absoluto de marginación 2000-2010* (Absolute index of marginalization 2000-2010). http://www.conapo.gob.mx/work/models/CONAPO/Resource/1755/1/images/IAM_00-04.pdf

Coordinación General del Plan Nacional de Zonas Deprimidas y Grupos Marginados. (1982). *Necesidades esenciales en México. situación actual y perspectiva al año 2000: Geografía de la marginación* (Vol. 5) (Essential needs in Mexico. Current situation and outlook to the year 2000: Geography of marginalization (Vol. 5)). Siglo XX.

Department of Commerce. (1999). Falling Through the Net: Defining the Digital Divide. https://www.ntia.doc.gov/legacy/ntiahome/fttn99/contents.html

Graham, M. (2008). Warped Geographies of Development: The Internet and Theories of Economic Development. *Geography Compass*, *2*(3), 771-789. https://doi.org/10.1111/j.1749-8198.2008.00093.x

Graham, S. & Marvin, S. (2001). *Splintering Urbanism: Networked Infrastructure, Technological Mobilities and the Urban Conditions*. Routledge.

Halford, S. & Savage, M. (2010). Reconceptualizing digital social inequality. *Information, Communication & Society*, *13*(7), 937-955. https://doi.org/10.1080/1369118X.2010.499956

Hargittai, E. (2002). Second-Level Digital Divide: Differences in People's Online Skills. *First Monday*, *7*(4). https://doi.org/10.5210/fm.v7i4.942

Hargittai, E. & Hinnant, A. (2008). Digital Inequality: Differences in Young Adults' Use of the Internet. *Communication Research*, *35*(5), 602-621. https://doi.org/10.1177/0093650208321782

Hilbert, M. (2011). The end justifies the definition: The manifold outlooks on the digital divide and their practical usefulness for policymaking. *Telecommunications Policy*, *35*(8), 715-736. https://doi.org//10.1016/j.telpol.2011.06.012

Instituto Nacional de Estadística e Informática. (2010). Censo de Población y Vivienda, 2010. Principales resultados por localidad (ITER) (Population and Housing Census, 2010. Main results by locality (ITER)). https://www.inegi.org.mx/programas/ccpv/2010/#Datos_abiertos

Instituto Nacional de Estadística e Informática. (2019). Encuesta Nacional sobre Disponibilidad y Uso de Tecnologías de la Información en los Hogares, 2019 (National Survey on Availability and Use of Information Technologies in Homes, 2019). https://www.inegi.org.mx/programas/dutih/2019/#Microdatos

Instituto Nacional de Estadística e Informática. (2020). *Censo de Población y Vivienda, 2020. Principales resultados por localidad (ITER)* (Population and Housing Census, 2020. Main results by locality (ITER)). https://www.inegi.org.mx/programas/ccpv/2020/default.html

International Telecommunication Union. (2019). *The State of Broadband: Broadband as a Foundation for Sustainable Development*. ITU. http://handle.itu.int/11.1002/pub/813c98f4-en

Keniston, K. & Kumar, D. (2004). *IT Experience in India. Bridging the Digital Divide*. SAGE.

Lebart, L., Morineau, A., & Piron, M. (2000). *Statistique Exploratoire Multidimensionnelle* (Multidimensional Exploratory Statistics). Dunod.

Lembani, R., Gunter, A., Breines, M., & Dalu, M. (2020). The same course, different access: the digital divide between urban and rural distance education students in South Africa. *Journal of Geography in Higher Education*, *44*(1), 70-84. https://doi.org/10.1080/03098265.2019.1694876

Mariscal, J. & Martínez Aguayo, M. (2014). La vida informacional de los marginados: Un estudio sobre acceso digital en tres localidades mexicanas (The Informational Marginalized Life: A Study on Digital Access in Three Mexican Cities). In D. Cardona (Ed.), *Proceedings of the 8th CPR LATAM - Communication Policy Research Conference 2014* (pp. 185-198). ACORN-REDECOM. https://doi.org/10.2139/ssrn.2462557

Martínez Domínguez, M. (2020). La desigualdad digital en México: un análisis de las razones para el no acceso y el no uso de internet (Digital inequality in Mexico: an analysis of the reasons for non-access and non-use of the internet). *Paakat: Revista de Tecnología y Sociedad*, *10*(19). https://doi.org/10.32870/Pk.a10n19.519

Mecinas Montiel, J. M. (2016). The Digital Divide in Mexico: A Mirror of Poverty. *Mexican Law Review*, *9*(1), 93-102. https://doi.org/10.1016/j.mexlaw.2016.09.005

Morineau, A. (1984). Note sur la caractérisation statistique d'une classe et les valeurs-tests (Note on the statistical characterization of a class and the test values). *Bulletin Technique du Centre Statistique et d'Informatique Appliquées*, *2*(1-2), 20-27.

Nakacha, J. P. & Confais, J. (2004). *Approche pragmatique de la classification* (Pragmatic approach to classification). Technip.

Norris, P. (2001). *Digital Divide. Civic Engagement, Information Poverty, and the Internet Worldwide*. Cambridge University Press.

Pearse, K. & Rice, R. (2013). Digital Divides From Access to Activities: Comparing Mobile and Personal Computer Internet Users. *Journal of Communication*, *63*(4), 721-744. https://doi.org/10.1111/jcom.12045

Pick, J., Nishida, T., & Sarkar, A. (2014). Broadband Utilization in the Indian States: Socio-Economic Correlates and Geographic Aspects. In J. Choudrie & C. Middleton (Eds.), *Management of Broadband Technology Innovation* (pp. 269–296). Routledge.

Pick, J., Sarkar. V., & Johnson, J. (2015). United States digital divide: State level analysis of spatial clustering and multivariate determinants of ICT utilization. *Socio-Economic Planning Sciences*, *49*, 16-32.https://doi.org/10.1016/j.seps.2014.09.001

Ranfla, A., Toudert, G., Alvárez G., & Ortega, G. (2001). An exploratory study of urban marginality in Baja California". In Ganster (Ed.), *Cooperation and sustainable development in comparative context* (pp. 125-146). Institute for Regional Studies of the Californias- San Diego State University Press.

Rogers, R. (2004). *Information Politics on the Web*. MIT Press.

Schleife, K. (2010). What really matters: Regional versus individual determinants of the digital divide in Germany. *Research Policy*, *39*(1), 173-185. https://doi.org/10.1016/j.respol.2009.11.003

Secretaría de Comunicaciones y Transportes. (2020). *Segundo Informe de Labores* (Second Progress report). https://www.gob.mx/sct/documentos/segundo-informe-de-labores-comunicaciones-2019-2020

Tirado-Morueta, R., Mendoza-Zambrano, D. M., Aguaded-Gómez, J. I., & Marín-Gutiérrez. I. (2017). Empirical study of a sequence of access to Internet use in Ecuador. *Telematics and Informatics*, *34*(4), 171-183. https://doi.org/10.1016/j.tele.2016.12.012

Toudert, D. (2013). La brecha digital en los contextos de marginación socioterritorial de las localidades mexicanas de más de 2500 habitantes: Exploración y discusión (The digital divide in the socio-territorial marginalization context in Mexican localities: Exploration and discussion). *Comunicación y Sociedad*, (19), 153-180. https://doi.org/10.32870/cys.v0i19.207

Toudert, D. (2015). Brecha digital y marginación socioterritorial: el caso de México (Digital divide and socio-territorial marginalization: the case of Mexico). In C. Garrocho & G. Buzai (Eds.), *Geografía Aplicada en Iberoamérica. Avances, retos y perspectivas* (Applied Geography in Latin America. Progress, challenges and perspectives) (pp. 343-370). El Colegio Mexiquense.

Toudert, D. (2019). Brecha digital, uso frecuente y aprovechamiento de Internet en México (Digital Divide, Frequently Use of Internet and Benefits in Mexico). *Convergencia. Revista De Ciencias Sociales*, (79), 1-27. https://doi.org/10.29101/crcs.v0i79.10332

van Deursen, A. & van Dijk, J. (2015). Toward a Multifaceted Model of Internet Access for Understanding Digital Divides: An Empirical Investigation. *The Information Society*, *31*(5), 379-391. https://doi.org/10.1080/01972243.2015.1069770

van Deursen, A., van Dijk, J., & ten Klooster, P. (2015a). Increasing inequalities in what we do online: A longitudinal cross-sectional analysis of Internet activities among the Dutch population (2010 to 2013) over gender, age, education, and income. *Telematics and Informatics*, *32*(2), 259-272. https://doi.org/10.1016/j.tele.2014.09.003

Warf, B. (2001). Segueways into Cyberspace: Multiple Geographies of the Digital Divide. *Environment and Planning B: Planning and Design*, *28*(1), 3-19. https://doi.org/doi/10.1068/b2691

Wilson, E. J. (2006). The Information Revolution and Developing Countries. MIT.

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