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This volume publishes a selection of the papers presented at the 14th Annual Communication Policy Research in Latin America (CPR Latam) conference. The conference brings together academics, civil society, and public and private sector leaders from across Latin America and the Caribbean to discuss the key issues facing the development of digital infrastructure and information ecosystems in the region. The 14th CPR LATAM conference was held on October 18-25, 2021 in a hybrid format with virtual and in-person attendees in Mexico City. The authors in this volume address a wide range of topics such as gender biases in mobile technology adoption, challenges of antenna deployment, data protection authority influence on the fulfillment of the rights of data subjects, B2C in small companies, 5G spectrum auction efficiency, mobile telecommunications concentration.

Judith Mariscal
2021 CPR Latam Chair

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Disaggregating the drivers of mobile technology adoption: the threat of unobservable gender biases

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BIOGRAPHY

As an Economist within GSMA Intelligence, Caroline is responsible for producing robust economic analysis across a range of GSMA programmes and initiatives. She holds an MSc in Economics for Development from the University of Oxford, and a BA (Hons) in Economics from the University of Durham.

ABSTRACT

This study seeks to better understand the key drivers of mobile ownership, mobile internet, and smartphone use, with a particular focus on gender. Discrete-choice models, including logit, probit and linear models, are used to estimate the probability of adoption of these three types of technology. By including a suite of control variables for observable drivers of mobile adoption (e.g. education levels, age, employment, rural-urban location), the coefficient for gender represents non-observable effects which could be a product of discrimination and cultural norms. Furthermore, importance is placed on the inclusion of interaction terms in the regressions (for example, gender interacted with rural location), in order to isolate different degrees of marginalisation across the female population.

KEYWORDS

Mobile technology, gender, inclusion.

INTRODUCTION

Recent growth in the mobile industry has driven an unprecedented increase in digital inclusion in low- and middle-income countries (LMICs) (GSMA, 2019). At the end of 2019, 3.8 billion adults owned a mobile phone in LMICs, 2.7 billion used mobile internet, and 2.7 billion owned a smartphone. As the reach of mobile grows, it is becoming an increasingly powerful tool for delivering life-enhancing information, services and opportunities to millions who have not had the opportunity to access them before.

However, despite this growth, mobile ownership remains far from universal. Across LMICs, 14 per cent of adults still do not own a mobile phone, 39 per cent do not use mobile internet and 38 per cent do not own a smartphone. These individuals tend to belong to the most marginalised groups: they are disproportionately rural, illiterate and older, and they are also predominantly female.

This research seeks to better understand the key drivers of mobile ownership, mobile internet, and smartphone use, with a particular focus on gender. By using a suite of control variables for observable drivers of mobile adoption (e.g. education levels, age, employment, rural-urban location), the coefficient for gender, which is the independent variable of interest, should represent if there are non-observable aspects related to gender, and the magnitude of these effects. Previous studies have found mixed results on this topic. For example, studies in Nigeria, Senegal, Burkina Faso, and Tanzania found that gender was associated with lower likelihood of owning a mobile phone. However, there was no significant gender effect in studies in Gabon, South Africa and Mozambique. The majority of studies have thus far focused on a single country and survey. A summary of relevant literature can be found in Annex 2 of the full version of this working paper.

The econometric analysis makes use of multiple years (2017, 2018, and 2019) of GSMA Intelligence consumer survey data, which covers 31 LMICs (a list can be found in the Annex of the full version of this working paper). This analysis will both inform the robustness, and build on previous studies, by utilising this dataset that includes both a wide range of LMICs over three years, with detailed survey questions on mobile technology adoption. Furthermore, this analysis could be further augmented by utilising this survey data that covers types of usage of mobile technology, and reported barriers to adoption of the technologies. Aside from the gender focus, the outputs from this analysis will aid understanding of the key predictors of mobile use more generally (and how these might vary by region), how they relate to each other, and which are the most important. This will provide important information for policy purposes.

In summary, we find that:

- Women are less likely to use mobile, mobile internet and smartphones than men, even when other relevant socioeconomic and demographic factors such as income, education and geography are controlled for. Women are 5 percentage points (pp) less likely to own a phone then men (other factors being equal), 6pp less likely to use mobile internet, and 4pp less likely to own a smartphone.

- This unobservable gender effect is more pronounced in certain regions, especially South Asia, but with no significant link in Latin America and Caribbean.

- The negative effect is enhanced for women that live in rural areas, have low levels of literacy and are not working.

DATA AND METHODOLOGY

This study primarily makes use of the GSMA Intelligence Global Consumer Survey (2017, 2018 and 2019), carried out by Ipsos MORI. In all countries, a nationally representative sample of the adult population was selected. At least 1,000 interviews were conducted in each country surveyed, with 2,000 conducted in India and China. To achieve a nationally representative sample, quotas were applied in line with census data on the following metrics: age category by gender; urban and rural distribution by gender; region/state, and socio-economic class (SEC) to ensure a representative portion of lower income respondents were included.

The surveys use a mix of purposive and random sampling approaches. Depending on the country, sampling points were either randomly distributed with an administrative area's probability of selection proportionate to the size of its population (random sampling), or selected to reflect the linguistic, cultural and economic variations of each country (purposive sampling). Based on the selection of sampling points above we can do similar and stratify the data to urban/rural areas. Within sampling points, systematic random routes were used for residence selection.

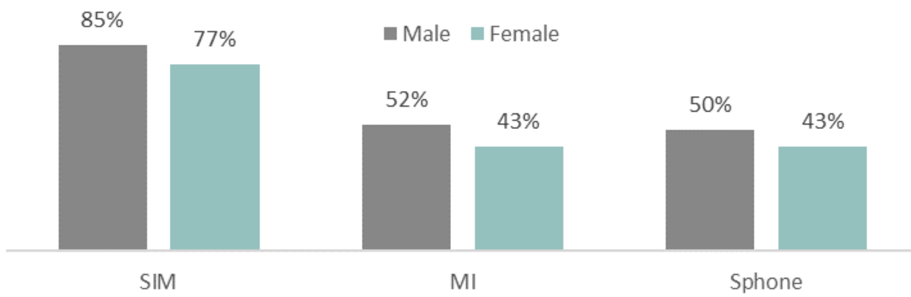


Chart 1: Summary of technology adoption by gender in the GSMA Intelligence Global Consumer Survey

Chart 1 presents the percentage of the population that has adopted each of the three mobile technologies by gender. This includes all respondents in surveyed countries in each year, and each observation is given equal weight (i.e. there is no weighting by country population as in the GSMA Mobile Gender Gap Reports).

EMPIRICAL MODEL

The empirical specification focuses on three dimensions of the use of mobile technology: (a) mobile ownership; (b) mobile internet use; (c) smartphone use. These dependent variables are binary and are defined as:

$$y_i \begin{cases} 1 \text{ if the } i\text{th individual has use of the mobile technology} \\ 0 \text{ if the } i\text{th individual does not have use of the mobile technology} \end{cases}$$

Dependent variable	Description
Mobile owner	"Mobile phone owner" and "mobile owner" are used interchangeably in this paper to mean a person who has sole or main use of a SIM card, or a mobile phone that does not require a SIM, and uses it at least once a month.
Mobile internet	A "mobile internet user" is a person who has used the internet on a mobile phone at least once in the last three months. Mobile internet users do not have to personally own a mobile phone, and therefore can be non-mobile phone owners who use mobile internet by accessing it on someone else's mobile phone.
Smartphone	A smartphone user is someone with a smartphone that they have the sole or main use of. Respondents that don't have an active SIM are removed i.e. if they aren't a mobile owner following the description above.

Table 1: description of dependent variables

We construct a model of the probability of adopting certain mobile technologies (mobile phone ownership (sim_i), mobile internet (mi_i), and smartphone use (spo_i)), conditional upon a vector of independent variables with gender (g_i) as the variable of interest, and a suite of control variables $(\boldsymbol{X})$.

We define a latent independent variable (y_i^*) as:

$$y_i^*(g_i, \boldsymbol{X};\ \beta_0, \beta_1, \boldsymbol{\beta}) \equiv \beta_0 + \beta_1 g_i + \boldsymbol{\beta X} + \varepsilon_i$$

This latent variable will determine the outcome variable (y_i) for each individual i in the following way:

$$y_i = \begin{cases} 0 \text{ if } y_i^* < 0 \\ 1 \text{ if } y_i^* \geq 0 \end{cases} \text{where } y_i \begin{cases} sim_i \\ mi_i \\ spo_i \end{cases}$$

By making the assumption (amongst others) that the errors follow a logistic distribution (*i.i.d.*), we can use the logit model to estimate the conditional probabilities of the three mobile adoption outcomes:

$$Pr(y_i = 1 | g_i, \boldsymbol{X})$$

The independent variable of interest is a binary variable representing gender. As this variable is nominal, either 0 or 1 is assigned to male or female, and in this case female is represented by '1' and male by '0'. This should reflect the effects of non-observable aspects related to gender.

This is regressed alongside the following control variables of observable drivers of mobile adoption (Table 2).

Socio-economic/demographic factor	Variable	Description
Gender	*Gender*	1 "Female", 0 "Male"
Age	*Age*	1 "18-24", 2 "25-34", 3 "35-44", 4 "45-54", 5 "55-64", 6 "65+"
Working status	*Not_working*	1 "Not working", 0 "Working"
Education	*Education*	1 "Primary or below", 2 "Secondary", 3 "Degree or above"
Rural-Urban Location	*Rural*	1 "Rural", 0 "Urban"
At least one child	*One_Dependent*	1 "At least one dependent", 0 "No dependents"
Literacy		1 "Low/no literacy skills", 0 "Fair/good literacy skills"
Household Income	*HH_Income*	1 "Low", 2 "Medium", 3 "High"[1]
Income Perception	*Income_Perception*	1 "Living comfortably on present income", 2 "Coping on present income", 3 "Finding it difficult on present income", 4 "Finding it very difficult on present income"
Years	*Year*	2018, 2019, 2017 (base)
Country	*Country*	Dummy variables for each country[2]

Table 2: Variables used to specify the model

Given that different segments of female populations face different degrees of digital exclusion (see for example After Access, 2018), we also explore interactions between gender and the control variables in the model, for example with rural/urban location, income and education. This would show, for example, whether women living in rural areas face constraints to owning a phone or using mobile internet that are additional to those faced by women or rural populations more generally.

Network effects that influence mobile phone use can arise through membership of religious, cultural, economic and other communities (see for example Forenbacher et al., 2019). In our models, standard errors are clustered at a within country 'region' and 'geography' level (e.g. Lagos-Urban and Lagos-Rural) to take account of these network effects. Annex 6 in the full version of this working paper presents the models at different levels of clustering.

INITIAL RESULTS

The results presented in Table 3 show that the average marginal effect[3] of 'female' on the probability of mobile ownership is -5 percentage points (pp), meaning that on average in our sample, women are 5pp less likely to own a

[1] For the 2019 and 2018 consumer survey, bands were: Low: Less than £15,000 a year, Medium £15,000 – £44,999 a year High: £45,000 or more. In the 2017 consumer survey: Low: Less than £20,000 a year, Medium £20,000 – £49,999 a year High: £50,000 or more - this causes issues with this variable as it cannot be pooled consistently across the three years. See Annex 4 in the full version of this working paper on income variable alternatives. We also ran the regressions excluding the income variable and the results for other coefficients did not materially change.

[2] See Annex 1 in the full version of this working paper

phone then men (other factors being equal).[4] The marginal effects for mobile internet and smartphone adoption are -6pp and -4pp respectively. This suggests that even when other drivers of the gender gap are controlled for (particularly employment, income and education), women are still less likely to use mobile technology than men.[5]

The results also show that individuals in rural areas are 3pp less likely to own a phone than urban populations. The marginal effect is even greater for mobile internet (9pp) and smartphone adoption (8pp). Other control variables are in the expected direction and are statistically significant:

- Individuals with lower incomes are less likely to use mobile, mobile internet and smartphones. For example, compared to high-income individuals, those earning a low income are 15pp less likely to use mobile internet and those earning middle income are 5pp less likely.
- Those not working are 4pp less likely to use each type of mobile technology than those that are employed.
- Individuals that have only completed primary education (or less) are 32pp less likely to use mobile internet than those with a degree or above. Those that have completed secondary education are 15pp less likely to use mobile internet.
- Individuals with low levels of literacy are 7pp less likely to own a phone than those with good literacy skills
- Adoption of mobile technology generally declines with age. For example, individuals aged 25-34 are 6pp less likely to use mobile internet than those aged 18-24; those aged 35-44 are 15pp less likely; those aged 45-54 are 25pp less likely and those aged 65 or above are 43pp less likely[6]. For mobile ownership, however, the impact of age does not appear to start until 45 and above.
- Having dependents is not linked to higher or lower use of mobile internet or smartphones, but there is evidence that it is linked to higher mobile ownership.
- Annex 7 in the full version of this working paper presents the results of regressions which also include a variable that represents if a person has a disability, and this variable interacted with gender. This survey question was limited to the 2019 survey only, and a smaller sample of countries. Although of high importance, this variable isn't included in the main regressions in order to take advantage of the full sample size by pooling the survey data where variables are available across the three years.

	SIM	Mobile internet	Smartphone
Female	-0.0548*** (-10.93)	-0.0620*** (-13.62)	-0.0429*** (-9.90)
Rural	-0.0347*** (-5.21)	-0.0897*** (-13.22)	-0.0821*** (-12.76)
Not working	-0.0395*** (-8.16)	-0.0369*** (-8.45)	-0.0397*** (-8.79)
Low income	-0.0562***	-0.149***	-0.164***

[3] We choose to present marginal effects rather than odd-ratios, as many argue that odds ratios are often unintuitive and generally present little indication of the magnitude of the effect of a variable (Karaca-Mandic et al., 2012). If the probabilities are low and close to zero then the odds ratios are approximately equivalent to the risk ratio, however they are unlikely to be that low in our data. Secondly, the odds ratios of interaction terms cannot be interpreted in the same way as singular variables, as the coefficient on the interaction term is the natural logarithm of the ratio of two odds ratios. Given the complexity of odds ratios, even without the addition of the ratio of odds ratios for an interaction term, this output and approach may be of little use.

[4] Marginal effects are calculated using the delta method at the means of the rest of the explanatory variables, and therefore may not hold when they are set to other values. "The standard error of the average marginal effect of female across all subjects in the sample is not equal to the standard error of the marginal effect of female evaluated at the means of the explanatory variables although the results may be numerically close", (Karaca-Mandic et al., 2012).

[5] Although it is true that without a fully saturated model it is possible that the unobservable effect measured by gender could also be capturing other unobserved mechanisms which aren't directly, but indirectly, related to gender, we have included an extensive range of socioeconomic and demographic variables to control for the drivers of mobile adoption identified in the literature (see Annex 2 in the full version of this working paper).

[6] This is likely to be a function of experience using relatively novel mobile technology in youth, and the younger generations with this experience will not necessarily give up this adoption when older.

	(-6.34)	(-17.35)	(-18.71)
Middle income	-0.0154* (-2.14)	-0.0534*** (-7.27)	-0.0668*** (-8.79)
One dependent	0.00922* (2.18)	0.00284 (0.65)	0.00309 (0.65)
Low education	-0.135*** (-19.85)	-0.319*** (-34.42)	-0.303*** (-31.44)
Middle education	-0.0556*** (-9.29)	-0.145*** (-19.31)	-0.141*** (-18.67)
No/low literacy	-0.0738*** (-12.29)	-0.134*** (-18.20)	-0.123*** (-18.26)
Age 25-34	0.0131** (2.91)	-0.0590*** (-12.99)	-0.0479*** (-9.06)
Age 35-44	0.00250 (0.51)	-0.151*** (-26.23)	-0.114*** (-18.98)
Age 45-54	-0.0343*** (-6.11)	-0.247*** (-38.27)	-0.200*** (-29.91)
Age 55-64	-0.0842*** (-11.78)	-0.351*** (-46.32)	-0.296*** (-33.83)
Age 65+	-0.147*** (-16.55)	-0.431*** (-50.02)	-0.363*** (-39.59)
N	61,526	61,526	59,457

**** p<0.1, ** p<.05, *** p<.01. Z-scores in brackets.***

Table 3: Marginal effects on the conditional probability of mobile ownership[7]

REGIONAL ANALYSIS

In Annex 5 in the full version of this working paper, we present the marginal effects when restricting the sample by region[8],[9], and in the mobile technology adoption rates by gender in each surveyed country are presented. In Table 4 below, the marginal effects of gender are presented for each region. We find that when controlling for other relevant factors:

- Women are as likely as men to use mobile technology (either mobile, mobile internet or smartphones) in Latin America and the Caribbean, once other relevant factors are controlled for.
- In the other regions, there is an unobservable gender effect – this is greatest in South Asia, where women are 20pp less likely to own a mobile phone than men, followed by Sub-Saharan Africa, and then MENA and East Asia & Pacific

	East Asia & Pacific			Latin America & Caribbean			Middle East & North Africa		
	SIM	MI	Sphone	SIM	MI	Sphone	SIM	MI	Sphone

[7] For a logit or probit model, the outcome of interest is the conditional probability that the dependent variable equals 1.

[8] East Asia & Pacific, Latin America & Caribbean, Middle East & North Africa South Asia, and Sub-Saharan Africa

[9] In these initial regressions, countries are unweighted, however there is implicit weight given to India and China based on their populations, as at least 1,000 interviews a year were conducted in each country surveyed, with 2,000 conducted in India and China.

Female	-0.03***	-0.04***	-0.02*	-0.003	0.01	0.004	-0.03**	-0.05***	-0.05**
	South Asia			Sub-Saharan Africa					
	SIM	MI	Sphone	SIM	MI	Sphone			
Female	-0.20***	-0.15***	-0.14***	-0.04***	-0.08***	-0.03***			

Table 4: Marginal effects on the conditional probability of mobile technology adoption, by region

INTERACTION VARIABLES

Including interactions between variables can inform how the marginal effect of gender changes with other variables – for example when the urban/rural indicator changes. For each observation, the cross-derivative will be the change in the conditional probability that y=1 for a change in rural and gender. It is the difference between male and female of the marginal effect of rural on the conditional probability that y=1.

In Table 5 below, we have calculated the derivative of the gender variable at different values of the 'urban/rural' variable using the mobile ownership regression as an example. The effect of the interaction term is calculated by taking the difference of these marginal effects (-4 percentage points). This represents the effect of the statistical change between male and female in an urban environment and the effect of the change between male and female in a rural environment (Karaca-Mandic et al., 2012). In other words, it shows that women are 4pp less likely than men to own a mobile phone in rural areas compared to urban areas.

Marginal effect	dy/dx
Of Gender in Urban	-0.0336
Of Gender in Rural	-0.0719
Difference (Female#Rural)	*-0.0383*

Table 5: The marginal effect of 'rural' and 'female' on the conditional probability of mobile ownership[10]

Table 6 presents the derivatives of gender at different states of the other socioeconomic and demographic variables in the regression. As explained above, taking the differences of the marginal effects at each step will result in the marginal effect of the interaction term. In summary, the results show in addition to women being – on average – less likely to own a phone or mobile internet than men, this effect is 'enhanced' (or made worse) by the following factors:

- Living in rural areas.
- Unemployment (e.g.women are 2.5pp less likely to use mobile internet than men if they are unemployed, compared to if they are employed)
- Having lower levels of literacy (e.g.women are 3.4pp less likely than men to own a mobile phone if they have low levels of literacy, compared to if they have high literacy levels)
- Having dependents (this implies that the positive effect of having a dependent for mobile phone ownership is only for men).

	Rural				Not working		
	SIM	**MI**	**Sphone**		**SIM**	**MI**	**Sphone**
Urban	-0.0336***	-0.0499***	-0.0290***	**Working**	-0.0494***	-0.0520***	-0.0351***
Rural	-0.0719***	-0.0790***	-0.0607***	**Not working**	-0.0621***	-0.0765***	-0.0544***
	One dependent				**No/low literacy**		
	SIM	**MI**	**Sphone**		**SIM**	**MI**	**Sphone**
No dependents	-0.0337***	-0.0503***	-0.0354***	**Literate**	-0.0463***	-0.0621***	-0.0389***
At least 1 dependent	-0.0641***	-0.0675***	-0.0465***	**No/low literacy**	-0.0806***	-0.0861***	-0.0787***

[10] For a logit or probit model, the outcome of interest is the conditional probability that the dependent variable equals 1.

* p<0.1, ** p<.05, *** p<.01

Table 6: the marginal effect of gender at different states of the control variables included in the model

4.3 Isolating the impact of unobservable and observable effects

The three charts below use the predicted probabilities from the three logit models (mobile ownership, mobile internet use and smartphone ownership) to isolate the effect of observable and unobservable drivers of the gender gap. Chart 1 shows that across the sample (for all countries and in all years), 85% of men and 77% of women owned a mobile phone respectively[11]. If we set the gender variable to zero, in order to remove any 'gender' effect, the difference between the predictions for 'female' and the predictions without the gender effect can be attributed to the non-observable aspects related to gender, such as discrimination and cultural norms. The effect of these unobservable aspects reduces the predicted probability of mobile ownership by women by 6 percentage points. The remaining difference of 2 percentage points can be attributed to observable characteristics, such as income and education.

Similarly, we find that unobservable factors are significant drivers of the gender gap in mobile internet use and smartphone adoption, reducing the predicted probabilities by 5 percentage points and 7 percentage points respectively.

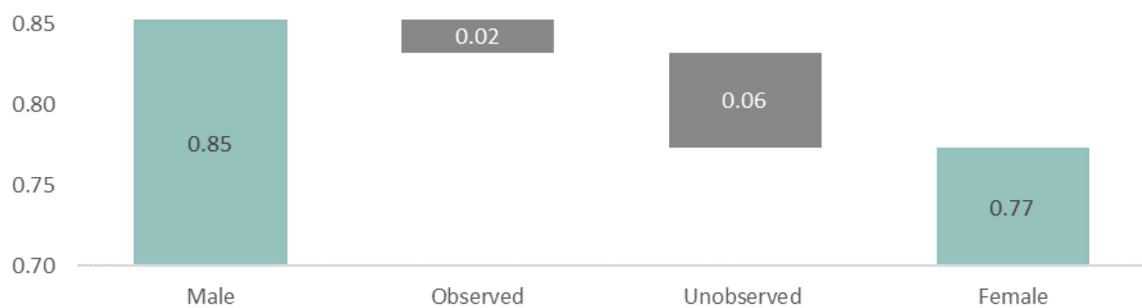
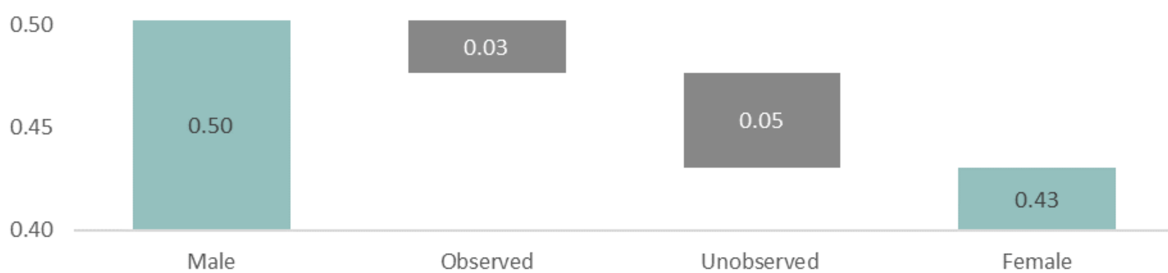


Chart 2: predicted probability of mobile ownership by gender: observable and unobservable differences



[11] These predicted probabilities are equal to observed values in the dataset (Chart 1).

Chart 3: predicted probability of mobile internet adoption by gender: observable and unobservable differences

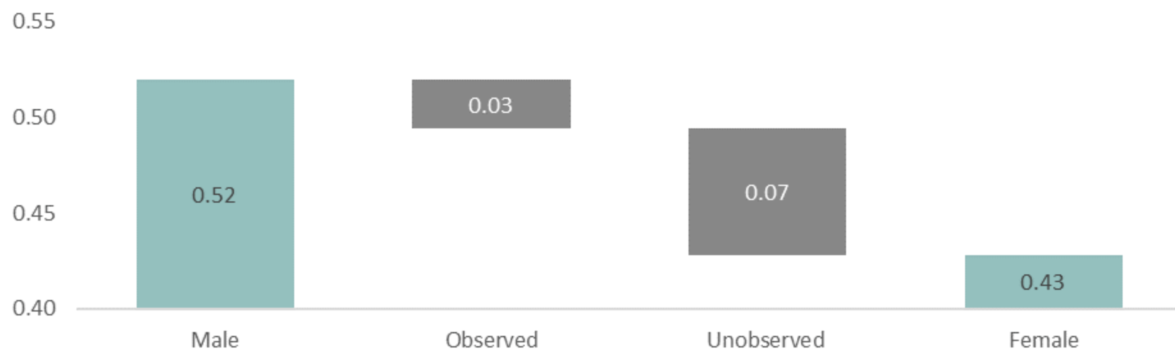


Chart 4: predicted probability of smartphone ownership by gender: observable and unobservable differences

NEXT STEPS

Additional analysis

We have initially explored the heterogeneity in the marginal effect of gender for regions, but we will also look at how the drivers of the gender gap vary by country. The GSMA Intelligence Global Consumer Survey includes questions on barriers to technology adoption that could be utilised for additional analysis on the mechanisms behind the gender gap[12].

Subsequent to the initial adoption of the different types of mobile technology, there may also be differences in the use of mobile technology by gender (see for example Girl Effect, Vodafone Foundation and MIT D-Lab, 2018) e.g. use of certain features or applications, such as mobile money accounts. As an extension to this work, we could replace the dependent variables to investigate the drivers of use of certain features of mobile technology.[13]

Identification and robustness improvements

We might be concerned about endogenous sample selection, as we can assume that an individual can only use mobile internet if they have access to a phone (SIM), and many of the same variables ($\boldsymbol{X_i}$) will influence mobile ownership ($\boldsymbol{sim}$) as well as mobile internet use ($\boldsymbol{mi}$). We observe not potential mobile internet use, but actual mobile internet use, and this is not representative of the whole population (because mobile phone access isn't random). The drivers of mobile internet adoption might not be the same once there is widespread access to mobile/SIM technology.

Allen et al. (2016) suggest using the Heckman selection model as they only observe when an agent makes a choice to use a bank account for savings when they have a bank account in the first place. The Heckman selection model could be used to estimate a relationship between gender and mobile internet adoption consistent with the whole population. The aim is to model both the relationship between gender and mobile internet adoption, and the mechanism by which individuals access mobiles/SIMs using a new variable ($\boldsymbol{z_i}$)[14], with the assumption of independence between this new variable and mobile internet adoption (the exclusion restriction).

$$\boldsymbol{mi_i = mi(X_i, sim_i, \varepsilon_i^*)}$$

$$\boldsymbol{sim_i = sim\left(X_{i,}\, z_i, \mu_1\right)}$$

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[12] For example, exploiting the Blinder-Oaxaca decompositions to identify how much each factor explains the gender gap, or using cross regional variation in gender gaps together with demand and financial factors.

[13] In the GSMA Intelligence Consumer Survey, a number of questions are asked of consumers on what activities they carry out on their mobile phones. This includes: using mobile banking/mobile money apps; purchasing goods/services; using healthcare services; educational services; e-Govt services; visit social networking websites; play games on a mobile phone; listen to music using a mobile phone.

[14] Potentially supply-side factors (e.g. coverage) could drive access to SIM only adoption.

We might also be concerned about potential endogeneity between the binary dependent 'technology adoption' variables and the independent variables. For example, Aker and Mbiti (2010) set out mechanisms through which mobile phones can provide economic benefits to consumers and producers in Sub Saharan Africa. One method to address this is the use of instrumental variables. We could also consider explanatory variables that make use of the time variation in survey data, however this would need to exploit exogenous changes over time e.g. technological shocks or policy changes. For the moment, these approaches are outside of the scope of this study as our primary objective is to understand the factors that are strongly associated with mobile ownership, mobile internet use and smartphone ownership.

In addition to a probability model, as a robustness check[15] we could consider applying the Ñopo (2008) matching method[16] used in the After Access (2018) paper. It allows us to quantify the explained and unexplained drivers of the gender gap. The wage gap decomposition in Ñopo's paper compares groups of observations with similar discrete and observable characteristics. The aim is to obtain a partitioned data set that contains four groups of observations of matched and unmatched males and females based on the characteristics (e.g. the control variables set out above). The observations within the sets of matched males and females have the same empirical distributions of probabilities for their characteristics, and the method is based on the assumption that individuals with the same observable characteristics should have the same level of technology adoption (in the case of Ñopo's paper, receive the same wages) regardless of their gender (Ñopo, 2008).

[15] The Ñopo methodology does not solve the selection bias without assuming ignorability, therefore, as another extension, non-parametric methodologies that try to account for selection bias when applying decompositions could be explored.

[16] Stata command: 'nopomatch'.

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Opportunities and challenges of a nationwide antenna policy: the issue of federal (mis)coordination on antenna deployment in Brazil

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ABSTRACT

Telecommunications´ infrastructure is a fundamental input for a flourishing, inclusive, and prosperous digital society. In Brazil, the distribution and density of telecommunications assets are challenged by, among other reasons, outdated legal and regulatory constraints. This research paper reports a grassroots supportive strategy towards local authorities and legislative bodies in themes such as technical, health, and environmental impact and the disclosure of the social and economic benefits of easing the deployment of infrastructure. Scientific-based references aim to mitigate misinformation around the theme and to overcome technical barriers for implementing a world-class regulatory approach on municipalities´ legislation. To ensure the utmost quality standard of the debate the authors have considered principles such as infrastructure sharing, environmental compliance, and efficiency targets to provide inputs for evidence-based decision making. Preliminary findings from an ongoing field experiment reveal a vigorous response of infrastructure density, and ultimately population connectivity, where local legislations had been updated.

Keywords

Infrastructure, Towers, Federalism, Brazil.

INTRODUCTION

Telecommunications´ infrastructure is a fundamental input for the digitization of the economy. The deployment and density of infrastructure assets are challenged by one hand by geographic, socioeconomic, and technical aspects, and, by the other, by outdated legal and regulatory constraints. These factors together affect the network rollout and eventually jeopardize the field deployment of infrastructure coping with the increasing demand for services and the introduction of new technologies.

The outbreak of the COVID-19 pandemic enacted an unprecedented sense of urgency regarding the connectivity within the Brazilian society. Legal and regulatory measures have been taken to overcome bureaucratic and investment shortcomings, as well as to establish wireless-based technologies as the entry means to cover unattended areas in a fast-fashion and affordable way.

By recognizing mobile technology as a policy priority, policymakers confirm it as a preferential habilitating technology to connect the population, particularly those from the access gap. That is due to the easier deployment of mobile infrastructure and the wider spread of services in lower human density areas.

The importance of mobile technologies is potentialized by the introduction of 5G technology. This technology is simultaneously a driver and an utmost beneficiary of the new landscape for infrastructure deployment nationwide. As a driver, it requires legal and structural changes to enable the installation of required networks necessary for its operability. Available references state that the 5G technology will require higher infrastructure density than legacy technologies for mobile communications (GSMA,2019). As a beneficiary of a better infrastructure density, 5G will allow high value-added services and an expected innovation bloom within Brazilian society.

The most prominent step towards the attempt to make it easier for the deployment of mobile infrastructure is related to the so-called “Lei das Antenas” (Antenna Law, in free translation). It establishes the general rules for implementation and sharing of telecommunications infrastructure nationwide. The Decree that regulates the law dates to 2020 and sets, among other directives, the incentives to infrastructure deployment, the constructive grant and the overall system governance.

Despite the law's innovation, the field installation of the infrastructure requires compliance with local rules where it will be finally deployed. It ends up becoming one of the main bottlenecks for increasing infrastructure density since most of the 5,565 Brazilian municipalities' regulation on the theme is either outdated or inexistent.

Although it focuses mainly on a regional issue, one must notice that reaching a fair mobile infrastructure density is a major challenge to most developing nations. Depending on where it is discussed the challenges cover aspects that range from the environment issues (Cáceres,2016; EPRS,2021) and health concerns (Chiaraviglio and Fiore, 2019) to competition and connectivity dimensions (OECD,2020).

Ultimately a proper infrastructure deployment is a preliminary and necessary step to reach the population connectivity policies and the consumers´ expectation for enhanced service quality and availability. That is why this research paper is based on a universal concern and relies on principles of general welfare, development, and resilience.

The authors’ approach to the theme is anchored on two main strategies. First, it aims to create a groundbreaking data-intensive map of the infrastructure density of the entire country and then to define clusters of socio-economic and technical homogeneous municipalities. By doing so, it is possible to classify the Brazilian municipalities and finally establish a strategy for local approach according to efficiency and impact dimensions.

This paper is organized into three main sections. The following one introduces the topics of connectivity and mobile infrastructure density as a necessary locus of research. After that, it presents the data and methods for empirical evaluation of the infrastructure density in Brazil. This section also introduces the clustering method, its data sources and the tracks for auditing and replication. Then it goes deeper into the theme of principles, information to the public, competing interests, and federalism aspects of antenna legislation. In addition, this section covers the key challenges of local legislative bodies and authorities in the recurrent themes of health, environment, and security, among others. Preliminary results of field experiments are presented in the final part of this paper.

PRELIMINARY THOUGHTS ON CONNECTIVITY AS A LOCUS FOR RESEARCH AND THE ISSUE OF TELECOMMUNICATIONS INFRASTRUCTURE DENSITY.

It is a widely established fact that infrastructure investment plays an important role in the process of economic growth. Research on this topic is settled on two theoretical branches. The neoclassical economics exogenous growth theory introduced by Solow (1956) and Swan (1956) states that exogenous factors are critical in determining the success of an economy, industry, or individual business. Its main perspective is that the determining factors for growth are largely based on external drivers that push forward the rate of capital accumulation and technological progress.

In contrast, Arrow´s (1962) and Romer´s (1986) endogenous growth theory focuses on the endogeneity of the growth process. Their theory emphasizes internal drivers that determine supply and demand within a specific nation, industry, or business marketplace. Endogenous growth models consider key economic factors that are specific to a business or an industry.

The endogenous growth theory is the main theoretical foundation that guides recent findings in the studies of economic growth. Particularly, authors in this branch have relied on empirical observations to identify internal economic factors that drive the entire economic system and lead to long-run economic growth (Dixit, 1990; Stiglitz 1990; Aghion and Howitt 2006;Romer,1994).

Several analyses assume infrastructure as a key reference to measuring endogenous-based economy growth. The underlying idea is that expanding and maintaining the quality of infrastructures enhances the efficiency and sustainability of the entire economic activities.

For example, Agenor and Dodson (2006) examine various channels through which a robust infrastructure can affect economic growth. These authors highlight the impact of developing infrastructure on investment adjustment costs like the durability of private capital and the production of public services. By its turn, Calderon and Serven (2004) assess the impact of quantity infrastructure stock on long-run economic growth and income inequality.

In common these researches highlight the relevance of infrastructure stock for a positive long-run effect on economic growth and negative effect on income inequality. It implies that infrastructure stock building can be used as a strategy for poverty reduction and to reduce bottlenecks for overall economic growth.

Telecommunications infrastructure and economic development

Telecommunications infrastructure displays a role in economic growth due to its multiplier effects and as transversal input to virtually all sectors of the economy and society. Capital investment in the sector leads to efficiency in industrial production and diversification and to shaping demand and supply for goods and services (Röller and Waverman,2001).

It is also correlated to increase the durability and efficiency of public capital. Evidence from 21 OECD countries over 20 years demonstrates a significant positive causal link between telecommunications infrastructure and economic growth (Röller and Waverman,2001).

The outbreak of the COVID-19 pandemics increased the pressure over better coverage and quality standards. The following figures exemplify how this external shock defined the trends in the sector and the sudden pressure it placed over mobile services that ultimately pushed for further requirements on infrastructure demand.

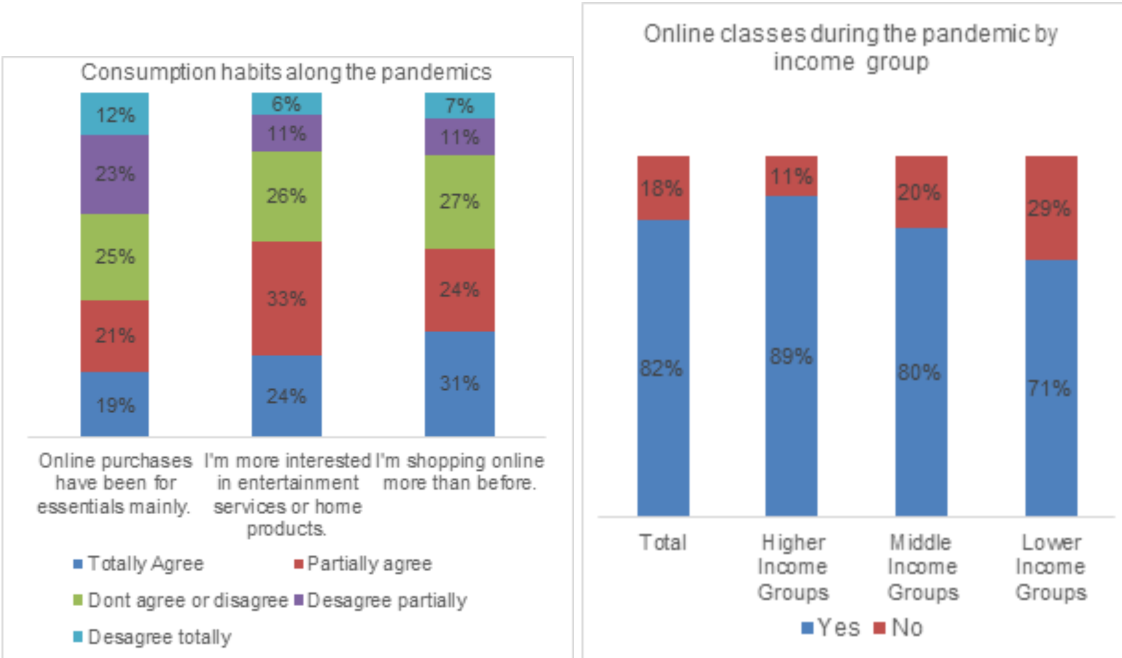

Figure 1. Examples of changes in demand behavior during the COVID-19 pandemic in Brazil

Source: Cetic.br (2021)

The figures highlight changes in e-commerce and online education along the first year of the pandemic in Brazil. Regarding the first topic, consumers willing to do e-commerce increased by 66% compared to the 44% recorded for 2018 (CETIC.BR,2021). Online schooling shows a record of 82% using internet-native tools to learn. Lower-income groups lack behind the national average exposing an access gap for lower-income families.

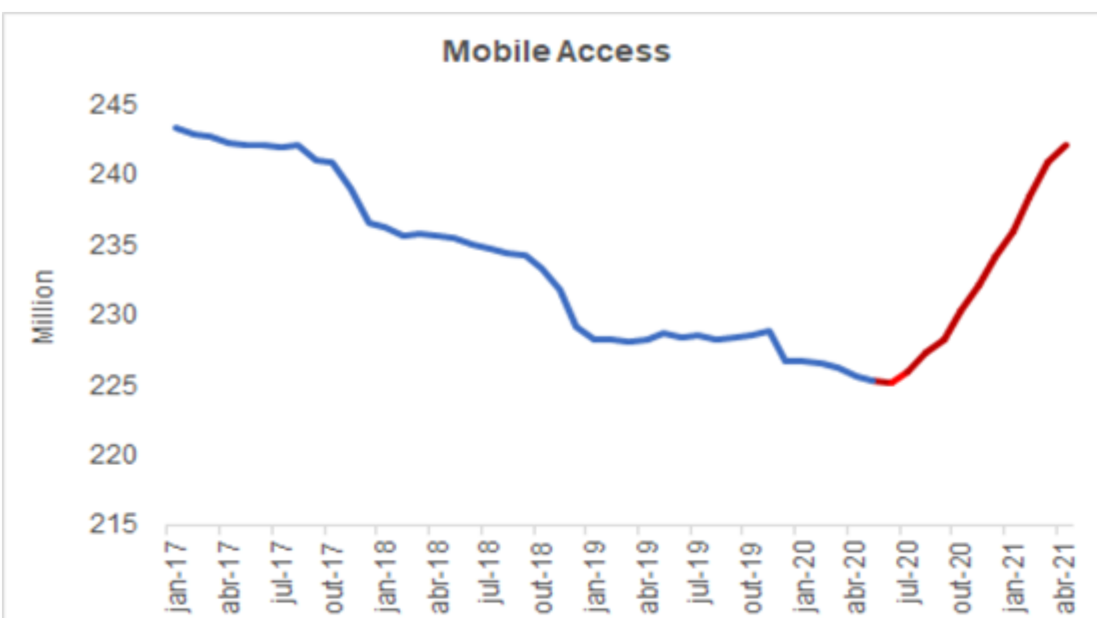

Figure 2. Mobile access in Brazil

While the service demand and use patterns display a bold growth rate and reinforce its position as the preferential service to connect lower-income groups, the growth rate in the antenna density reduced over the last years. It imposes odds to the expected quality and coverage targets set in public policies. The following figure shows the park of active antennas evolution and the year-over-year growth rate over the last 20 years.

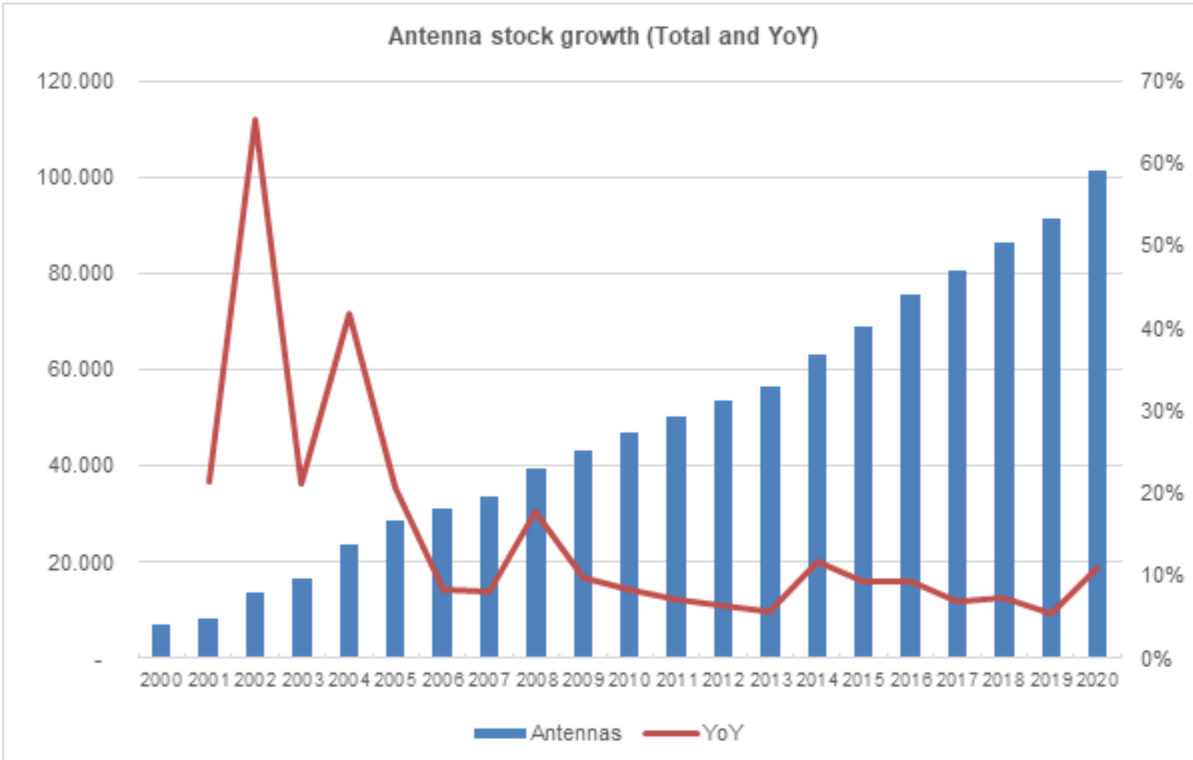

Figure 3. The stock of active antennas in Brazil (2000-2020)

Infrastructure also plays a crucial role in the roll-out of the 5G technology to its full potential. As the first commercial applications of this technology arrive, the urgency around the theme increases.

Higher 5G quality is an enabler for large-scale applications and innovations. For instance, the value-added applications in the Internet of Things (IoT), that will connect physical objects such as vehicles, machine tools, street lights, wearables, wind turbines, and people, via connectivity solutions to enable communication, exchange of data, and derive actions will strongly rely on a stable, integrated and high-quality network. Since 5G services are data-intensive and require lower latencies, the demand for more antennas is likely to surge with the increasing deployment of 5G in the world's major economic hubs (GSMA,2021).

DATA AND METHODS

This section highlights the dataset and introduces the clustering process. It implies identifying groups of homogeneous municipalities out of preselected technical, economic, and social variables.

Data sources

The database considered to define the clusters of municipalities is arranged in a cross-sectional structure of 6 variables for the year 2020. Population, municipality area, and the Human Development Indicator (HDI) are all provided by the Brazilian Census Bureau (IBGE,2021). By its turn, the antenna density index is made available by the National Regulatory Agency (ANATEL,2021). The following summary statistics refers to these variables. For the sake of a better frequency distribution among clusters, urban and rural municipalities were taken as categorization variables.

Variable	Mean	Std Dev	Std Error	Minimum	Maximum
Population	10.417,62	9.364,86	160,07	776,00	83.182,00
Households	3.369,57	2.913,05	49,79	258,00	27.406,00
Antenna Density Pop.	5,57	4,06	0,07	-	38,66
Antenna Density Area	0,01	0,02	0,00	0,00	0,38
HDI	0,64	0,09	0,00	0,32	0,86
Area (km^2)	1.556,80	5.535,13	94,61	18,61	122.461,09

Table 1. Descriptive Statistics for Rural Municipalities (n=3.423)

Variable	Mean	Std Dev	Std Error	Minimum	Maximum
Population	82.188,7	354.845,09	7.667,06	1.467,00	123.252,32
Households	27.583,81	121.657,48	2.628,63	505,00	4.250.080,00
Antenna Density Pop.	4,66	3,01	0,07	-	27,27
Antenna Density Area	0,13	0,46	0,01	0,00	6,59
HDI	0,71	0,09	0,00	0,39	0,90
Area (km^2)	1.474,34	5.721,01	123,61	3,57	159.533,31

Table 2. Descriptive Statistics for Urban Municipalities (n=2.142)

The summary statistics shows that Infrastructure density ranges from the complete lack of infrastructure, and therefore service availability, to areas of developed world-class standard coverage. The rural municipalities display relatively lower population density and higher average areas compared to urban municipalities. Regarding the number of rural households, they are smaller than their urban counterparts and spread out in a larger area.

Antenna density is broken down into two indexes - antennas per 10.000 people and antennas per km^2 for each municipality in the sample. By doing that, the authors expect to cover the two-dimensional approach commonly taken in international studies about antenna density. Both indicators of density are considered input variables for the clustering process.

Taking the dimensions of density alone, one might notice that the rural municipalities display higher average antenna presence per 10.000 people (5,57) compared to the urban municipalities (4,66). On the other hand, there is an opposite picture when the area reference is used. In this case, the urban municipalities display an average higher density (0,13) than the rural municipalities (0,01). That is why the authors decided to take the two-dimensional approach as complementary references.

Clustering techniques

After fully characterizing the municipalities according to relevant and non-redundant socio-economic and technical variables, the dataset was submitted to a nonhierarchical and unsupervised learning algorithm method known as k-means (Macqueen,1967). This method allows for partitioning the municipalities into a pre-defined number of K clusters.

For this study, municipalities were classified into four clusters for two categories of municipalities –rural and urban, according to the official designation by the Brazilian Census Bureau (IBGE,2021). The authors' decision concerning the number of clusters included a close examination of the frequency distribution among clusters and the root mean square standard deviation in the clusters. These tests are better explored in the preliminary results section.

Based on the pre-defined number of clusters, the algorithm randomly selects a centroid for each cluster. To set the distances from the cluster´s centroids to every single object it employs the Euclidean Distance Method, which refers to a geometrical measure in the multidimensional space between the clusters´ centroids $X=[x_1, x_2,\ldots,x_p]$ and the individual municipalities references $Y=[y_1,y_2,\ldots,y_p]$, computed as follows:

$$d_{xy} = \sqrt{(x_1-y_1)^2+(x_2-y_2)^2+\ldots+(x_p-y_p)^2} = \sqrt{\sum_{i=1}^{p} (x_i-y_i)^2}$$

The initial seed is useful for defining the cluster centroid (Dubes and Jain,1979). It refers to the mean values of the municipalities contained in the cluster regarding each of the selected variables. Each municipality is then assigned to the closest cluster center. Final municipality designation in a specific cluster is defined according to a minimizing function.

This methodology allows a better understanding of the specificities of the municipalities and to define a prioritization strategy. Ranking them according to their priorities will foster more efficient use of resources and a higher impact on social welfare.

SETTLING THE CONDITIONS FOR LOCAL INFRASTRUCTURE DEPLOYMENT: PRINCIPLES, INFORMATION TO THE PUBLIC, AND STEPS FORWARD.

One main outcome of this research deals with assembling a comprehensive set of references for local authorities and legislative bodies on themes commonly associated to the field infrastructure deployment. To assure the best practices on the subject, it considers principles such as infrastructure sharing, environmental compliance, constitutional competencies, and efficiency targets, among others.

The following subsection addresses some of the debates to be carried out by this proposal regarding topics such as environmental and urban-related problems, health impact, and the extension of the benefits of telecommunication services. A couple of principles are taken as a reference in designing a strategy for a more efficient antennas deployment in Brazil. These principles might be categorized into three main pillars. First and foremost is the bureaucracy rationalization pillar that embodies principles such as 'streamlined constructive grant'' (or "silêncio positivo", as known in Brazil) and the 'right-of-way'. The second pillar deals with public concerns on health, urban and environmental aspects usually attached to antennas deployment in public areas. Finally, there is the techno-economic pillar which addresses investment-friendly efforts and technology requirements.

Streamlined constructive grant and the right-of-way principles: breakthrough regulatory innovation.

The 'streamlined constructive grant' principle is related to the licensing timeframe of the site and its complexity. Before the enactment of the Antenna Law, it was up to the municipality to decide on the timeframe necessary for infrastructure deployment licensing. According to the Antenna law, it must happen within 60 days counting from the licensing request application, except for a few cases. According to the Decree nº 10.480/2020, which nationally regulated the Antenna Law, there will be an automatic grant if the local authority does not decide in time.

This practice is considered, within the legal arrangement, as tacit approval of licensing which would ultimately encourage an expedited approval of infrastructure licensing. Once this dispositive motion is set off, the interested entity is authorized to carry out the installation, following the conditions of the application submitted and the other rules stipulated in the governing legislation.

By its turn, the 'right-of-way' principle refers to the suitability of placing telecommunications infrastructures along public roads or any other public properties used by people. It provides the necessary legal security from a regulatory standpoint. It also differs from the sharing of infrastructure principles, described in the following subsection, which occurs on a compensatory basis.

Infrastructure sharing policies.

Infrastructure sharing comprises the sharing with third parties' assets used in the provision of public utility services. Its purpose is the search for greater efficiency in the allocation of scarce resources, essential to the provision of services, and optimization of investment and operating costs.

Sharing arrangements in the telecommunications industry is amongst the most sophisticated inter-business cooperation initiatives (Freitas et al.,2020). Its use dates to the period of the Brazilian telecommunication market opening in the 1990s, when mandatory sharing solutions were established in the law and, later, in regulations.

From the 2000s onwards, new spontaneous sharing models spread throughout Brazil. The differentiation in terms of coverage or ownership of infrastructures, dominant strategy in the initial periods of universalization of services, was supplanted by initiatives aimed at differentiation by price and quality and by the search for greater allocative efficiency and cost reduction.

This positioning has become an essential component for the subsequent expansion of telephony and broadband services to regions with a lower return on investment, located in the urban fringes, peripheries, and rural and remote areas of the country.

The argument in favor of sharing is also supported by technical advances related to the standardization of communication technologies and protocols (Meddour et al.,2011, Sidenbladh,2002). In these terms, experiences of sharing sites and antennas used for mobile communications suggest a potential reduction in capital costs of up to 30% and operating costs of up to 45%.

The regulation of the Antenna Law also refers to the joint use of facilities to serve as a basis for the provision of public services. Poles, towers, pipelines, urban subsoil, conduits, and administrative easements are all explicitly referenced in the regulation. In this case, it seeks to regulate the joint implementation of public interest infrastructure and to organize the relationship between the telecommunications service providers and the managers of the basic infrastructure assets.

Environmental requirements and health-related concerns: legal mandate and federative matters.

Uncertainties around a rapidly changing landscape for emerging technologies and misinformation about their risks and benefits are inherent to the rollout of any major innovation. As the new connectivity technologies are associated with a higher density of physical infrastructure outdoors they are likely to be inquired by the locals on issues such as environmental and health risks.

To put it in context it is useful to distinguish the different federative roles in the matter of telecommunications legislation. Thus, by one side the Brazilian Constitution (CF,1988) assigns to the Union (Federal level) the exclusive competence to legislate on telecommunications. On the other hand, it establishes common competence to its federated units in matters of environmental protection and other measures to cope with pollution in any of its forms. It also defines the duties of the Union, the States, and the Municipalities to legislate on affairs such as the urban planning law, environmental protection and pollution control, and liability for environmental damage.

While the Union oversees establishing general norms, the States have a supplementary legislative role on issues not covered by general norms. Finally, the municipalities oversee legislating in matters of local interest and to supplement federal and state legislation duties where applicable, and to promote adequate territorial ordering, among other matters. The constitutional provisions, therefore, assign only supplementary law enforcement to municipalities to act in the matter.

Concerning antenna licensing, the issue is set on the Complementary Law nº140/2011. According to this Law, the municipalities must legislate on activities that cause or may cause environmental impact. By its turn the Law nº11.934/2009, which handles the limits of human exposure to electric, magnetic and electromagnetic fields, assigns to the federal regulatory body the mandate to define and enforce rules on the matter of non-ionizing radiation.

Back to the 'Antenna Law', it addresses, in accordance with the Law nº11.934/2009: (a) the competence to establish limits in the federal sphere of law and regulation; b) the competence of inspection and licensing of these activities rests with the federal regulatory agency; c) the joint obligation of all federative unities to communicate the federal regulatory body about signs of irregularities. This normative path states that the antenna licensing process at the municipal level should not be attached to concerns about the protection of human exposure to electromagnetic fields.

RESEARCH OUTCOMES: PRELIMINARY RESULTS FROM DATA ANALYSIS AND FIELD EXPERIMENTS.

To reach the objectives of the research, the authors have gone through a bottom-up review of the antenna's infrastructure availability for the entire Brazilian territory. For those localities with lower infrastructure density and higher population concentration authors carried out a fieldwork to provide local authorities with supporting technical knowledge and science-based documental references.

At this point, it must be acknowledged that there are several intertwining initiatives aiming to develop infrastructure locally. This research project takes into consideration the progress carried out so far and arranges it in an accountable, methodology-grounded, and measurable way.

Preliminary results of the clustering assembling

The following figure resumes the estimated clusters of rural and urban municipalities according to the criteria e methodology introduced earlier in this paper. Each and all clusters are defined according to homogeneous patterns identified after an unsupervised learning algorithms classification.

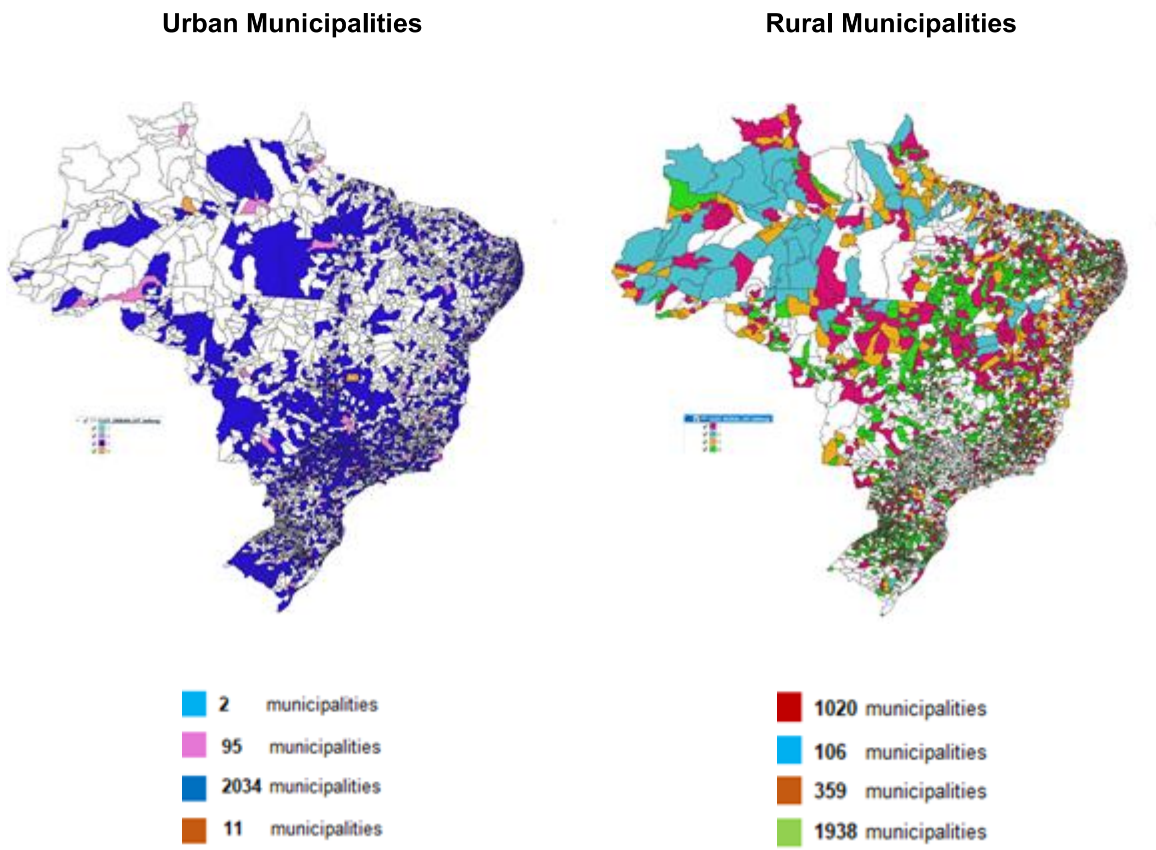

Figure 4. Clusters of municipalities.

By analyzing these different clusters, one might start a process of efficiency analysis and seek a better allocative effort. Ranking the clusters from higher to lower priority is a possible starting point to focus on localities where impacts are relatively higher. Even though this strategy was adopted for the field experiment described below, further research on prioritization might add value to the analysis.

Field experiment: some preliminary pieces of evidence

Expanding infrastructure density is a multiple-sided interest effort. Industry and service provider's interest converge to building common sense on the theme with the objective to invest and provide better services. Society requires better services, quality and coverage. Public authorities are interested in assuring a stable and high-capacity network to implement their services over this layer of connectivity.

Therefore, it might be expected that initiatives have evolved to settle rationality in the theme. There are a couple of examples of municipalities that have already engaged in modernizing their local legislation on the of modernizing local legislation to easy antenna deployment.

The case of "São José dos Campos", a municipality located 94 km from the city of São Paulo, Brazil, and with about 500,000 inhabitants, is an example that stands out. It evolved from a lower density infrastructure pattern to a leading position in the cluster of attended areas exemplified in the previous subsection.

To reach its position, the municipality reviewed its legislation to favor the implementation of antennas in its territory. According to the 'Internet-Friendly Cities Ranking' (TELECO,2019), a private initiative that measures the antennas density in Brazil, the municipality escalated from the 21st place in 2015 to the 1st position in 2019, after reviewing its legislation, ending restrictions and reducing bureaucracy for antenna licensing.

Other localities followed similar pattern. Some of them pursuid better performance by free will of public authorities to increase quality and availability of mobile services, others motivated by the inputs discussed over this study.

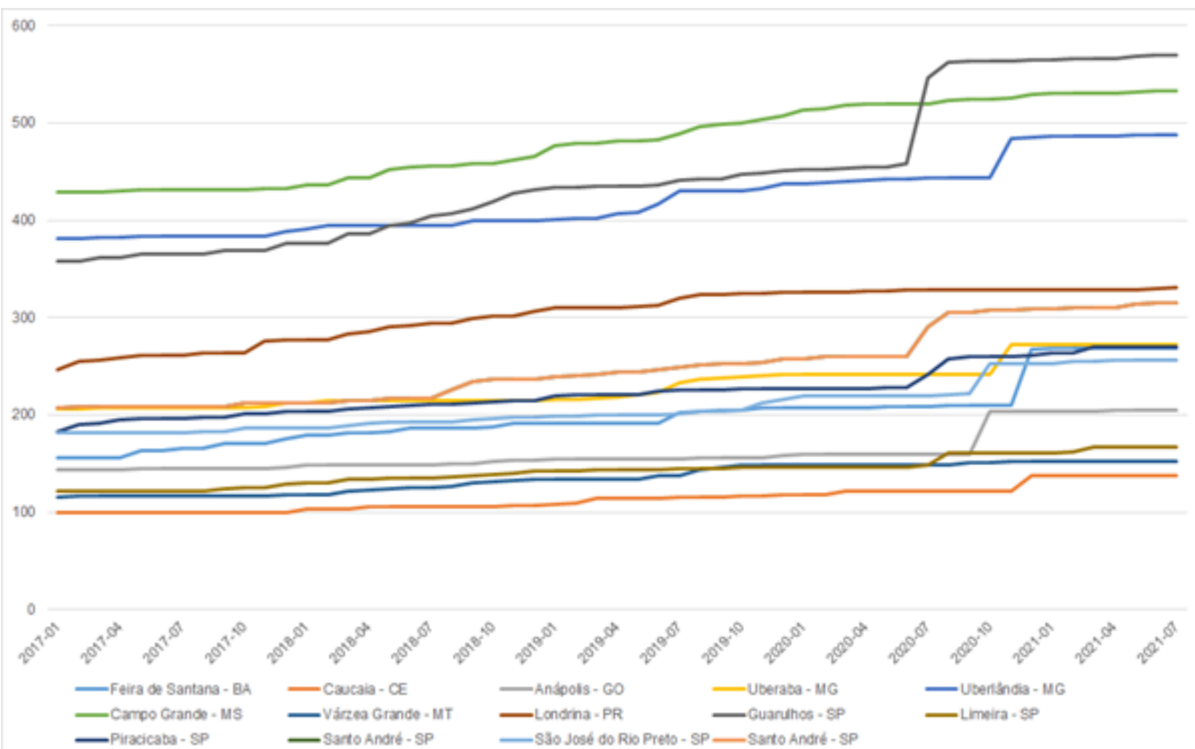

Figure 5. Preliminary evidence of antennas licensing after municipalities engagement in local legislation update.

These preliminary outcomes reveal a vigorous response of new antenna licensing in municipalities that engaged in the local regulations update.

CONCLUSION

This research paper highlights grassroots-applied ongoing research about the municipal level implementation of the Antenna Law in Brazil. This infrastructure is the fundamental input for wireless-based technologies defined by policy makers as the entry mean to cover unattended areas in a fast-fashion and affordable way.

Despite the legal basis enacted by the legislative and regulatory innovations, the field installation of the infrastructure requires compliance with local rules where it will be finally deployed. It ends up becoming one of the main bottlenecks for increasing infrastructure density since most of the 5,565 Brazilian municipalities' regulation on the theme is either outdated or inexistent.

This research addresses the research problem by delivering a comprehensive documental and technical support effort to assist local authorities and legislative bodies in themes such as technical, health, and environmental impact and the disclosure of the social and economic benefits of easing the deployment of infrastructure. These scientific-based references together with a proposal of a modern law project aim to mitigate misinformation around the theme and to overcome technical barriers for implementing a world-class regulatory approach on municipalities legislation.

The approach towards the municipalities follows a clustering methodology that assigns groups of municipalities according to socioeconomic and technical variables. By doing so it is possible to define different strategies to approach local authorities.

Preliminary outcomes of this ongoing research reveal a vigorous response of new antennas licensing in municipalities that engaged in the local regulations update.

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What are the US spectrum auctions for 5G teaching us about auction efficiency?

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BIOGRAPHY

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ABSTRACT

This paper assesses the efficiency of the first 5G spectrum auctions held in the United States. In 2018 and 2019, the Federal Communications Commission (FCC) administered auctions 101 and 102 to assign spectrum in the 28 GHz and 24 GHz bands, respectively. Auction 101 sold spectrum on the 28 GHz band for Upper Microwave Flexible Use Service licenses and raised a total of about $700 million. Auction 102 assigned spectrum on the 24 GHz band for Upper Microwave Flexible Use Services. It raised a total of close to $2 billion. In July 2020, the FCC auctioned the 3.5 GHz band for Priority Access Licensees, raising over $4 billion in Auction 105.

I implement an assessment of the efficiency of an auction based on its observed bidding data during the clock rounds of the auctions, while relying on revealed preference theory. Data are available at the FCC's Auctions website. Bidding data are organised by geographical area and for each geographical area, demand for blocks of license type for each round, for each bidder. I rely on the application of the well-known Generalised Axiom of Revealed Preference or GARP, and the lesser-known Homothetic Axiom of Revealed Preference or HARP, to calculate two indexes, Afriat Efficiency Index (AEI) and Homothetic Efficiency Index (HEI) as proxies for a measurement of rational bidding associated with each bidder.

The US FCC relied on an auction format, which uses demand revelation but allows the bidders to state the price at which they would demand a number of units of a product (that is, a number of blocks or licenses over a distinctive geographical area). In essence, the auction format for auctions 102 and 105 followed a multiple round format with an ascending clock not entirely driven by the auctioneer, whereby a bid is best described as a stepwise (ascending or descending) demand function on price range set revealed by the auctioneer at every round, for each product. My work consisted of suitably adapting the auction data to the usual data set format assumed by GARP or HARP tests. Using an efficiency approach, I assess each auction at two levels: an assessment of efficiency through utility maximisation via AEI, and an assessment of efficiency through homotheticity via HEI.

Auctioneers, in particular, and spectrum authorities, in general, are concerned with the economic aspects of their spectrum assignment processes. The most important issue that pertains the results of the auction is the answer to the question, was the spectrum assigned to those bidders who can make the best use of it?

Answering the question places us on the grounds of auction efficiency. Devising methods to use the auction bidding data to answer such question has been a long-standing question. GARP and HARP are two revealed preference approaches that do not require us to adopt a parametrized utility function to represent bidder's preferences. These methods use the observed data and define a rigorous consistency test on the data.

Keywords

US 5G spectrum auction, GARP, HARP, FCC, Efficiency Indices.

1. INTRODUCTION

This paper assesses the efficiency of bidding behaviour in the first 5G spectrum auctions held in the United States. In 2018 and 2019, the Federal Communications Commission (FCC) administered auctions 101 and 102 to assign spectrum in the 28 GHz and 24 GHz bands, respectively. Auction 101 sold spectrum on the 28 GHz band for Upper Microwave Flexible Use Service licenses and raised a total of about $700 million. Auction 102 assigned spectrum on the 24 GHz band for Upper Microwave Flexible Use Services. It raised a total of close to $2 billion US dollars. For over $4 billion, in July 2020, the FCC auctioned the 3.5 GHz band for Priority Access Licensees in Auction 105. It is expected that activity in the so-called CBRS ecosystem include utilisation of 5G technologies.

I implement an assessment of the efficiency for auctions 102 and 105 based on the observed bidding data during the Clock Rounds stage of the auctions, while relying on revealed preference theory. Data are available at the FCC's Auctions website[1]. Bidding data are organised by geographical area and, for each geographical area, data consist of demand point pairs – price, quantity - for each round, for each bidder. I rely on the application of the well-known Generalised Axiom of Revealed Preference or GARP, and the lesser-known Homothetic Axiom of Revealed Preference or HARP, to calculate two indexes, Afriat Efficiency Index (AEI) and Homothetic Efficiency Index (HEI) to calculate measurements of rational bidding associated with each bidder.

For the auctions studied here, the US relied on an auction format that allows the bidders to state the price at which they would demand a number of units of the same item (that is, blocks or licenses). In essence, the auction formats for the Clock Rounds stage of auction 102 and for auction 105 followed a simultaneous multiple round format with (multiple) ascending price clocks that, at each round, display a minimum price (posted price) and a maximum price (clock round price). Over such range a bidder 'reveals' a stepwise (ascending or descending) demand function. Unlike the direct interpretation of bidding data in a Combinatorial Clock auction, whereby the clock price is set by the auctioneer for every round, for every service area, and the bidder chooses a number of units to express their demand, in auctions 102 and 105, demand revelation being through a stepwise function, potentially adds more data points per round. This imposed some extra work to our data extraction job.

Spectrum authorities, in general, and auctioneers, in particular, are concerned with the economic aspects of their spectrum assignment processes. The most important issue that pertains the results of the auction is the answer to the question, was the spectrum assigned to those bidders who can make the best use of it? Answering the question places us on the grounds of auction efficiency. Devising methods to use the auction bidding data to answer such question has been a long-standing question. GARP and HARP are two revealed preference approaches that do not require us to adopt a parametrized utility function to represent bidder's preferences. These methods use the observed data and define rigorous consistency tests on the data. The results speak of the degree to which data are consistent, allowing us to reach conclusion about efficiency, and the form of the bidder's utility functions.

The paper unfolds as follows. In section 2 and 3, I discuss auction design aspects of Auction 102 and Auction 105, respectively. In Section 4, the paper deepens on the activity rules of both auctions. In Section 5, I present the theoretical support that allows for an understanding of the revealed preference axioms and the efficiency indexes used for data analysis. Section 5 is complemented by Appendix 1. In Section 6, the main results of the paper are presented. Section 7 concludes.

2. FCC'S AUCTION 102

Auction 102 was a spectrum auction to sell up to seven different spectrum licenses (also known as blocks) in each of 416 geographical regions, known as Partial Economic Areas (PEAs). In each PEA, licenses were divided into two categories: Lower, or L, and Upper, or U. The auction defined a **product** as a pairing of one PEA and one license category. For each PEA, a bidder was allowed to bid for up to 2 L licenses and up to 5 U licenses.

The auction consisted of two phases: the Clock phase and the Assignment phase. The clock phase proceeded in rounds. The assignment phase was a combinatorial auction that would allocate specific bands to the winner of generic bands in the clock phase.

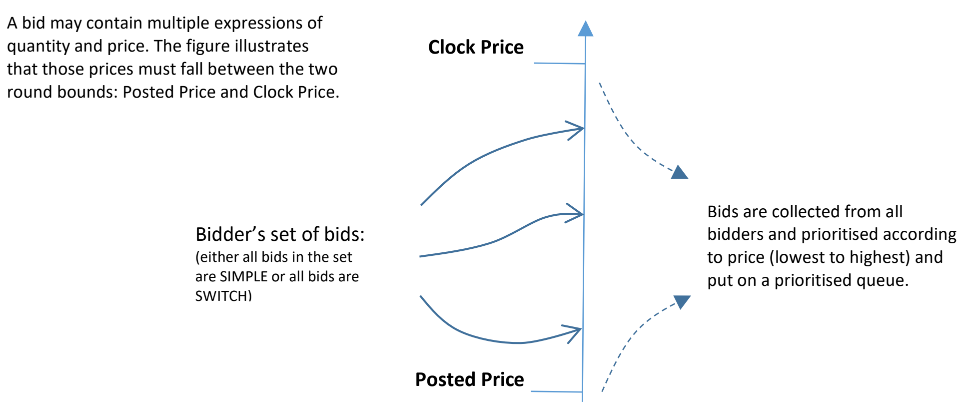
[1] https://auctiondata.fcc.gov/

The clock phase allowed a bidder to express its preferences in a somewhat rich "bidding language". **Intra-round** bidding is the concept that explains how this rich expression of preferences is done. For any round *k* (from round 2 on), two price points were defined: the Posted Price, PP_{k-1}, which was the formed price from the previous round, *k-1*, and the Clock Price, CP_k, which was the announced price for the current round *k*. At such round *k*, for a given product a bidder was able to submit a bid with bid prices in the [PP_{k-1}, CP_k] interval.

A bid could be either **simple** or **switch**. These two in-round mutually exclusive options enrich the bidder's preference expression (compared to that of the CCA). On one hand, a simple bid was a collection of pairs, each consisting of an amount and a price. A simple bid expresses the bidder's demand curve in the price interval [PP_{k-1}, CP_k] in a stepwise (either non-decreasing or non-increasing manner). On the other hand, a switch bid allowed a bidder to exchange a number of blocks won (in a previous round) from one category for the same number of blocks in the opposite category within then same PEA. Any bid could only be of one type, mutual exclusivity within a round, in a given PEA. Some restrictions were imposed on bids such as the fact that the same amount could not be bid at two different prices, and the same price could not be bid for two different amounts.

The figure below shows how simple and switch bids must conform to the price interval defined by Posted Price (of the previous round) and the Clock Price.

Figure 1. A clock round's price range



In summary, for each PEA a bid could be placed either as a collection of (quantity, price) pairs - which can be understood as the bidder partially revealing a stepwise description of their preferences for blocks in the PEA - or as a request to swap blocks that the bidder was temporarily winning from the previous round with blocks of the opposite category.

The demand process determined, at each round, who got which blocks of a given product (PEA plus category) and the price at which they (temporarily) got them. The process collected the bids (simple or switch) from bidders and, excluding the restricted bids, sorted the bids by price, awarding blocks to the highest prices. This is similar to multi-unit auctions whereby the highest price bid is first allocated the number of demanded units, and then if supply has not been exhausted the next highest price will be allocated its associated demand or partial demand if the remaining supply is exhausted, and so on. In other words, blocks were assigned to highest bids until supply got exhausted; these were deemed temporary winners, who were informed about it by the auctioneer. Other bidders, who won nothing, just got news about the aggregate demand on the round (the sum of all demanded blocks by all bidders).

In Auction 102, a bidders' bidding activity was heavily constrained by the so-called activity rule. Section 5 provides more details for the activity rule type used in this auction.

3. FCC'S AUCTION 105

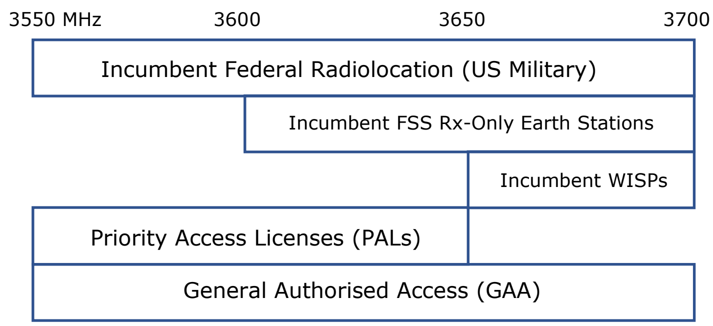
The Citizens Broadband Radio Service, CBRS, is a three-tiered spectrum sharing space spanning from 3550 MHz to 3700 MHz, also known as 3.5 GHz band. The tiers are occupied by incumbent users on the upper tier (mainly federal aeronautical services and non-federal fixed-satellite services and terrestrial wireless operations), new entities known as Priority Access Licensees (PALs) on the middle tier, and a non-licensed access mode called General Authorised Access (GAA) on the bottom tier.

This space allows for the shared use of the spectrum and the opportunistic use of the band by radio devices, requiring a coordination mechanism, known as the Spectrum Access System (SAS) that provides coordinated access and protection to higher-tier users from interference due to lower-tier users. Figure 2 shows the CBRS current band-sharing scheme. In the CBRS sharing framework, incumbents have the highest priority and their exclusive access is granted regardless of other types of users that may need to use the band; second tier users, or PAL, use the band via spectrum licensing; and, GAA's access via the SAS are granted over 100 MHz of spectrum on an opportunistic basis.

With Auction 105 the FCC allocated up to seven licenses to a wide range of large and small operators across about 3,330 US counties. It was a simultaneous ascending clock auction for each county, proceeding in rounds. A round was a fixed-time duration interval of time during which a bidder could submit its bids to the auctioneer's web-based system.

Figure 2. The CBRS sharing framework

Source: CBRS Alliance, 2018



A bid consisted of pairs (p, q) where p is a price, and q is a quantity. In fact, the bid is the expression of the bidder's demand function in a stepwise form. However, it is only a limited "view" of the demand because, on a round k, it only reveals it over the round price range, that is, a price range within two limits: the start-of-round price, either s_k, and the clock price, c_k.

Before round one of the auction started, a bidder had to declare the bidder's initial eligibility e_0. This was determined by the bidder prior to the auction and was an indication of the aggregate size of the bidder's preferred counties, as each county was weighed by a number of units. A bidder's eligibility was a bound on its activity during the auction. For a given round, the bidder's activity was the sum of units across the counties in the bid. A bidder was not be allowed to submit a bid if the bidder's activity exceeded the bidder's *eligibility* for the round.

At round 1, a bid was simply the number of blocks a bidder would demand at the minimum opening prices, for each county i. From round 2 on a bid could be one of three types: a bid to maintain demand, a bid to reduce demand, and a bid to increase demand. The latter two types had to be "one directional", meaning that once the bid or any of its elements was received within the round's time, the m pairs (p_j, q_j) in the bid had to comply with:

$$q_j > q_{j-1} \quad \text{or} \quad q_j < q_{j-1} \quad \text{for } j = 2, 3, \ldots, m.$$

Once the auction was under way, the auctioneer, for each round, had to validate the bids and collect all bids from all bidders. Bid processing happened then based on normalizing all bids. When the start-of-round price was s_k, and the clock price was c_k, and the bidder´s bid contained the pair (p, q), the price point pp corresponding to bid price p was defined as

$$pp = \frac{p - s}{c - s}$$

The price p component of a pair (p, q) in a bid, was then replaced by its price point so that the auctioneer sorted all pairs belonging to all bids, in increasing order according to their price points. Bid processing determined then that those bids that maintained demand were totally applied first; then bids to change demand (reduction or increase) were applied only to the maximum extent possible and following the prioritization for bids from lowest price point to highest, across all pairs from all bidders.

The process keeps a queue of bids that have not been entirely applied. After a bid is applied either partially or totally, the queue is re-tested to see if any non-fully applied bids can be continued to be applied. Re-testing continues until no longer a bid can be applied.

In Auction 105, a bidders' bidding activity was heavily constrained by the so-called activity rule. Section XX provides more details for the activity rule type used in this auction.

4. ACTIVITY RULES

An activity rule is "*a constraint on the bids that a bidder is permitted to submit in a given round of a dynamic auction, as a function of the bidder's prior bidding history*" (Ausubel & Baranov, 2020).

An activity rule constrains a bidder's bids to be in a feasible set for each round. At each round *t* a price vector p^t is announced with each bidder *i* responding with a demand vector q_i^t. The collection of these demand vectors over all rounds is the bidder's demand history. A function, named v( ), characterises the bidder's preferences.

If Ω is the set of all possible bundles of *M* heterogeneous goods, $D(p,v) \subseteq \Omega$, the demand correspondence, denotes the bundles in Ω that maximise the bidder's utility function at prices $p \in \mathbb{R}_+^M$, that is,

$$D(p,v) = \underset{z \in \Omega}{\operatorname{argmax}}\{v(z) - p \cdot z\}$$

A bidder bids straightforwardly (Ausubel & Baranov, 2020) according to its value function v( ), when the bidder's demand $q_i^t \in D(p^t, v)$, in all rounds *t*.

Activity rules are important to this discussion because they are the main mechanism the auctioneer uses to promote active bidding while discouraging bidding strategies that may be detrimental to the auction objectives.

The activity rules in the FCC auctions are point-monotonic. Essentially, one unit of each good in a service area k is allocated a number eligibility points, $g(k), \quad k = 1, \ldots, M$.

When a vector z of products or bundle is demanded, an activity level is calculated as the product of *z* and the vector of corresponding eligibility points, $A(z) = g \cdot z$

In (Ausubel & Baranov, 2020) it is argued that desired properties an activity rule should ideally comply with are:

1. The activity rule should allow bidders to switch only to bundles that have become relatively less expensive.
2. It should allow straightforward bidding.
3. The feasible set at round *t* must include at least one of the bundles demanded in previous rounds.

A point-monotonic activity rule is such that the feasible set of bids in round t consists of demand vectors (bundles) for which their eligibility is no greater than the activity of the bid (bundle demanded) in round *t* - 1. The feasible set of bids in round $t \geq 2$ is $X^t = \{z \in \Omega : E(z) \leq A(q^{t-1})\}$

It is easy to see that point-monotonic rules satisfy Axiom 3. However, in general. They cannot guarantee the validity of Axiom 1 or Axiom 2. In fact, point-monotonic rules may be inconsistent with these axioms.

A alternative rule can be built for quasilinear preferences. The GARP Activity Rule states that the feasible set of bids in round $t \geq 2$ is

$$X^t = \{z \in \Omega : (p^1, q^1), \ldots, (p^{t-1}, q^{t-1}), (p^t, q^z) \text{ satisfies quasilinear GARP }\} \quad \text{(see Section 2).}$$

As shown in (Ausubel & Baranov, 2020) the GARP activity rule satisfies Axioms 1, 2 and 3.

4.1. Calculating the bidder's activity in Auction 102

The self-declared number of total points the bidder decided to start the auction with is called bidder's eligibility, E_0. When a round was open for bidding, the *activity* of a bidder was calculated as the sum of bidding units associated with the demand the bidder indicates it was willing to accept at the clock price across all regions the bidder submitted bids on. In other words, the activity of bidder i is given by the following sum:

$$\sum_{r \in N} q_{i,r} \cdot b_r$$

where $q_{i,r}$ denotes the requested demand of bidder i for bocks in region r at the clock price and b_r denotes the number of bidding units associated with region r.

Next, E_0 constrained the bidder's next bid measured by its activity to a combination of regions and number of licenses per region which could not exceed E_0. At a later round k the constraining value either remained at its initial level, E_0, or was decreased to the sum of points on the licenses that the bidder bid for at k-1.

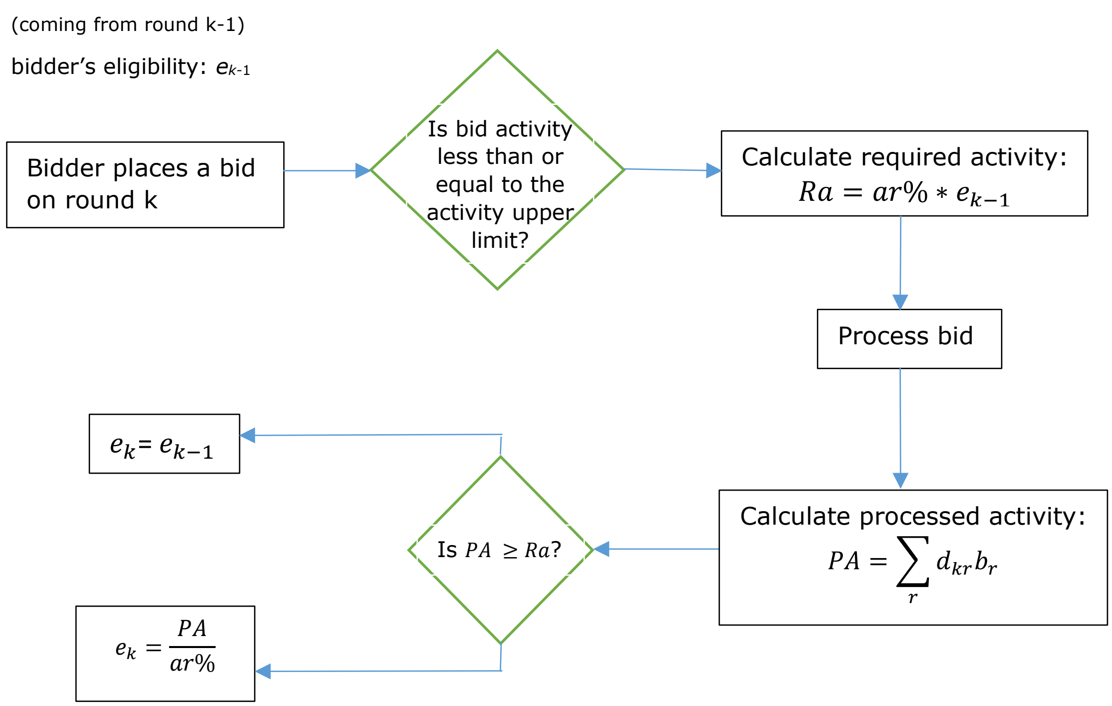
A bidder's *processed activity* was equal to the total number of bidding units associated with the bidder's processed demand after the bid processing of the round. A bidder's eligibility in subsequent rounds was calculated based on its eligibility in the previous round, its processed activity, and an activity requirement.

4.2. Calculating the bidder's activity in Auction 105

At all times the amount a bidder was bidding on, known as the bidder's activity, was constrained by the bidder's eligibility. I refer to the process by which the auctioneer determines the bidder's eligibility in round k, ek, as the Activity Calculator. Figure 3 displays the calculator to show how the auction determined whether a bidder's bid satisfied the eligibility constraint and how its eligibility was updated after his demand was processed. Every time a bidder with eligibility e_{k-1} placed a bid in round k the calculator updated all activity-related variables for round k.

Figure 3. The Activity Calculator

Source: FCC 2019



A bidder's **eligibility** for round 1 corresponded to the initial payment the bidder made to the auctioneer. Such payment was for a number of total bidding units that indicated the size (in terms of the aggregate population) of the total geographical coverage the bidder sought to bid on his first bid. Later, in any round $k > 1$, bidder's eligibility was determined after the demand was processed.

Before processing the demand, the system had to calculate the bidder's activity. At any round k, if q_{kr} denoted the number of blocks demanded on county r at the clock price of round k, and b_r denoted the number of bidding units associated with county r, the bidder's **activity** was

$$A = \sum_r q_{kr} b_r$$

At round k, after demand was processed, and for each county r, the bidder's processed demand d_{kr} and county r bidding units b_r determined the **processed activity**, or,

$$PA = \sum_r d_{kr} b_r$$

It is also at this point in time that the bidder's minimum activity required to maintain his eligibility was determined. Known as the **required activity**, or Ra, it was calculated as,

$$Ra = ar\% * e_{k-1}$$

where $ar\%$ was the activity requirement percentage. At most 100%, $ar\%$ was at auctioneer's discretion and the same for all bidders during a given round, but may have changed from round to round.

In summary, determining the bidder's eligibility for the next round worked as follows: if $PA \geq Ra$ then the bidder maintained his eligibility and $e_k = e_{k-1}$; otherwise, $e_k = \frac{PA}{ar\%}$.

At any new round a county's clock price is the previous round posted price times a county-specific percentage increment. The auction defined a basic increment, to be use as the basis to raise the prices, known as the basic increment percentage.

Understanding the specifics of these auctions' activity rules is important to the present analysis because point-based activity rules alone constrain the flexibility of bidders to refocus their bidding efforts when prices become too high on their currently desired items. In such case, auction rules should provide the means for bidders to switch to bidding on other products, as long as they bid rationally. Lack of such flexibility may lead to inefficient auction outcomes.

5. GARP AND HARP

The bidding history of a bidder in either Auction 102 or Auction105 can be used to calculate a measurement of bidding consistency for the clock-rounds stage of each auction. For a given bidder, we denote such data as a set of price vectors $\{ p_i \}$ and chosen bundles $\{ q_i \}$ that form the set of observed points (p_i, q_i) for $i = 1, \ldots, N$.

In his work on revealed preference, Varian (2006) defines GARP for a set S of observed data $\{(p_i, q_i)$ for $i = 1, \ldots, N \}$ and discusses four basic questions about necessary and sufficient conditions for observed demand data to be consistent with utility maximization. The four questions refer to consistency, form, recoverability and forecasting on aspects of the utility function and the demand. This paper is concerned with consistency and form. In particular, the consistency issue is dealt with by attempting to answer the question: "when is the observed behaviour consistent with utility maximization?", whereas form is about the question "when is the observed behaviour consistent with maximizing a utility function of a particular form?".

A condition for utility maximization revealed by the set of observed data is that the sought utility function $u(q)$ rationalizes the set of observations, that is, $u(q)$ is such that $u(q^t) \geq u(q)$ for all q such that $p^t q^t \geq p^t q$.

Work on the first question led to Afriat's theorem (Varian 2006), which states – using a reduced version of the theorem – that the following two conditions are equivalent:

1. The data set $\{ (p_i, q_i)$ for $t = 1, \ldots, T \}$ satisfies GARP
2. There exists a non-satiated, continuous, monotone, and concave utility function $u(q)$ that rationalizes the data.

In other words, GARP can be used as an empirical test on the observed data to establish whether bidding behaviour is indeed consistent with utility maximization. Such results can help establish whether efficient bidding occurred at an auction such as Auction 105. They can also be helpful in understanding bidding efficiency in the Clock Rounds stage of Auction 102. Prices obtained during a clock rounds stage of a two-stage auction are the most influential price signals used next on the, usually, single-round Assignment stage.

The information revealed by any round of the clock rounds is a set of packages (demanded quantities for each area where the bidder is eligible to bid) for each bidder and a set of prices corresponding to the prices of each area. For any bidder we consider the set S of pairs $\{(p_i, q_i)$, i = 1, …, N$\}$, where q_i is the vector (package) of the quantities (blocks) demanded at each area at round i and p_i is the vector of prices for each area at round i.

5.1. GARP

In simple terms, GARP establishes a "consistency condition" on the preferences revealed by a bidder through her demanded packages. In particular, for two rounds i and j, if we can find evidence that the bidder prefers package p_i to package p_j, then it cannot be the case that bidder prefers p_j to p_i.

Now, it is important to notice that the technical definition of preference in one direction ("… bidder prefers package p_i to package p_j, …") is not exactly the same as that in the other direction ("… that bidder prefers p_j to p_i."). The precise definitions formalizing these ideas follow.

Formally, for two rounds i and j, if $p_i \cdot q_i \geq p_i \cdot q_j$ then it is said that q_i is *directly revealed preferred* to q_j and is denoted as $q_i \, R_0 \, q_j$.

When the inequality is strict, that is $p_i \cdot q_i > p_i \cdot q_j$, then it is said that q_i is *strictly directly revealed preferred* to q_j and is denoted as $q_i \, P_0 \, q_j$.

Also, for any two rounds i and j, if there's a sequence of round indexes $u_1, u_2, \ldots, u_m$, such that $p_i \cdot q_i \geq p_i \cdot q_{u1}$, $p_{u1} \cdot q_{u1} \geq p_{u1} \cdot q_{u2}$, . . . , $p_{um} \cdot q_{um} \geq p_{um} \cdot q_j$, or, equivalently,

$$q_i \, R_0 \, q_{u1} R_0 \, q_{u2} \ldots \; q_{um} \, R_0 \, q_j$$

we denoted as $q_i R q_j$.[2]

The data set S satisfies the Generalised Axiom of Revealed Preference (GARP) if for each pair of bundles q_i, q_j the following holds:

$$\text{If } q_i \, R \, q_j \text{ then it is not the case that } q_j \, P_0 \, q_i \qquad [1]$$

GARP states that having preferred package q_i to package q_j at prices p_i, a rational bidder would not prefer q_j to q_i at prices p_j.

The key to using GARP as a condition for rationality lies on the following result under the Afriat theorem, namely, a finite set of data is consistent with utility maximization if and only if it satisfies GARP.

It is necessary to check that GARP is satisfied for all pairs of observed data pairs (p_i , q_i) and (p_j , q_j) for which $q_i R q_j$. If we find that the bidder's data set S satisfies GARP then the bidder's bidding behaviour is consistent with utility maximization. When this is true for all bidders, we can conclude the auction was efficient. In general, we can employ a method to test GARP that directly tests conditions [1] for every pair of rounds i and j. It starts with finding whether $q_i R q_j$ and then proceeding to check (on the data set S) whether $p_j \cdot q_i \geq p_j \cdot q_j$. If it is not, then the data set does not pass GARP.

An equivalent definition of GARP, when a bidder's preferences are quasilinear is provided in (Ausubel and Baranov, 2020). Therein the definition states that an observed data set S satisfies GARP if for any choice of distinct indices $t_1, \ldots, t_s$ in $\{1, \ldots, T\}$ it is true that

$$p^{t_1} \cdot [x^{t_1} - x^{t_s}] + p^{t_2} \cdot [x^{t_2} - x^{t_1}] + \cdots + p^{t_s} \cdot [p^{t_s} - p^{t_{s-1}}] \leq 0.$$

This definition of GARP is instrumental in the characterization of activity rules that satisfy some desirable properties, as seen in section 4.

5.2. "How far" from GARP is a data set?

Since GARP is unambiguous, it only provides a "pass/not pass" answer. In order to learn "how far" a data set S is from passing a GARP test we can calculate the Afriat Efficiency Index, AEI. The index calculates the maximum number e in the interval [0 , 1] for which all data points (p_i, q_i) satisfy a suitable modification of the GARP condition, known as GARP(e), as further explained below. Such modification allows us to express the efficiency in the [0, 1] range, which in turn allows us to go beyond the mere "pass/not pass" result provided by GARP.

For an observation point, such that $q_i \, R \, q_j$, if GARP condition is not satisfied then the theorem invalidates the whole set S. A refinement of GARP to account for "how much" the condition is violated, or, in other words, in the context of the present work, how far from "consistent bidding" a bidder may be, follows.

[2] The set of all q_k ,q_h such that $q_k R q_h$ is the **transitive closure** of R_0

In order to achieve that, first of all, let's work with normalized prices. All products $p_i \cdot q_i$ are normalised to 1, that is, $p_i \cdot q_i = 1$ for all i.

Let $0 \leq e \leq 1$. For every pair (p_i, q_i) of observed quantities and prices consider those q_j, ($j \neq i$) such that

$$e * (p_i \cdot q_i) = e * 1 \geq p_i \cdot q_j \quad [2]$$

Such inequality defines a relation $R_o(e)$ in Q x Q, (where Q is the set of all bundles) such that (q_i, q_j) Є $R_o(e)$ if and only if [2] holds. We can then focus on, $R(e)$, the transitive closure of $R_o(e)$.

A modification of GARP is now necessary. It is said that S satisfies GARP(e) if for each pair of bundles (q_i, q_j), $j \neq i$, the following holds:

If $q_i R(e) q_j$ then it is **not** the case that $q_i P_o(e) q_j$

where $q_i P_o(e) q_j$ is the expression: $e > p_j \cdot q_i$ (because we normalised the products $p_i \cdot q_i$)

Assuming that we have produced the transitive closure of the observed data set S on a matrix A, following is an algorithm by Cherchye et al (2012), that searches for the maximum e in [0,1])= that makes all data pairs conformant with GARP(e). The resulting e* is the AEI. Appendix 1 shows the algorithm for calculating the AEI.

5.3. HARP

GARP provides an accurate test for looking into the rational consistency of the data set *S*. As explained, following Afriat's theorem, if the data set passes GARP then the bidder's bidding behavior is consistent with utility maximization.

A more potent test with higher discriminatory power is based on the Homothetic Axiom of Revealed Preference (HARP). Intuitively, HARP establishes stringent conditions on the consumer (bidder) rationality, which is ultimately a statement about her utility function.

In the context of household consumption, Heufer and Hjertstrand (2019) find that as the efficiency of the test approaches 1, the theory of utility maximization, that is, using a GARP test, "performs about as well as a theory that explains consumer demand as purely random behavior". In contrast, homothetic utility maximization provides a better explanation of the observed data.

Definition: A data set S satisfies the Homothetic Axiom of Revealed Preference (HARP) if for all distinct choices of indices $i, j, k, \ldots, l$, it holds that:

$$(p_i \cdot q_j)(p_j \cdot q_k) \cdots (p_l \cdot p_i) \geq 1$$

A theorem by Varian (Varian 1983) states a necessary and sufficient condition for a bidder's preferences to be represented by a homothetic utility function in the theorem that follows.

Theorem (Varian 1983): A finite set of data *S* satisfies HARP if and if and only if there exists a homothetic function[3] that rationalizes the set of observations.

We use a test for HARP [4], which just like GARP, is an unambiguous test: either the set *S* satisfies HARP or it does not. If HARP is not satisfied and the whole set *S* is invalidated.

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[3] A utility function $u(.)$ is homothetic if it is a monotonic transformation of a linearly homogeneous utility function. The latter means that if $u(q_i) > u(q_j)$ then $u(\square q_i) > u(\square q_j)$ for all $\square > 0$.

[4] A test for HARP on a data set S can be determined using an observation by Varian that provides an efficient method to test the set *S* for consistency with HARP. Noting that the HARP condition

$$(\bar{p_i} \cdot q_j)(\bar{p_j} \cdot q_k) \cdots (\bar{p_l} \cdot q_i) \geq 1$$

for all distinct choices of indices $i, j, k, \ldots, l$, is equivalent to,

$$\log(\bar{p_i} \cdot q_j) + \log(\bar{p_j} \cdot q_k) + \cdots + \log(\bar{p_l} \cdot q_i) \geq 0 \qquad [*]$$

with $\bar{p_i} = \frac{p_i}{p_i q_i}$ for all i, if $\log(\bar{p_i} \cdot q_j)$ represents the length of an arc (i, j) in a directed graph G' then inequality [*] is true if and only if G' has no negative arc-length cycles.

For that reason, we can modify HARP so that it can be used as a measure of efficiency. In fact, the modification can be understood as a measure of a consumer's waste in her consumption expenditure. Such waste is measured by $e \in (0,1]$, as follows:

It is said that a set *S* of observations satisfies HARP(e) if for all choices of indices $i, j, k, \ldots, l$, it is true that

$$\left(\frac{\bar{p}_i \cdot q_j}{e}\right)\left(\frac{\bar{p}_j \cdot q_k}{e}\right) \cdots \left(\frac{\bar{p}_l \cdot q_i}{e}\right) \geq 1$$

The expression is useful to define an index that measures efficiency in terms of HARP. More specifically:

Definition (Heufer & Hjerstrand, 2014): For a set *S* of observations, the Homothetic Efficiency Index (HEI) is the greatest $e \in (0,1]$ such that *S* satisfies HARP(e).

We use an algorithm proposed originally for GARP (similar to the algorithm presented in Appendix 1) that calculates HEI for any data set S. (Beltran, 2018).

6. GARP AND HARP TEST RESULTS

In simple terms, GARP establishes a "consistency condition" on the preferences revealed by a bidder through its demanded packages or combinations *q* of demanded blocks over the regions, $\{1, 2, \ldots, R\}$. In particular, for two rounds *i* and *j*, if we can find evidence that the bidder prefers combination q_i (with $q_i = [q_{i1}, q_{i2}, \ldots, q_{iR}]$) to combination q_j, then it cannot be the case that bidder prefers q_j to q_i.

When all bidders' clock round bidding data sets pass the GARP test, we cannot determine any meaningful differences in the rationality that may allow us to make any further inferences about the bidders' bidding behaviours. All we can state is that the observed data is consistent with utility maximization, which indeed is a very strong result as it states the auction is efficient.

Another, more potent revealed preference condition is HARP. With a higher discriminatory power HARP establishes stringent conditions on the consumer (bidder) rationality, hence, on her utility function.[5] A test for HARP measures the degree of consistency that a bidder's bidding data set has with a homothetic utility function.

We use the GARP to produce the values of the Afriat Efficiency Index (AEI) for each bidder. We also HARP, and associated index, the Homothetic Efficiency Index, HEI. While GARP and associated AEI are used to determine efficient bidding behaviour, HARP and associated HEI are used to further reveal measures of economic efficiency resulting from the bidders' bidding plans.

Using GARP and HARP for a selection of bidders in Auction 102 and Auction 105, this section discusses the extent to which their bidding behaviour were consistent in the sense explained in (Varian, 2006). Such measure of consistency leads to assert the degree to which a bidder's biding behaviour is consistent with utility maximization. Both conditions are unambiguous measures of rational bidding: they only provide a "pass/not pass" answer. For that reason, the insight extends into calculating AEI and HEI, indexes that quantify the degree of violation of the rationality conditions defined by GARP and HARP.

For each bidder's clock rounds bidding data set, GARP is checked for every pair of packages (q_j , q_i) for which it is found that one is preferred to the other in the GARP sense. The number of check-ups is of order n^2 in the worst case, where *n* is the number of rounds. We run the GARP test and then use it to calculate the respective AEI. Table 1 shows the results of testing the GARP condition and the AEI for a selected group of bidders in Auction 102. The selection was based on the size and scope of each bidder. For such reason many bidders were not considered for the calculations of the indexes. Their bidding behaviour was straightforward and bids were placed on one or very few PEAs.

Table 1: Efficiency Indexes, AEI and HEI, in US Auction 102

Bidder	AEI	HEI
AT&T	0.99	0.92

[5] In the context of household consumption, Heufer and Hjertstrand (2019) find that as the efficiency of the test approaches 1, the theory of utility maximization, that is, using a GARP test, "performs about as well as a theory that explains consumer demand as purely random behavior". In contrast, homothetic utility maximization provides a better explanation of the observed data.

TMobile	0.99	0.98
US Cellular	0.72	0.31
Cellco(*)	0.99	0.98
Crestone	0.99	0.73
LCIT	0.99	0.41
Starry	0.99	0.88
Windstream	0.98	0.95

The relatively high values of the AEI obtained for bidders in the clock rounds, led us to perform a HARP test and respective efficiency index HEI. HEI measures the extent to which a bidder's bidding data complies with HARP. The efficiency measured, in the [0, 1] interval, explains the consistency of the bidding data with utility maximization, assuming the utility function is homothetic.

Table 1's data suggests that bidders can be divided into two groups: bidders highly conformant with homothetic utility maximization (HEI larger than 0.9) and bidders with lower HARP efficiency (HEI less than 0.75). While it is tempting to associate this observation with particular behaviors (for instance, asserting that a value of the HEI may indicate propensity to behave in a certain strategic way), for now, however, we note that HEI reveals a qualitative measure of behavior due to the fact that the bidders' utility functions are different in the HARP sense.

Table 2: Efficiency Indexes, AEI and HEI, in US Auction 105

Bidder	**AEI**	**HEI**
Actel	1	0.98
Alabama	0.99	0.97
CableOne	0.22	0.62
Chevron	1	0.96
Cincinnati	1	0.95
Cox	0.96	0.46
KBW	0.99	0.82
LICT	1	0.96
SAL	1	0.99
Shenandoah	0.97	0.96

Table 2 displays the indexes for a selected handful of bidders participating in Auction 105. With one notable exception, bidders' AEIs are quite high, indicating that violations of GARP were basically harmless. HEI exhibits two cases in which efficiency in the HEI sense is not particularly high.

Although more evidence is needed, the results seem to suggest bidders in Auction 105 were more conformant to rational bidding in the GARP sense than bidders in Auction 102. The reported results come from bidding occurring during the respective clock phases. With Auction 102 clock phase being less restrictive of bidding behaviour, it is possible bidders in Auction 105 were forced to stay closer to straightforward bidding most of the time.

All these auctions implemented a point-based activity rule that would constrain a bidder to keep its bids below the current eligibility level at each round, allowing the violation of the rule if a revealed preference test was passed. While the 700 MHz and 2500 MHz used a revealed preference based on the weak axiom of revealed preference, the

600 MHz auction implemented a full GARP-based violation exception. These conditions meant to provide bidders with a rational way to explore combinations of blocks (demand points) that may have become attractive later during the course of the auction, conformant with the GARP condition but "large" in the sense of the number of points (activity).

7. CONCLUSIONS

This paper investigated how efficient the first 5G spectrum auctions held in the United States were. Auctions studied here are Auction 102 and Auction 105. In 2019, Auction 102 assigned spectrum on the 24 GHz band for Upper Microwave Flexible Use Services. It raised a total of close to $2 billion. In July 2020, the FCC auctioned 70 MHz in the 3550 MHz to 3650 band for Priority Access Licensees in the CBRS band, raising over $4 billion.

Testing auction efficiency used Afriat Efficiency Index (AEI) following the application of the Generalised Axiom of Revealed Preference or GARP. Completing this approach, results were also obtained for the Homothetic Efficiency Index (HEI) Homothetic Axiom of Revealed Preference or HARP. While AEI provided results to assess auction efficiency, HEI provided results to establish how conformant to the homothetic property the each bidder´s utility function is.

The tests were only concerned with the Clock Rounds, which is the longer auction stage in each case. In fact in one of the auction the Clock Rounds is the only stage in the auction.

Measured on the [0,1] interval relatively high values (close to 1) of the AEI were obtained for bidders in both auctions. HARP test and respective efficiency index HEI, measuring the extent to which a bidder's bidding data complies with HARP, explained bidding was consistent with utility maximization, and a homothetic utility function.

Bidders in Auction 105 were more conformant to rational bidding in the GARP sense than bidders in Auction 102. This may have corresponded to the auction rules allowing more freedom of action in Auction 102 than in Auction 105.

In Auction 102 two groups of bidders were identified: those highly conformant with homothetic utility maximization and bidders with low HARP efficiency. The results suggest that, even though each selected bidder's bidding was efficient, some bidders' utility function was not a homothetic function, their preferences being distinctively particular and perhaps tending to behave in a certain strategic way.

In Auction 105 the selected handful of bidders turned out to bid efficiently for the most part, with oe exception. The auction's calculated HEIs show two bidders whose utility functions were notably different from the rest of bidders in the homothetic sense.

With spectrum authorities having mandates that spectrum allocation methods have to be efficient, testing the auction data for tests such as those used in this paper affords evidence to improve auction design. The methods are rigorous and do not assume any parametric values. The indexes allow to state clear conclusions about bidder's bidding behaviour and functional form of their preferences.

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Appendix 1: Algorithm for calculating the AEI (Cherchye et al, 2014).

Algorithm to find the maximum value *e** for which the observations in *S* satisfy GARP(*e**)
Entries: *S,* set of observations, (P_i, q_i); *i* =1,. . ., N, where q_i is the bundle demanded at round *i* at prices P_i, and N is the last round.
Output: *e**, maximum value of *e* in [0, 1] for which all observations satisfy GARP(*e*)

For each round *i* (= 1, …, N) normalize prices P_i as follows:

$$\text{Let } p_i^1 = \frac{P_i^1}{p_i q_i} \text{ where } P_i = \left[P_i^1, P_i^2, \cdots, P_i^n\right]$$

Construct an array A of all values $p_i \cdot q_j \leq 1$ for $i \neq j$
Sort these values in ascending order
While A has more than one element

    Let *x* be the median value in A.
    Test GARP(*x*).
    If GARP(*x*) is satisfied then
        Remove all values lower than or equal to *x* from A
    Else
        Remove all higher values
End While

Let *e** = *x*.

Data Protection Authority Influence on the Rights of Data Subjects and other Data Protection Legal Institutions in Latin America

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ABSTRACT

Personal data protection has experienced an outburst of attention since the European Union announced the discussion outlined more than twenty years ago. The data protection literature has been since focusing on the GDPR itself, its implementation and effects from several angles by listing and analyzing the main aspects of the GDPR and how to comply with the data protection obligations found in it, or the influence of the GDPR in a wider context, such as its effects on rights, security, digital economy, governance, and compliance by companies, which outgrows the comparative research endeavors on the topic. This paper focuses on that gap by scanning Latin American countries' regulation on personal data protection through the lenses of the TLICS Model. This paper compares the framework of all South American countries according to 6 institutional forms, divided in 28 legal institutions and 51 legal institution subtypes both through the lenses of a qualitative and quantitative approach. Based on the neo institutional theory of law and statistical analyses, this study found that the two sets of countries usually mentioned in the literature to compare legal personal data protection – with or without a specific data protection legal framework – are insufficient to do the job of real categorization of Latin American countries according to the level of personal data protection. The TLICS Model variables explain the similarities and differences in a much more granulated way. In addition to the qualitative analysis, the quantitative analysis, for the first time in the literature, proves a connection – not only implied – between the existence of data protection authorities and the protection of several specific data subject rights and data protection institutions.

Keywords

Data protection comparison. Data protection indicators. Data protection authority. Latin America. TLICS Model.

INTRODUCTION

Personal data protection has experienced an outburst of attention since the European Union announced the discussion outlined more than twenty years ago through the Directive 95/46/EC, officially presented as a directive on the protection of individuals with regard to the processing of personal data and on the free movement of such data. This Directive built the grounds for the approval of the General Data Protection Regulation (GDPR), Regulation (EU) 2016/679, in force since May 25th, 2018.

The data protection literature in Europe has been since focusing on the GDPR itself, its implementation and effects from several angles. One of them (Voigt & Bussche, 2017; Calder, 2019; Giménez & Domenech, 2018; Hoofnagle, Sloot, & Borgesius, 2019; Mraznica, 2017; Rochfeld, 2018; Martial-Braz, 2018) focuses on listing and analyzing the main aspects of the GDPR and how to comply with the data protection obligations found in it, such as the scope of application (*e.g.*, definitions of processing, personal data, controller, processor, beneficiaries of protection, personal data jurisdiction), organizational requirements (*e.g.*, accountability, records, data protection impact assessment, privacy models, data processors obligations, data breaches notification procedures), material requirements (*e.g.*, data protection principles, legal justifications for data processing, legal permission for processing personal data, protection of individuals' vital interests, data transfers between countries), rights of data subjects (*e.g.*, right to access, erasure, rectification, restriction, data portability, object and restrictions of the data subjects rights), procedures (*e.g.*, cooperation and consistency mechanisms, interaction between data processing entities, data subjects and supervisory authorities), and enforcement (*e.g.* investigative powers of the supervisory authorities, right to claim compensation, liable parties, administrative fines against alleged infringement of the data protection regulation, corrective powers of the supervisory authorities).

Another approach focuses on the influence of the GDPR in a wider context, such as its effects on rights, security, digital economy, governance, and compliance by companies (Burri & Schär, 2016; Chirica, 2017; Dumas, 2019; Lynskey, 2015; Clément-Fontaine, 2018).

The proliferation of papers on data protection regulation and its implications outgrow the comparative research endeavors on privacy, which suffers from a gap in social science analyses (Schünemann & Baumann, 2017, p. 2). The branch of literature concerning comparative enquiry of national and subnational data protection frameworks is scarce (Polido & Anjos, 2018; Resta, 2016; Pardau, 2018; Peasley, 2018; Grafenstein, 2018) and those with a quali-quantitative approach are even scarcer (Nieuwesteeg, 2016). Add to that the demand for a quali-quantitative research that reveals a solid methodological choice on what to be considered as data key characteristics, and the researcher will be left alone in the dark.

This paper focuses on that gap by scanning Latin American countries' regulation on personal data protection through the lenses of the Telecommunications Law Indicators for Comparative Studies (TLICS Model), first applied to the data protection field in Mendes *et al.* (2019). By adopting a model that makes use of building blocks of complex juridical attributes that can be studied both separately and as a set of interconnected guarantees, we relied on the variables devised by Mendes *et al.* (2019, pp. 147-159) to depict a more comprehensive picture of 24 Latin American countries' personal data frameworks.

We compared the framework of each country according to 6 institutional forms (legal person, legal quality, legal object, legal status, personal legal relations, and objective legal relations) divided in 28 legal institutions (data protection authority, data protection board, data subject, processor, controller, research body, data protection officer, personal data, sensitive personal data, territorial scope, material scope, database, impact assessment, legal grounds for personal data processing, legal grounds for sensitive data processing, anonymized, blocked or deleted data, cross-border processing, shared use of data, liability and loss compensation, administrative sanctions, data processing, sensitive data processing, processing of children and adolescents' data, processing of data by public authorities, anonymization, data controller obligations, governance and accountability mechanisms) and 51 legal institution subtypes shown in Table 1 below.

Institutional Form	Legal Institution
Legal Person **- valid presentation of an entity that is capable of acting**	Data Protection Authority (Autonomous/Independent, Federal/Unitary presentation) Data Protection Board
Legal Quality **- valid presentation of a characteristic of a person**	Data Subject (right to rectification, right to be forgotten, right to restrict processing, right to data portability, and so forth) Processor Controller Research Body Data Protection Officer
Legal Object **- valid presentation of an entity that can serve as an object of the performance of certain acts**	Personal Data Sensitive Personal Data Territorial Scope Material Scope Database Impact Assessment

Legal Status **- valid presentation of a property of an object**	Legal Grounds for Personal Data Processing (consent, performance of a contract, legal obligation, protection of the vital interests of the data subject, public interest, legitimate interest research purpose, regular exercise of rights in judicial process, health protection, credit protection, public access, anonymization, civil register) Legal Grounds for Sensitive Data Processing (explicit consent, legal obligation, public interest, studies, regular exercise of rights in judicial process, protecting data subject, protect health, and so forth) Anonymized, blocked and deleted data
Personal Legal Relations **- valid presentation of a set of expectations of persons about reciprocal behavior**	International Data Transfer or Cross-border Processing (adequacy decision, consent, binding corporate rules, certificates and codes of conduct)
Objective Legal Relation **- valid presentation of a relation between a person and an object**	Data Processing Sensitive Data Processing Processing of Children and Adolescents' Data Processing of Data by Public Authorities Anonymization Data Controller Obligations Governance and Accountability Mechanisms

TABLE 1 – Personal Data Protection Institutional Forms and Legal Institutions (Amended from Mendes *et al*., 2019, pp. 147-159)

QUALITATIVE ANALYSIS

We analyzed all Latin American independent countries with an autonomous legal framework: Argentina, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Sint Maarten, Uruguay, and Venezuela. Several qualitative results caught our attention, as follows. The usual division between countries that have approved a specific regulation on personal data protection and those that lack a specific legal framework on that matter will be used below to show that an analysis based on institutional variables of personal data protection can bring to light a myriad of different data protection features. The mere reference to the existence of personal data protection regulation is not enough to draw a reliable image of the legal environment on personal data protection. The institutional forms devised in Mendes *et al.* (2019) summarized in Table 1 not only can show differences between countries with an updated personal data protection legal framework, but also atomize the all-encompassing concept of personal data protection into variables that make it possible for a quantitative analysis to show how important each legal institution really is for the design of a sound personal data protection framework.

Countries with a specific regulation on personal data protection

A number of countries in Latin America have already taken a closer look and issued specific acts to deal with the growing concerns on personal data protection.

Personal data protection legal framework in Brazil

The Brazilian General Data Protection Law (Portuguese acronym LGPD) was enacted on August 14th, 2018, after an intense public debate on transferring of personal data. The new law (Law No. 13,709/2018) changed the legal underpinnings guiding data protection. The Brazilian law covers 10 (ten) authorizing hypotheses (legal grounds) for the treatment of personal data in comparison to 6 (six) provided for in the European GDPR in article 6 (consent, performance of a contract, compliance with a legal obligation, protection of the vital interests of the data subject or of another natural person, performance of a task carried out in the public interest, legitimate interests). The four additional legal bases are provided in article 7: (i) The LGPD is responsible for carrying out studies by a research body (article 7, IV); (ii) The regular exercise of rights in judicial process (article 7, VI); (iii) health protection (article 7, VIII); and (iv) protection of credit (article 7, X). The Brazilian Law provides all principles established in the European Regulation and stipulates three additional principles: security, prevention and non-discrimination. Mendes *et al.* (2019) shows a detailed comparison between the Brazilian LGPD and the European GDPR.

Personal data protection legal framework in Peru

The Peruvian Personal Data Protection Law No. 29,733 was enacted in July 2011 and amended by the Legislative Decree No. 1,353 in January 2017. Together with its regulation (Supreme Decree No. 003-2013-JUS-Regulation), it is the primary data protection provision in the country and applies to any processing of data by an establishment or a database holder. These norms are supervised and controlled by the Peruvian National Authority for Personal Data Protection, which is linked to the Ministry of Justice. Compared with the European Union, Peru provides for almost the same legal bases for personal data processing only with reduced hypotheses, but fewer rights to data subjects. Regarding cross-border processing, Peru has restrictions on data transfer to other jurisdictions which, according to Peru, do not provide similar levels of protection as the ones established in its own legislation.

Personal data protection legal framework in Colombia

In Colombia, the Law No. 1,581 was enacted on October, 17th, 2012 and is regulated by the Decree No. 1,377 of 2013. The Colombian law is a hallmark in Latin America, taking into account that it has been effective since 2012. One of the most interesting aspects of the Colombian legislation is that even though it does not explicitly include the principle of accountability, introduced later by the decree as “displayed responsibility”, the country persistently applies this principle, even establishing a guideline for its implementation, which should be overseen by national authorities. Additionally, the Colombian law is fairly similar to the European GDPR, covering almost all the legal basis for personal data processing.

Personal data protection legal framework in Sint Maarten

The protection of personal data in Sint Maarten is provided for in the Personal Data Protection Ordinance, published in December 2010, in compliance with the country's Constitution. Sint Maarten is to instate an independent Data Protection Supervisory Committee. Legal grounds for personal data processing and rights to data subjects are rare in Sint Maarten’s legal framework. In addition, data controllers only have security-related obligations and there are no provisions on anonymization procedures. With regards to cross-border processing, Sint Maarten has restrictions on data transfer to other jurisdictions that the country considers not to provide for an adequate level of protection.

Personal data protection legal framework in Costa Rica

In Costa Rica, the Law No. 8,968, approved on July 7, 2011, regulates data protection nationwide, covering the public and private sectors. In its thirty-four articles, this law presents objectives, the scope of application, definitions of elements and institutes related to data protection, and the creation of a data protection authority. An aspect worth highlighting is the presence of a chapter that aims at explaining basic principles and rights: informative self-determination; the requirement for informed consent; the quality of information, which covers topicality, veracity, and adequacy. Nevertheless, Costa Rica's legal framework lacks from an article defining legal grounds.

Personal data protection legal framework in Mexico

The same absence can be found in the Mexican law that regulates data processing carried out by private agents. The Federal Law for the Protection of Data in Possession of Individuals - approved on April 27, 2010, and in force since July 5, 2010 - also establishes the scope of application, definitions of elements and institutes related to data protection, prediction of rights and principles, and recognizes the Federal Institute for Access to Information and Data Protection as the independent authority that is responsible for law enforcement. Mexican efforts towards a detailed explanation of the responsibilities of this authority, including a description of data protection, supervision, and sanction application procedures are worth mentioning. Moreover, the Regulation of the Federal Law for the Protection of Data in Possession of Individuals includes several aspects necessary for its implementation, such as a detailed procedure for the implementation of the rights on personal data and a clear set of competences to be executed by the data protection authority. It also describes some elements, such as the territorial scope of application and the characteristics of consent. Furthermore, the Federal Law on Transparency and Access to Government Public Information regulates personal data handled by public authorities and recognizes principles and rights, such as purpose, consent, and the rights of access and rectification.

Personal data protection legal framework in Panama

Panama's Law No. 81/2019 establishes personal data protection principles, rights, obligations, and procedures. In comparison with European law, the Panamanian standard is more streamlined, providing fewer principles and rights for the data subject. It also includes a more restricted scenario of legal basis for data protection processing. Regarding cross-border processing, it establishes a clear possibility, if the person responsible for data storage complies with the personal data protection law.

Personal data protection legal framework in Uruguay

In Uruguay, Law No. 18,881/2008 has been regulated by Decree No. 314/2009. The law created an autonomous authority responsible for regulation and control of personal data with detailed functions. Several provisions in the law are more developed than provisions in the European law, such as provisions on rights of data subjects and legal bases for data processing. However, the Uruguayan law includes an extensive approach to habeas data, with ample provision on its procedural matters.

Personal data protection legal framework in Trinidad and Tobago

Trinidad and Tobago enacted Law No. 13 in 2011, which establishes the legal parameters for processing data. The country foresees the creation of the "Office of the Information Commissioner", led by "the Commissioner", appointed by the President for a five-year term and who can only be removed for just cause. Not only does the Commissioner stand out for autonomy but also the broad spectrum of powers to ensure compliance with the law. However, the list of rights of data subjects is restricted when compared with the European GDPR. Data process is limited to hypotheses of the holder's consent, a legal obligation, or public interest. Concerning cross-border processing, international transfer is only possible in cases where foreign jurisdiction is compatible with the law, and such analysis is to be done carefully by “the Commissioner”.

Personal data protection legal framework in Chile

The protection of personal data in Chile is legally supported by Law No. 19,628, enacted on August 18, 1999, and amended in 2012 by Law No. 20,575. However, there is no provision for a specific or autonomous authority responsible for the inspection or previous control in the use and treatment of personal data. Thus, the Judiciary is responsible for adopting the appropriate measures for effective protection of personal data and to compensate for the damage suffered. The rights granted to data subjects and the legal basis for data processing largely converge with those provided for by the European Union. However, the hypotheses for handling sensitive data are more restricted when compared to other countries. Although the legal text does not make specific restrictions regarding the international transfer of personal data, it is inferred that the referred procedure is possible in cases where there is compatibility with the provisions of the treaties and agreements in force.

Personal data protection legal framework in Argentina

Finally, Argentina enacted Law No. 25,326 in 2000, which was regulated by Decree No. 1,558, of 2001. There are several subsequent laws and regulations that supplement the subject, such as rules and decisions enacted by the Agency of Public Information Access, the Law No. 27,275, of September 14th, 2016, on right of access to public information, and more than 45 statutes and regulations that either add provisions to that law or change it. Currently the country is discussing a personal data protection bill that follows the European GDPR. Although it preceded the European hallmark on data protection, Argentine legislation is advanced in terms of establishing definitions for technical terms regarding data, in addition to guaranteeing the individual’s right to access, rectification, and exclusion of personal data. Moreover, the law is incisive about the use and processing of personal data, in addition to requiring express consent as a key element for the processing of data. Furthermore, the subsequent legislation addresses specific topics such as punishment in case of non-compliance with data processing legislation and reaffirms the citizen’s right to privacy. With such legislation, in 2003 the European Union recognized Argentina as one of the countries with adequate protection for personal data.

Personal data protection legal framework in the Dominican Republic

Data protection was introduced in the Dominican Republic by Law No. 172, enacted on December 13th, 2013. Even though the Dominican legislation has made some advances on the matter, with many aspects similar to those of the European GDPR, the law focuses on credit issues, at the expense of the remaining institutional variables of data protection.

Countries that lack a specific legal framework on personal data protection

A set of countries in Latin America have not yet addressed personal data protection as an autonomous legal topic or even a legal codification, consolidation, or specific law.

Personal data protection legal framework in Bolivia

Despite recognizing privacy and intimacy as fundamental rights, Bolivia, for instance, does not have a comprehensive data protection framework. On the matter, there are only some sectoral provisions in the different legal bodies.

Personal data protection legal framework in El Salvador

Similarly, El Salvador does not have a legal regime that regulates data protection in a systematic way. However, a draft bill is currently under discussion in the Legislative Assembly.

Personal data protection legal framework in Guatemala

Privacy and data protection are constitutionally protected in Guatemala, but there is no general data protection law, only sectorial legislation, including the Law on Access to Public Information, which aims to ensure the right to know and protect personal data contained in government files, including the definition of personal data, sensitive data, and *habeas data* in devices.

Personal data protection legal framework in Paraguay

Paraguayan data protection law is relatively old when compared with most of Latin American countries. Data protection Law No. 1,682 was enacted on January 16th, 2001, and amended by Law No. 1,969 on September 3rd, 2002. The law brings few provisions in its twelve sections and focuses on financial information. A new law would be necessary to cover situations brought by technological developments over the last years. Currently, discussions on a new personal data protection law are being held.

Personal data protection legal framework in Belize

Although Belize approved a “Freedom of Information Act” in 2011, the country does not have specific regulation on personal data protection. The referred Act includes provisions on the protection of personal information. However, it does not cover electronic data.

Personal data protection legal framework in Honduras

Similarly, Honduras has not yet regulated the protection of personal data. However, a bill on the topic has been recently drafted and Honduras’s Constitution includes a provision on *habeas data*.

Personal data protection legal framework in Cuba

Moreover, Cuba has recently approved its new Constitution which, among other changes implemented, recognizes the right to access, correction, update, and removal of personal data located in records, files, or other databases and information of public nature. In spite of the constitutional provision, a law guaranteeing the parameters for the use and treatment of personal data in Cuba has not yet been approved.

Personal data protection legal framework in Suriname

Suriname, besides not having a specific legal regime for the protection of personal data, only provides for the protection of privacy as a fundamental right.

Personal data protection legal framework in Ecuador

Since 2016, Ecuador has been discussing a personal data protection bill that aims to safeguard the identity and data of all Ecuadorians. Although this topic is recurring on the political agenda, Ecuador has not yet approved the referred project. Even so, the Constitution of Ecuador, enacted in 2008, requires authorization from the holder or the law for the collection, filing, processing, distribution, or disclosure of personal data; it also provides for the right to access, rectification, and deletion of data, and the adoption of security measures necessary for the archiving of sensitive data. Ecuador makes possible to repair damages eventually caused by the violation of personal data, despite not having a specific law.

Personal data protection legal framework in Venezuela

The Constitution of Venezuela recognizes the protection of privacy, confidentiality and intimacy as citizens’ rights, defines the right to *habeas data* and protects the individual’s access to information. However, Venezuela does not have a structured legislation on data protection. There are only sectoral laws and bills under evaluation.

Personal data protection legal framework in Haiti

Similarly, Haiti does not have either a legal regime that regulates data protection in the country or sectoral laws. Moreover, the subject is not even mentioned in its Constitution.

QUANTITATIVE ANALYSIS

All the results above are important field discoveries by themselves through the lenses of the TLICS model institutional forms and legal institutions, although they pale when compared to the quantitative results, which show the pivotal role played by the variable of data protection authority on the legal framework likeability to protect certain data subject rights. Different from other studies, that show tables and summaries of legal features on personal data protection in each country, focusing on one legal institution, such as the data protection authority (Greenleaf, 2019), the TLICS model allows for a much broader analysis, by depicting the personal data protection framework as a set of more than 60 specific legal features.

Significance analysis of variables on personal data

To test the significance of the relationship of the legal institutions (as categorical variables) listed in Mendes *et al.* (2019) on personal data legal protection summarized in Table 1, 2x2 contingency tables that measure the degree of association between the presence or absence of each legal institution in the countries analyzed can be applied. The statistical significance of the association of each categorical variable (individual legal institutions) on personal data legal protection can then be tested using Fisher exact test (Cohen, Cohen, West, & Aiken, 2003).

To compare the probability of the presence of data protection legal institutions in Latin American legal systems, we used a concept borrowed from biostatistics (Pagano & Gauvreau, 2000, p. 144). In this context, the relative risk is defined as the ratio of the probability of the presence of a personal data legal protection feature in a given group of countries that present a certain legal institution in their legal system to the probability of the presence of that personal data legal protection feature in the absence of that particular legal institution. A measure of risk greater than one implies that the chance of a country having the requisites for personal data legal protection and, as a consequence, the possibility of personal data exchange, is increased when that particular legal institution is present in their legal system.

This paper focuses on comparing the likelihood of the presence of a set of key data protection legal institutions, such as right to be informed, right to access, right to rectification and so forth, with the existence of a data protection authority according to the formula:

$$RR = \frac{P(data\ protection\ legal\ institution\ |presence\ of\ data\ protection\ authority)}{P(data\ protection\ legal\ institution\ |absence\ of\ data\ protection\ authority)}$$

Namely, we focused on the data protection features of right to be informed, right to access, right to rectification, right to be forgotten, right to cancel, right to restrict processing, right to data portability, blocking or restriction of processing, right to human intervention, restrictions to implementing the rights, the existence of a research body, the performance of impact report, the existence of provisions on legal grounds for personal data processing (regular exercise of rights in judicial process, health protection and credit protection), provisions on shared use of data, liability and loss compensation, administrative sanctions and governance and accountability mechanisms, or record of processing.

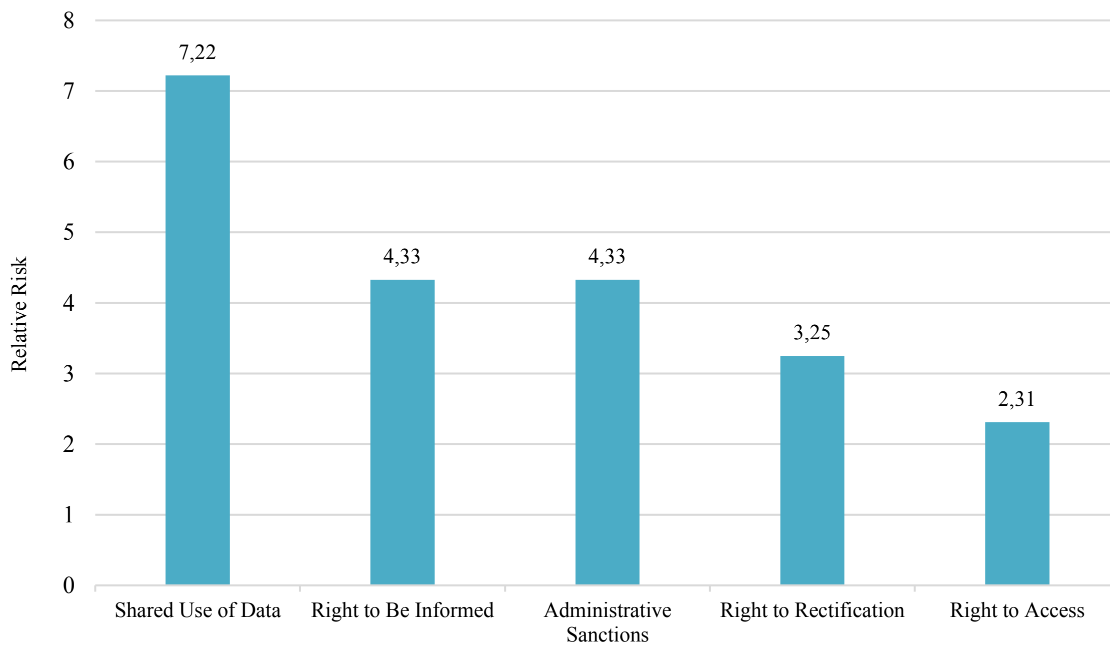
Relative risks greater than 1 for a particular data protection feature indicate that the presence of data protection authority increases the chances of that group of countries to also present a particular data protection legal institution. For instance, among the countries analyzed, the right to be informed is present in 12 countries, namely Brazil, Argentina, Chile, Colombia, Costa Rica, Dominican Republic, Mexico, Nicaragua, Peru, Trinidad e Tobago, Sint Marteen, and Uruguay. Among these, data protection authority was absent only in Argentina, Chile, and Dominican Republic.

Since all 9 countries that present data protection authority also present the right to be informed, P(data protection authority/presence of right to be informed) = 9/9 = 1. Moreover, since 3 out of 13 countries that present the right to be informed do not present data protection authority (the 12 above as well as Argentina), P(data protection authority/absence of right to be informed) = 3/13 = 0.23. Therefore, applying the definition, these data result in a Relative Risk of 1/0.23 = 4.33. In other words, using relative risk measures, the chance of a country that has a data protection authority of also protecting the right to be informed is 4.33 times greater than the chance of that country not protecting the right to be informed ($p < 0.001$, Fisher-Exact test).

Likewise, if the country has data protection authority, it is also 2.31 times more likely to also protect the right to access ($p = 0.031$), 3.25 times more likely to also protect the right to rectification ($p = 0.002$), 7.22 times more likely to also have shared use of data ($p = 0.023$), and 4.33 times more likely to also have administrative sanctions ($p < 0.001$). Moreover, a country that has data protection authority is more likely to also have impact report or impact assessment ($p = 0.002$), regular exercise of rights in judicial process ($p = 0.002$), and governance and accountability ($p = 0.002$). On the other hand, there is no relation between a country having data protection authority and the right to be forgotten, the right to cancel, the right to restrict processing, the right to data portability, blocking or restriction of processing, the right to human intervention, restrictions to implementing the rights, the existence of a research body, the existence of provisions on health protection, credit protection, or liability and loss compensation, since the p-values associated with these respective relative risk measures, calculated by the Fisher exact test, were greater than 0.05, thus lacking statistical significance.

The relative risk and the corresponding p-values, which define the statistical significance (or lack thereof if $p > 0.05$) of the relative risk measure for the variables related to legal status and personal legal relations are illustrated in Figure 1.

Figure 1 – Relative risk of the variables related to the rights of data subjects



The only significant relative risk measures are those associated with a p-value less than 0.05. Thus, the significant relative risk measures are those associated with the variables shown in Figure 1, *i.e.*, shared use of data ($p = 0.023$), administrative sanctions ($p < 0.001$), right to rectification ($p = 0.002$), and right to access ($p = 0.031$).

As shown in Figure 1, the probability of a country that has a data protection authority to also enforce the right to be informed is 4.33 times greater than the probability of that country not to enforce it. Likewise, if the country has data protection authority, it is also 2.31 times more likely to protect the right to access, 3.25 times more likely to also protect the right to rectification, 7.22 times more likely to also have shared use of data, and 4.33 times more likely to also have administrative sanctions.

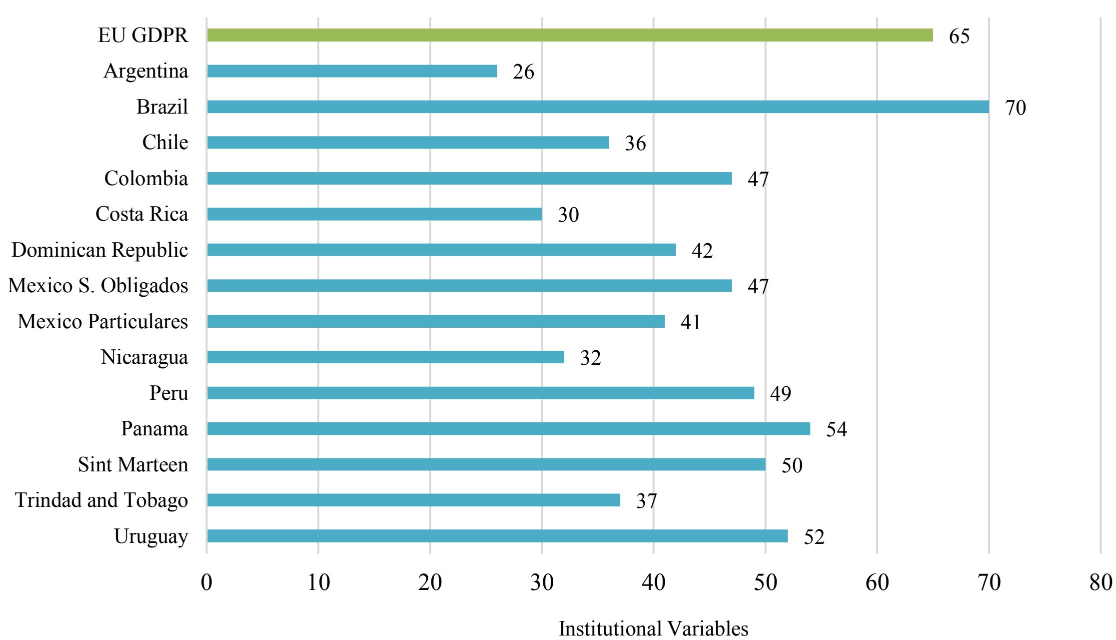
CONCLUSIONS

This paper applies the TLICS Model (Aranha, 2011) to the endeavor of comparing Latin American personal data protection legal frameworks by focusing on legal variables devised through a neo institutional approach. The analysis found that the two sets of countries usually mentioned in the literature to compare legal personal data protection – countries with and without a specific legal provision on data protection – are insufficient to do the job of real categorization of Latin American countries according to the level of personal data protection. The TLICS Model variables explain the similarities and differences in a much more granulated way by focusing on the institutional guarantees of provisions on personal data protection. The model was first used to address the problem of ambiguous concepts in the ICT comparative research by decomposing the federal clause into 42 institutional variables (ARANHA & OLIVEIRA, 2016). The same was achieved for personal data protection, as a complex of juridical interconnected guarantees, or more precisely, a set of 61 legal institutions of personal data protection (Mendes *et al.*, 2019, pp. 147-159).

The two sets of countries with and without specific regulation on personal data protection help to distinguish between extremes. The effort of categorizing each country as having a specific data protection legal framework does not tell the whole story on where exactly lies a country as far as data protection legal institutions are concerned. This information is adamant, for example, to allow for the exchange of personal data with the European Union. By applying the legal institutions on data protection to Latin American countries, a better picture is drawn of the relative position of a country in comparison to the usual benchmarking provided by the European GDPR. Peru, for example, provides for almost the same legal bases for personal data processing as Europe and Brazil, although with reduced hypotheses, and fewer rights to data subjects. Colombia, on the other hand, does not explicitly present the principle of accountability, introduced later by the decree as "displayed responsibility", but persistently applies this principle, even establishing a guideline for its implementation, which should be overseen by national authorities. Costa Rica's legal framework, in turn, presents objectives, the scope of application, definitions of elements and institutes related to data protection, and the creation of a data protection authority. It also includes a chapter dedicated to explaining basic principles and rights, but lags behind by not addressing legal grounds for personal data processing. Each country adds specific features or strengthens certain aspects of the data protection legal institutions. The length of this paper does not allow for the table with the results to be published, so we left it with open access to the public at the website of the University of Brasilia Telecommunications Law Research Group (www.getel.org), in "Research – TLICS Model Data Protection – Countries Analyzed".

We compared the framework of each country according to six institutional forms divided into over twenty-five legal institutions and over fifty legal institutions subtypes, both through the lenses of a qualitative and quantitative approach. However, we are not talking only about numbers. A better picture is drawn of the relative position of a country in comparison to the usual benchmarking provided by the European GDPR. And this makes it possible for policymakers to identifies which institutions and variables need to worked on in order to enhance adequacy when it comes to decisions on international transfer of personal data.

Figure 2 – Benchmark of Personal Data Legal Institutions



Figures 3 to 16 show the relative position of each country analyzed compared to the legal institutions identified at the European GDPR.

Figure 3 – Argentina's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

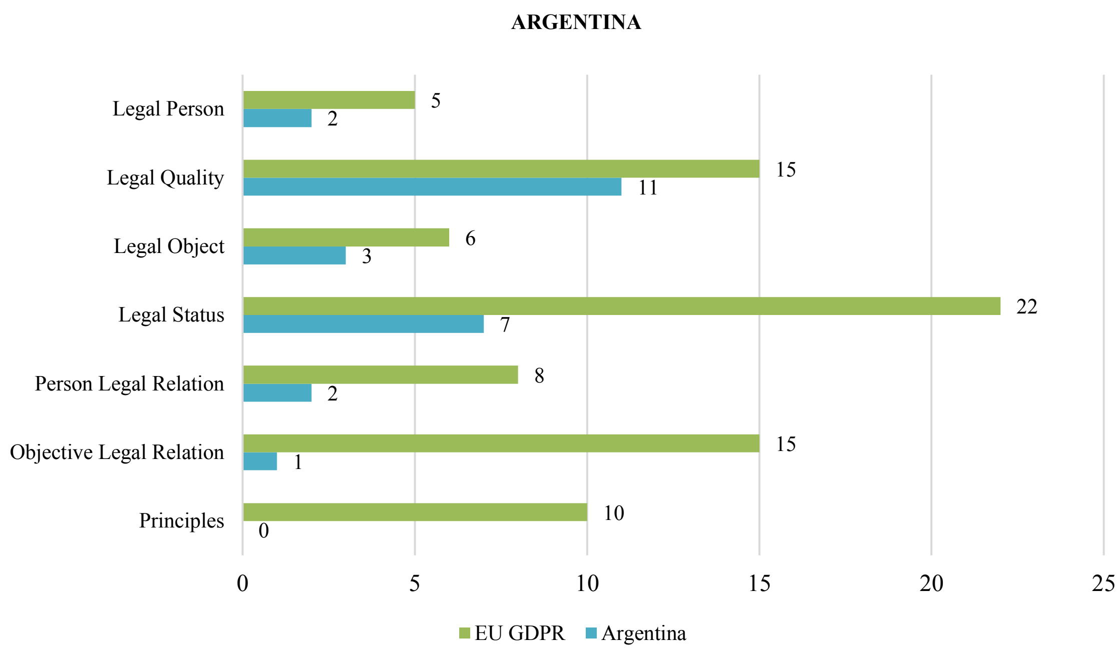


Figure 4 – Brazil's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

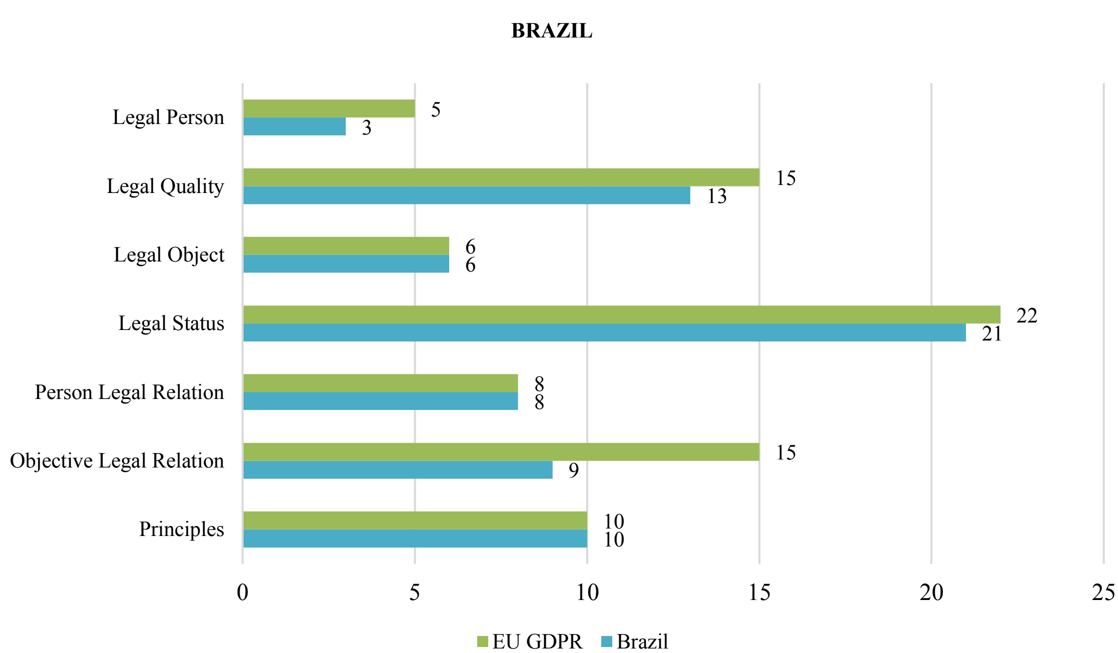


Figure 5 – Chile's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

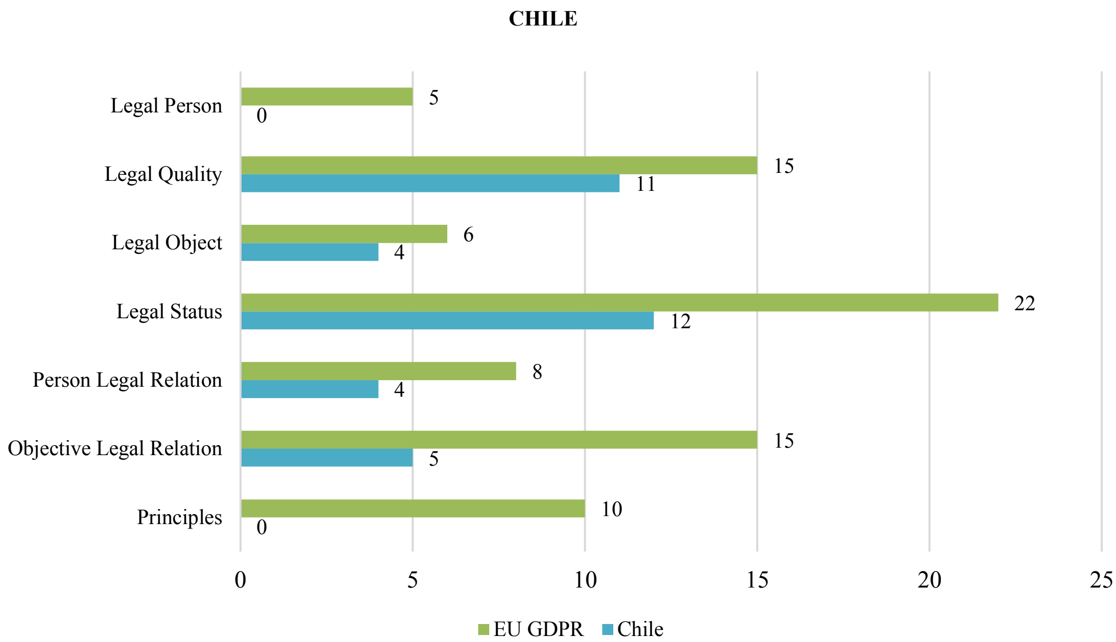


Figure 6 – Colombia's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

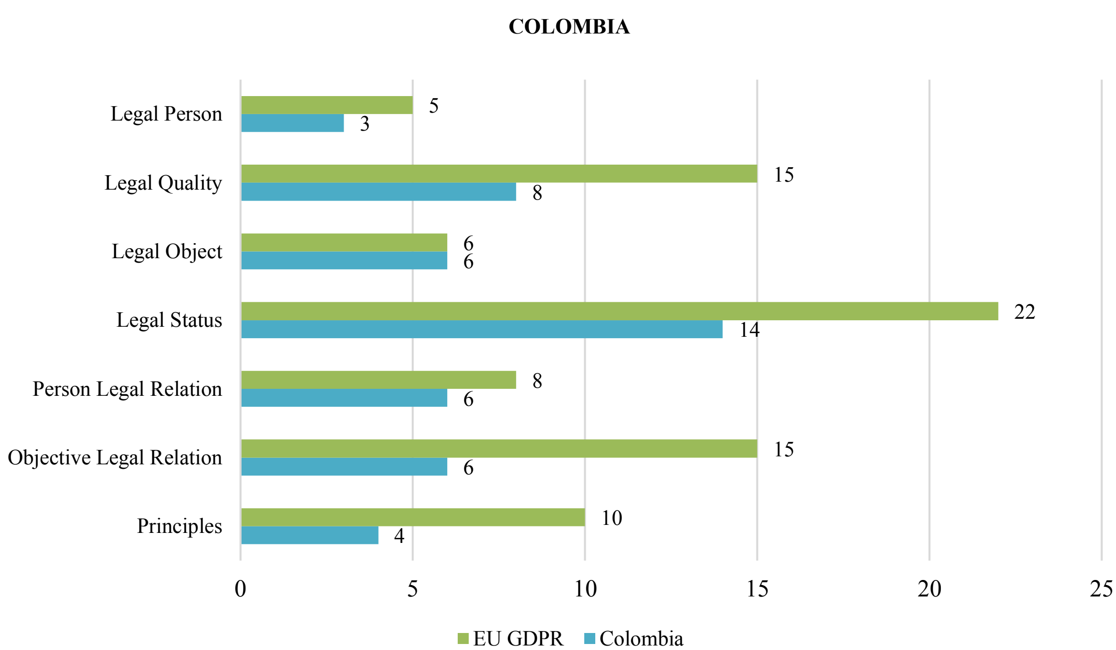


Figure 7 – Costa Rica's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

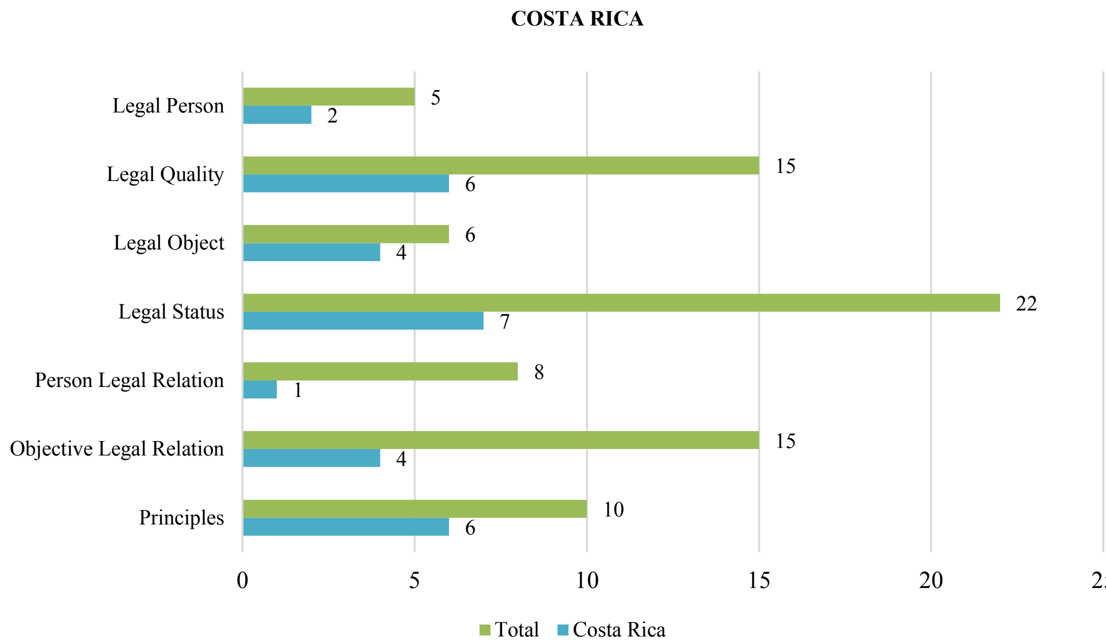


Figure 8 – Dominican Republic's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

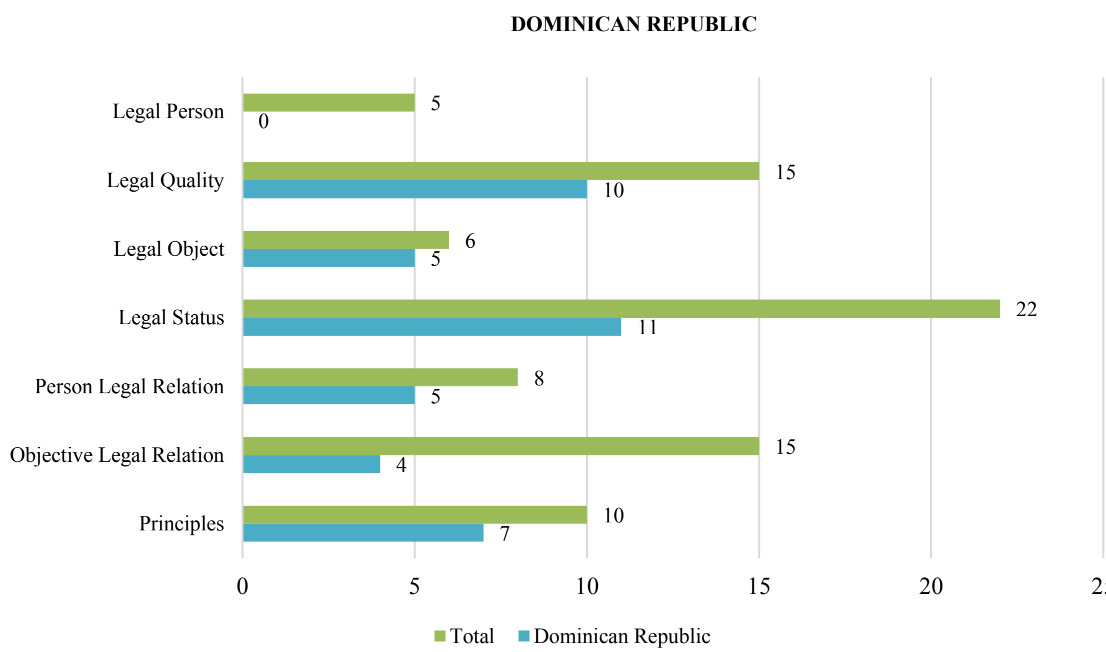


Figure 9 – Mexico's Position regarding the Public Sphere in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

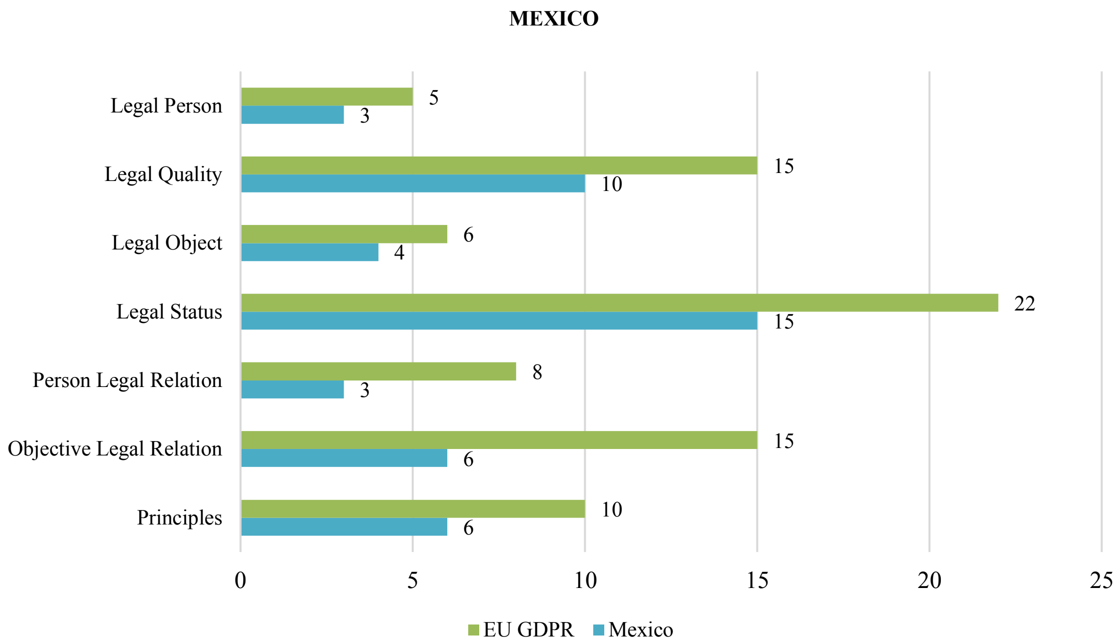


Figure 10 – Mexico's Position regarding the Private Sphere in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

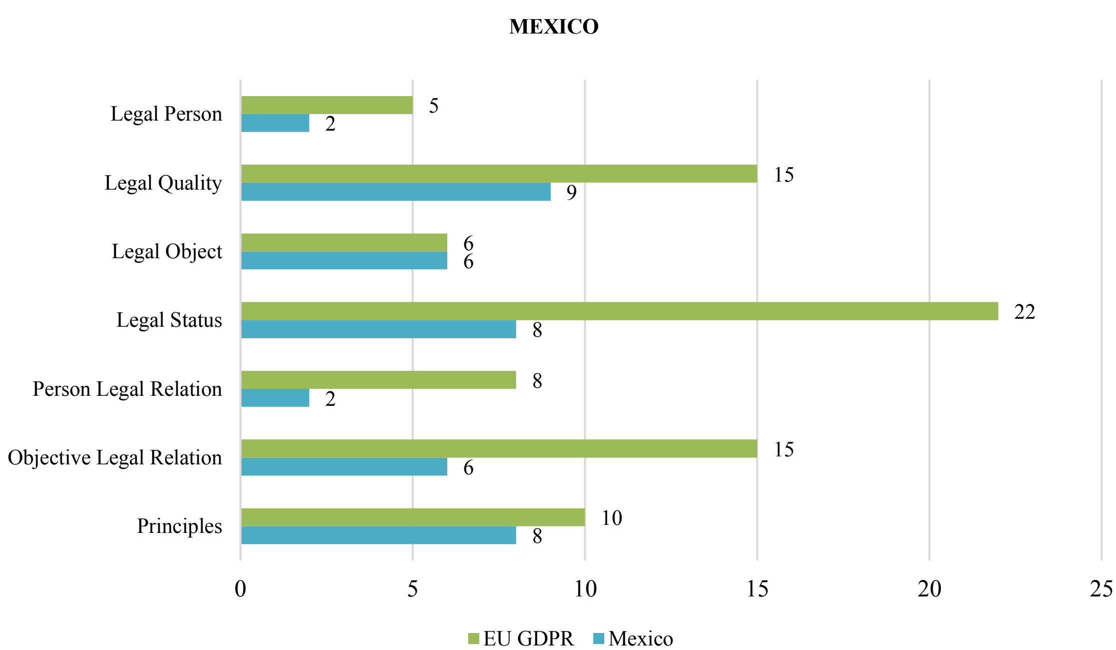


Figure 11 – Nicaragua's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

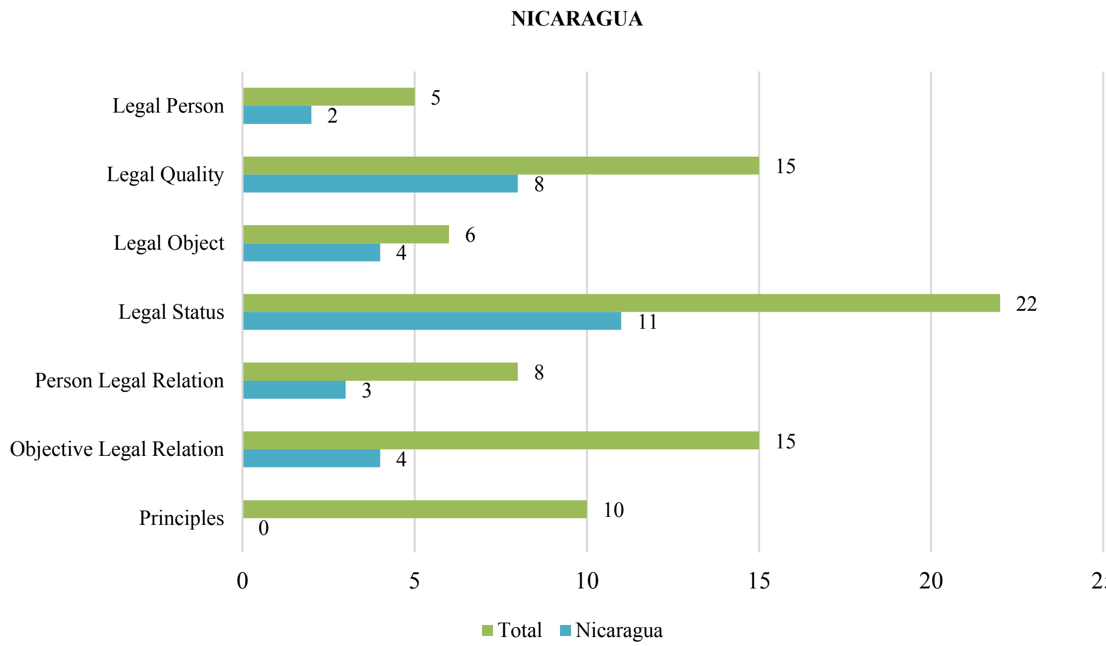


Figure 12 – Peru's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

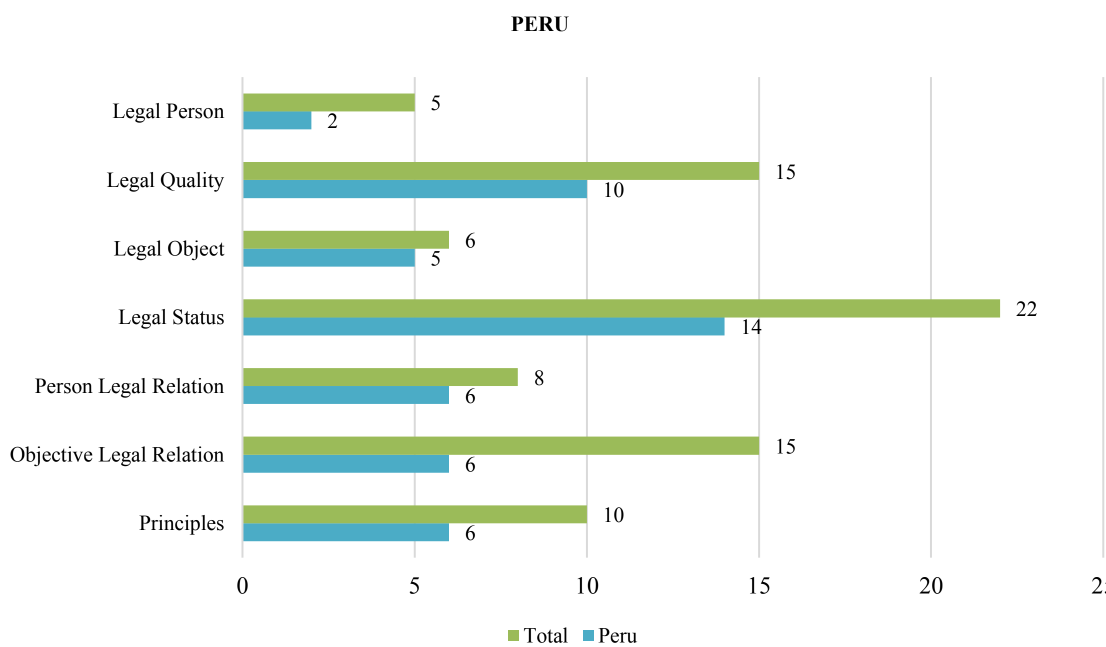


Figure 13 – Panama's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

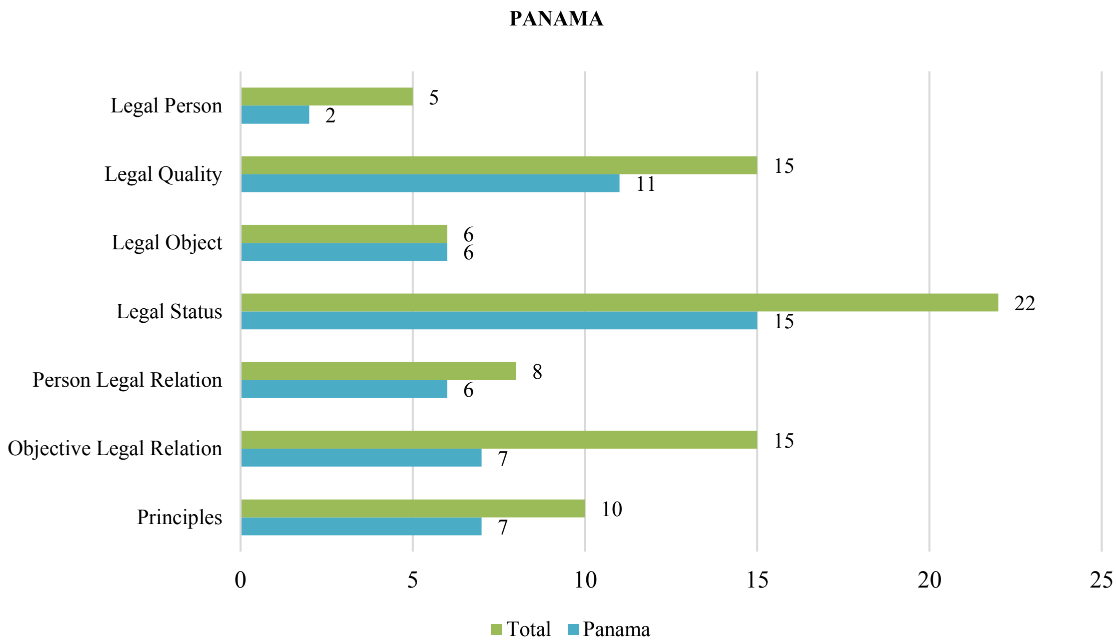


Figure 14 – Sint Marteen's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

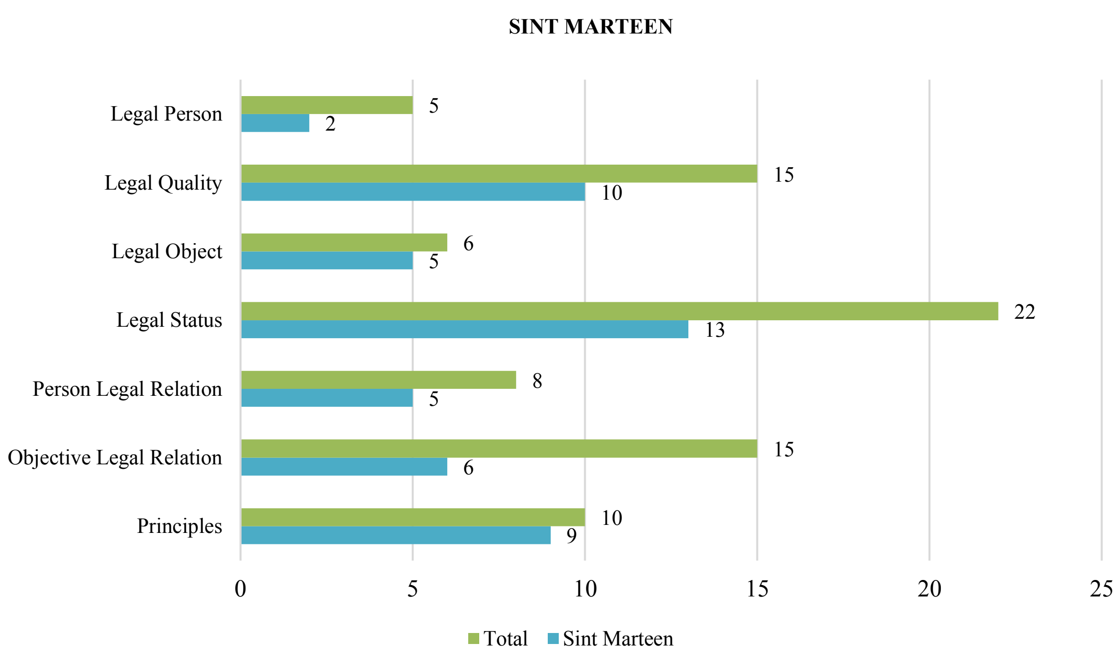


Figure 15 – Trinidad and Tobago's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR

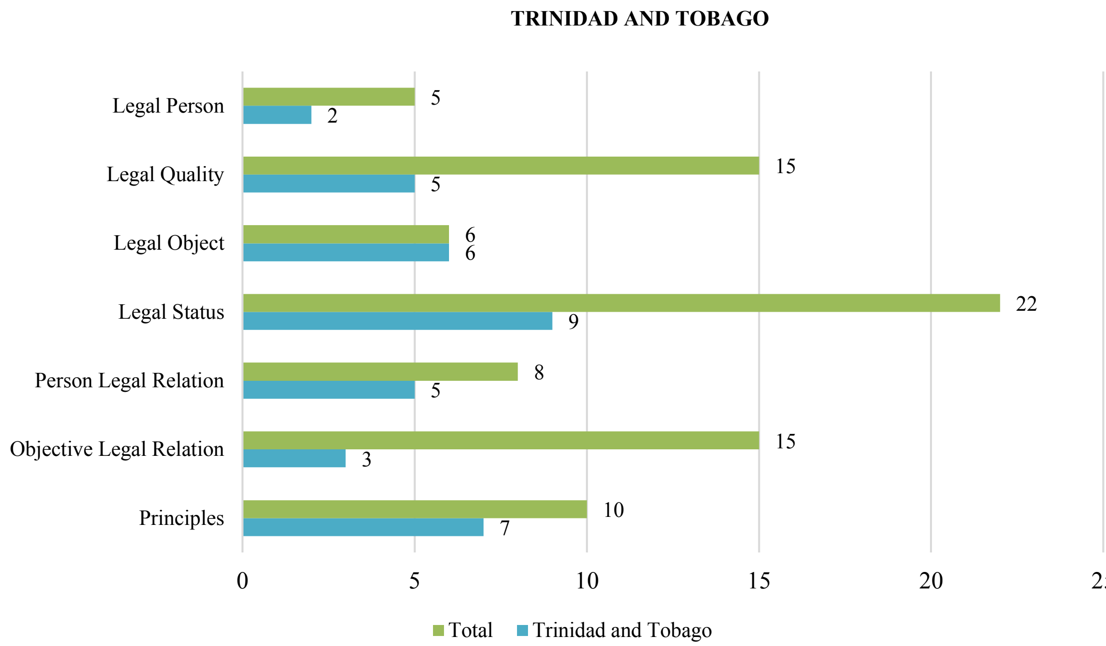
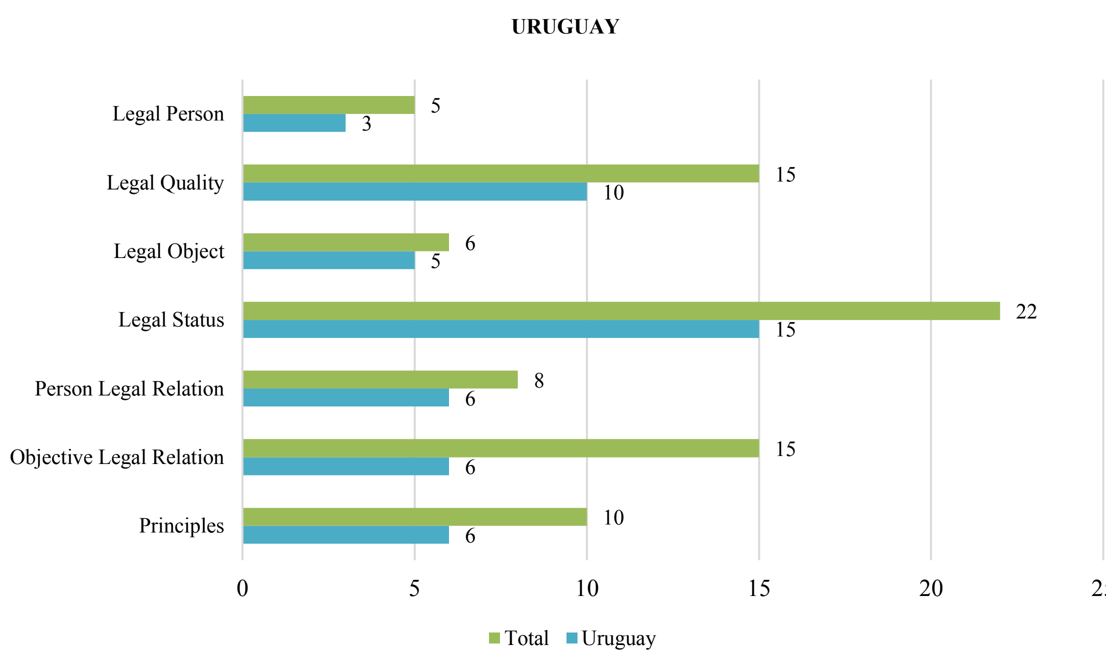


Figure 16 – Uruguay's Position in comparison with the benchmarking provided by the legal institutions identified in the European GDPR



The quantitative analysis, for the first time in the literature, proves a connection – not only implied – between the existence of data protection authorities and the protection of specific rights, namely the right to be informed, the right to access, the right to rectification, and the presence of administrative sanctions, impact report or impact assessment, regular exercise of rights in judicial process governance and accountability.

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Competencia e inversión en los servicios móviles: Una evaluación de los factores determinantes de la inversión en México*

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ABSTRACT

This article investigates if there is an inverted U shape relationship between competition and infrastructure investment in mobile telecommunication services; furthermore, it analyzes other factors that have affected investment. We found evidence for an inverted U shape relationship between economic competition, measured by market share, and investment. This finding implies that market share has a positive effect on investment, however if market share is very high, the investment begins to fall. Other factors that affect the investment are license fees, percentage of 3G connections, total spectrum per subscriber, percentage of urban population, per capita income, per capita Gross Domestic Product, and market size.

Keywords

Competition, investment, mobile services, license fees

RESUMEN

Este artículo investiga si existe una relación en forma de U invertida entre la competencia y la inversión en infraestructura de los servicios de telecomunicaciones móviles en México; asimismo, analiza otros factores que han influido en dicha inversión. Se encuentra evidencia de una relación en forma de U invertida entre la competencia económica, medida a través de la participación de mercado, y la inversión. Este hallazgo significa que la participación de mercado tiene un efecto positivo sobre la inversión; sin embargo, si la participación de mercado es muy elevada se desincentiva la inversión. Otros factores que afectan la inversión son el pago de derechos, el porcentaje de conexiones 3G, la cantidad de espectro por suscriptor, la disponibilidad de espectro a través de las licitaciones, el ingreso promedio por usuario, el porcentaje de población urbana, el ingreso per cápita, el producto interno bruto per cápita y el tamaño de mercado.

Palabras clave

Competencia, inversión, servicios móviles, pago de derechos.

* La investigación y resultados mostrados en el presente documento son responsabilidad de la autora y no necesariamente reflejan el punto de vista del Instituto Federal de Telecomunicaciones ni de su Centro de Estudios. Por otra parte, este documento forma parte de un estudio más amplio titulado Factores que explican la evolución reciente de los flujos de inversión en las telecomunicaciones.

INTRODUCCIÓN

El presente documento contribuye al debate en torno a la relación entre la competencia e inversión, pues la literatura relativa a este tema ha señalado dos posibles efectos contrapuestos. Por una parte, existe el *efecto escape a la competencia* de Arrow (1962) el cual establece que en mercados competitivos existen mayores incentivos para invertir y por otra parte el *efecto schumpeteriano* (1942), en el cual el monopolista tiene mayores incentivos para invertir o innovar.

A este respecto la literatura empírica ha obtenido diversos resultados en cuanto al efecto que tiene la competencia en la inversión en infraestructura de servicios de telecomunicaciones móviles. Por ejemplo, Elixmann, Godlovitch, Henseler-Unger, Schwab y Stumpf (2015) no encuentran una relación entre la inversión y la concentración de mercado en Reino Unido, Austria, Francia, Alemania, Irlanda, Italia, Países Bajos, Australia, Japón, Corea y EE.UU. Kang, Hauge y Lu (2012) encuentran una correlación positiva entre la concentración de mercado y la inversión en redes móviles para el caso de China. Lestage, Flacher, Kim, Kim y Kim (2013) muestran que existe una relación positiva entre la intensidad de la competencia y la inversión cuando el operador es estatal y una relación negativa cuando el operador es privado en países de la OECD. Jeanjean y Houngbonon (2017) encuentran que, si la competencia es simétrica, esta impacta negativamente la inversión y con competencia asimétrica, impacta positivamente la inversión en 17 países de Europa. Houngbonon y Jeanjean (2016) muestran que existe una relación en forma de U invertida entre la intensidad de competencia y la inversión para el caso de 69 países.

Adicionalmente, la literatura ha señalado otros factores que influyen en la inversión de los operadores móviles como son variables que afectan a los costos de inversión, así como variables relacionadas con las características de los mercados. En este sentido, el presente artículo analiza algunas de estas variables como son el pago de derechos,[1] el porcentaje de conexiones 3G, la cantidad de espectro por suscriptor, la disponibilidad de espectro a través de las licitaciones, el ingreso promedio por usuario, el porcentaje de población urbana, el ingreso per cápita, el producto interno bruto (PIB) per cápita y el tamaño de mercado.

Con el objetivo de determinar si existen una relación en forma de U invertida entre la competencia y la inversión en las telecomunicaciones móviles en México se estima un modelo tipo panel con efectos fijos individuales y temporales con base en información de los tres principales operadores móviles de México, así como datos agregados a nivel nacional, para el periodo de 2005 a 2020.

Los resultados de este artículo muestran que la participación de mercado tiene un efecto positivo sobre la inversión; sin embargo, conforme esta aumenta, desincentivan la inversión, lo cual es consistente con una relación en forma de U invertida entre la competencia y la inversión. Este resultado es robusto debido a que se mantiene esta relación cuando se incluyen otros factores, que afectan a la inversión de los operadores móviles, como las características de mercado.

El resto del artículo se estructura de la siguiente manera, en la sección siguiente se presenta un resumen de la revisión de literatura relativa a la relación entre la competencia y la inversión, y algunos de los principales factores que influyen en la inversión de los operadores móviles. La tercera sección describe las variables, su fuente y metodología utilizada. La cuarta sección muestra los principales resultados de los modelos econométricos. Finalmente, en la sección quinta se presentan las conclusiones de este artículo.

REVISIÓN DE LITERATURA

La relación entre la competencia y la inversión ha sido objeto de un largo debate, tanto teórico como empírico. La literatura ha identificado dos posibles efectos contrapuestos: el *efecto de eficiencia o schumpeteriano* y el *efecto escape a la competencia* (Arrow, 1962; Houngbonon et al., 2016; Schumpeter 1942).

En relación con ambos efectos, Aghion, Bloom, Blundell, Griffith y Howitt (2005) explican que cuando la competencia es baja al inicio y una proporción elevada de empresas se encuentran niveladas, el *efecto escape a la competencia* dominará el *efecto schumpeteriano*, por lo que en equilibrio la innovación incrementa con la mayor competencia. Sin embargo, cuando la competencia es elevada al inicio y las empresas se encuentran desniveladas, el líder busca estar un paso delante de sus competidores y el *efecto schumpeteriano* domina el *efecto escape a la*

[1] El pago de derechos corresponde al pago que realizan los operadores móviles anualmente por el uso, goce, aprovechamiento o explotación de bandas de frecuenta del espectro radioeléctrico, por cada región en la que operen y por cada kiloherz concesionado de conformidad con la Ley Federal de Derechos en México.

competencia, por lo que en equilibrio la innovación decrece con la competencia. Por su parte, Belleflamme y Vergart (2011) muestran que bajo competencia a la Cournot el incentivo por beneficios de la innovación disminuye con el número de empresas o tiene una forma de U invertida. Mientras que con competencia a la Bertrand el incentivo por beneficios de la innovación disminuye o aumenta con el número de empresas.

Desde el punto de vista empírico, algunos autores como Elixmann et al. (2015) no encuentran un vínculo entre una mayor concentración en los mercados móviles y un incremento en la inversión ya que, está última tiende a seguir ciclos de inversión a largo plazo. Por otro lado, Kang et al. (2012) encuentran una correlación positiva entre la concentración de mercado y la inversión en redes móviles para el caso de China. Genakos, Valletti y Verboven (2015) encuentran que el número de empresas tiene un efecto en la inversión de manera que los mercados con más operadores tienen una disminución en la inversión por operador que en aquellos mercados donde hay menos operadores. Lestage et al. (2013) encuentran una relación positiva entre la intensidad de la competencia y la inversión en infraestructura cuando el operador es estatal y una relación negativa entre la competencia y la inversión cuando el operador es privado. Houngbonon et al. (2016), muestran que existe una relación en forma de U invertida entre la intensidad de competencia y la inversión para el caso de 69 países.

Jeanjean y Houngbonon (2017) muestran que el número de operadores y la asimetría en la participación de mercado[2] tienen efectos en la inversión. En mercados simétricos, un mayor número de operadores disminuye la inversión y este efecto negativo es mayor en los operadores que pierden una participación de mercado superior al promedio. Sin embargo, el efecto de la estructura de mercado sobre la inversión depende fuertemente de la asimetría en términos de calidad. Entre mayor la variación en la asimetría, representada como cambios en las participaciones de mercado con respecto a las de sus rivales, mayor será la inversión. Estos hallazgos son consistentes con las predicciones de Vives (2008) quien muestra que, en mercados simétricos, el incremento del número de empresas impacta negativamente la inversión.[3] Así también, son consistentes con lo señalado por Schmutzler (2013) quien muestra, en mercados asimétricos, que el efecto de la competencia sobre la inversión tiende a ser positivo en las empresas que inicialmente son relativamente más eficientes y negativo en las empresas seguidoras.[4]

Otros factores que podrían incidir en la inversión de los operadores móviles son los pagos por las licencias del espectro radioeléctrico. Sin embargo, existe un debate si esta variable es un costo hundido que no tiene influencia en la inversión (Cambinia et al., 2017; Park, Lee y Choi, 2011) o, por el contrario, como señala Bauer (2003) bajo ciertas características económicas e institucionales de los mercados móviles, los pagos por licencia del espectro sí podrían tener efectos. Datta (2012) a través de un modelo teórico llega a la conclusión que altos pagos por las licencias de espectro generan una caída en el promedio de inversión física en la industria de las telecomunicaciones, considerando que la reacción de los bancos ante altos pagos por las licencias es aumentar las tasas de interés con las cuales se financian los proyectos de infraestructura. Marsden, Ihle y Traber (2017) encuentran una correlación entre estos altos pagos por el espectro y una reducción en la inversión, lo cual es relevante para el caso de Latinoamérica pues se observa que estos pagos por el espectro son superiores a los observados en países de Europa.

[2] En el modelo teórico, Jeanjean et al., (2017) se refieren a asimetría en la diferencia en calidad entre los operadores. Sin embargo, dado que la calidad no es observable, ellos utilizan la participación de mercado para evaluar dicha asimetría.

[3] Esto sucede porque el crecimiento del mercado no compensa la caída en la participación de mercado de cada empresa. De acuerdo con Vives (2008) el incremento en el número de empresas genera dos efectos, uno directo el cual denomina *efecto demanda* mediante el cual se genera una caída en la participación de mercado de las empresas y otro indirecto que *denomina efecto presión de precios* debido a un incremento en el número de empresas que tiende a reducir los precios e incrementar el tamaño del mercado. Si la reducción en precios no incrementa el tamaño del mercado el efecto demanda dominará y el incremento en el número de empresas tendrá un impacto negativo sobre la inversión. Por su parte, si se consideran la magnitud de las barreras a la entre y el grado de sustitución de los productos la competencia tiene un efecto positivo sobre la inversión.

[4] Schmutzler (2013) identifica cuatro mecanismos por los cuales la competencia afecta las inversiones: i) el *efecto margen*, el cual es negativo pues la mayor competencia reduce el margen de ganancias para las inversiones; ii) el *efecto sensibilidad del producto* el cual es positivo ya que la mayor competencia asigna el producto a las más eficientes empresas; iii) el *efecto producto* que depende de las asimetrías en costos entre las empresas y es negativo para las empresas menos eficientes y positivo para las más eficientes, y iv) el efecto traspaso de costos mediante el cual la reducción de costos derivado de la inversión es trasladado a los consumidores vía reducción de precios y este efecto es positiva para la competencia en cantidades y negativo para la competencia en precios. El efecto total de la competencia sobre la inversión será la suma de estos efectos, por lo que el signo es indeterminado.

Por otra parte, la transición de una tecnología a otra (por ejemplo, del 3G al 4G) y el incremento del tráfico de datos ha ocasionado que los operadores necesiten invertir en infraestructura de sus redes móviles existentes al mismo tiempo que invierten en nuevas (Stühmeier, 2012). Las redes de infraestructura móvil son desplegadas en dos fases. En la fase inicial se busca expandir la cobertura geográfica de las redes mientras en la subsecuente fase se busca incrementar la capacidad de las redes (Bauer, 2013). El mayor monto de inversión en infraestructura se realiza en la primera fase (Harmantzis y Tanguturi, 2007; Lutilsky, Jurjević e Ivić, 2011).

Dentro de los factores que también influyen en la inversión en infraestructura móvil están las características del mercado. El ingreso de los consumidores, el producto interno bruto per cápita y el tamaño de mercado influyen positivamente en la inversión de los operadores, ya que indica la capacidad de los individuos para consumir los servicios (Gutierrez y Berg, 2000; Jeanjean et al., 2017; Jeanjean, Lebourges y Liang, 2019; Luiz y Stephan, 2012; Moshi y Mwakatumbula, 2017).

De la revisión de literatura es importante destacar que una discusión en cuanto al efecto de la competencia sobre la inversión en la industria de las telecomunicaciones. Particularmente se observan posibles efectos contrarios dependiendo del tipo de empresa estatal o privada, del tipo de competencia (simétrica o asimétrica) o el tipo de indicador que se utilice para aproximar la competencia. Esto debido al *efecto schumpeteriano* y al *efecto escape a la competencia*.

Adicionalmente, existe un debate en torno a si los pagos por el espectro afectan o no la inversión. Para el caso de México, resulta relevante analizar el efecto que tiene el pago de derechos por el uso del espectro radioeléctrico en la inversión de los operadores móviles. Se observa que la tasa de crecimiento promedio anual del pago de derechos por el uso del espectro es de 9.45%[5] para el periodo de 2005 a 2020.

Respecto a los factores de mercado que influyen en la inversión existe un consenso de que el mayor tamaño de mercado, medido a través de diversos indicadores como ingresos, PIB per cápita, población, entre otros, tiene un efecto positivo sobre la inversión.

DESCRIPCIÓN DE DATOS Y METODOLOGÍA

El objetivo de este documento es investigar si existe una relación de U invertida entre la competencia y la inversión en infraestructura de los servicios de telecomunicaciones móviles en México, así como determinar otros posibles factores que han influido en dicha inversión. De la revisión de literatura se pudo observar que existe un debate en torno al posible efecto de la competencia sobre la inversión.

Al igual que otros estudios empíricos (Genakos et al., 2015; Houngbonon et al., 2016; Jeanjean et al., 2017; Jeanjean et al., 2019; Kang et al., 2012; Lestage et al., 2013), como variable proxy de la inversión de los operadores móviles se utiliza el gasto en capital (CapEx). Por su parte, para analizar el efecto de la competencia sobre la inversión se utiliza la participación de mercado en términos de conexiones de los tres principales operadores móviles en México.[6]

La Gráfica 1 muestra la evolución de las conexiones móviles, así como la participación de mercado de los principales operadores móviles en México. En esta gráfica se puede observar que las conexiones móviles se han incrementado a lo largo del tiempo y la participación de mercado del principal operador móvil en México ha disminuido.

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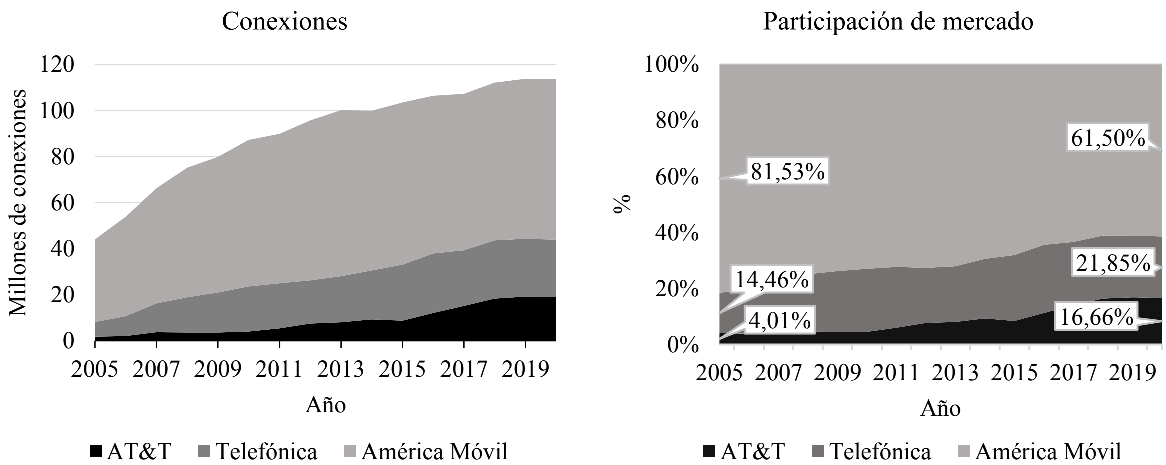
[5] Estimaciones propias a partir de la información contenida en el artículo 244 de la Ley Federal de Derechos de 2005 a 2020 de México.

[6] Cabe señalar que, para tener un panel balanceado, a AT&T se le imputaron los valores de Nextel y Unefon antes de 2015.



Gráfica 1. Conexiones móviles y participación de mercado por operador

Fuente: Elaboración propia con datos de GSMA Intelligence.

Adicionalmente, otros factores que influyen en la inversión de los operadores móviles son los relacionados con los costos de inversión y las características de mercado, los cuales se muestran en los **Erro! Fonte de referência não encontrada.** y 2. Se recolectó información de diversas fuentes a nivel empresa de los tres principales operadores de telecomunicaciones móviles en México, así como variables agregadas a nivel nacional durante el periodo de 2005 a 2020.[7] Los datos obtenidos provienen de GSMA Intelligence, Omdia, Banco de Información de Telecomunicaciones (BIT) del Instituto Federal de Telecomunicaciones (IFT), Registro Público de Concesiones (RPC) del IFT, la Ley Federal de Derechos (LFD), del Instituto Nacional de Estadística, Geografía e Informática (INEGI) y del Consejo Nacional de Población (CONAPO).

Cuadro 1. Descripción de datos

Variable	Fuente
lnCapex – Logaritmo del gasto de capital en términos reales de cada operador móvil.	Omdia
PM – Porcentaje de participación de mercado de cada operador móvil, en términos de conexiones.	GSMA
%3G – Conexiones totales con tecnología 3G por operador móvil.	GSMA
Espectro – Cantidad estimada de espectro utilizado por cada operador móvil sobre el total de conexiones.	Estimación con datos del RPC
lnARPU – Ingreso promedio por usuario de cada operador (ARPU, por sus siglas en inglés).	Omdia
%Urb – Porcentaje de la población urbana en México.	ENOE-INEGI
lnPIBpc – PIB per cápita a precios constantes de 2013.	INEGI y CONAPO
lnIngpc – Ingreso per cápita real.	ENOE-INEGI
lnMercado – Total de conexiones móviles.	GSMA

Para determinar la existencia de una relación en forma de U invertida entre la competencia y la inversión se estima el siguiente modelo tipo panel.

$$\ln Capex_{it} = \alpha_0 + \beta_0 PM_{it} + \beta_1 PM2_{it} + \beta_2 \ln Derechos_{it} + \beta_3 \ln Derechos2_{it} + \beta_4 \%3G_{it} + \beta_5 Espectro_{it} + \beta_6 \ln ARPU_{it} + \beta_7 \ln Licitado_{it} + x_{it} + \mu_i + \eta_t + \varepsilon_{it} \quad \textbf{[1]}$$

Como variable dependiente se tiene el logaritmo del gasto de capital realizado por los operadores (***lnCapex***). Como variable explicativa relacionada con la competencia económica, se utiliza la participación de mercado de cada operador móvil (***PM***), así como su término cuadrático (***PM2***), con el fin de capturar el posible efecto no lineal de la competencia económica sobre la inversión. Las otras variables que podrían influir en la inversión se señalan en el Cuadro 2. Las variables x_{it} incluyen las características del mercado como ***%Urb***, ***lnIngpc***, ***lnPIBpc*** y ***lnMercado***.

[7] En la muestra no se incluyeron los operadores móviles virtuales debido a que no suelen invertir en infraestructura móvil.

μ_i y η_t representando los efectos fijos individuales (por operador) y los efectos fijos temporales, respectivamente. Las estadísticas descriptivas se muestran en el Cuadro 2.

Cuadro 2. Estadísticas descriptivas

Variable	Unidades	Observaciones	Media	Desviación estándar	Mínimo	Máximo
lnCapex	($MX)	48	48	22.58	1.28	19.02
PM	(%)	48	33.27	27.22	4.00	81.00
PM2	(%)	48	18.32	22.99	0.16	65.61
lnDerechos	($MX)	48	21.67	0.35	21.09	22.28
lnDerechos2	($MX)	48	469.63	15.00	444.79	496.40
lnARPU	($MX)	48	5.00	0.57	3.65	6.08
%3G	(%)	48	31.38	24.27	0.00	71.00
Espectro	(%)	48	4.67	5.33	0.75	26.58
%Urb	(%)	48	76.84	0.02	76.79	76.87
lnIngpc	($MX)	48	1.97	0.18	1.73	2.30
lnPIBpc	($MX)	48	11.84	0.05	11.75	11.91
lnMercado	(Conexiones)	48	18.29	0.27	17.60	18.55
Licitado	Variable dummy de la cantidad de espectro licitado	2010, 2016 y 2018 como años de licitación y 240 MHz para el año 2010, 80 MHz para el año 2016 y 120 MHz para el año 2018				

RESULTADOS

En esta sección, se presentan los resultados de los modelos estimados (Cuadro 3). Cabe señalar que todas las variables son significativas y no cambian sustancialmente cuando se agregan las variables relativas a las características de mercado. Adicionalmente, las pruebas estadísticas presentadas en el Anexo señalan que se deben estimar modelos con efectos fijos y temporales.

Cuadro 3. Efectos en la inversión de los operadores móviles

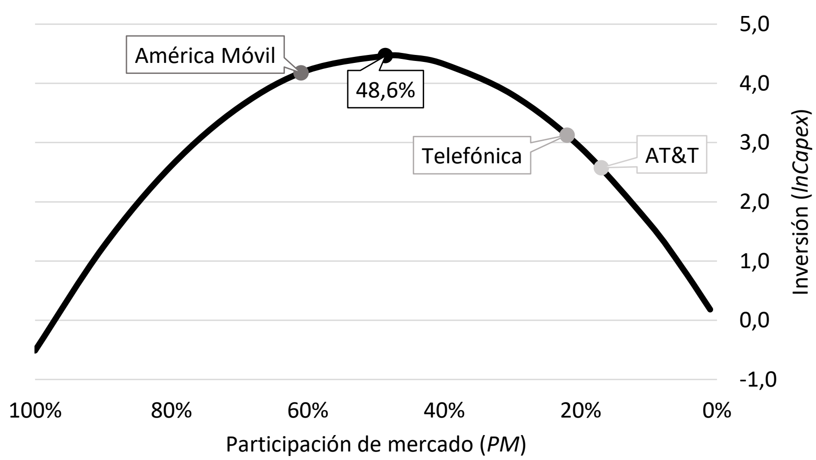
Variable dependiente	Inversión (lnCapex)				
Modelos	(1)	(2)	(3)	(4)	(5)
PM	18.3604*** (2.0288)	18.3604*** (2.0288)	18.3604*** (2.0288)	18.3604*** (2.0288)	18.3604*** (2.0288)
PM2	-18.8723*** (2.3695)	-18.8723*** (2.3695)	-18.8723*** (2.3695)	-18.8723*** (2.3695)	-18.8723*** (2.3695)
lnDerechos	35.9122** (16.4375)	35.9122** (16.4375)	35.9122** (16.4375)	35.9122** (16.4375)	35.9122** (16.4375)
lnDerechos2	-0.8234** (0.3770)	-0.8234** (0.3770)	-0.8234** (0.3770)	-0.8234** (0.3770)	-0.8234** (0.3770)
lnARPU	0.4295*** (0.0930)	0.4295*** (0.0930)	0.4295*** (0.0930)	0.4295*** (0.0930)	0.4295*** (0.0930)
%3G	-0.9711** (0.4838)	-0.9711** (0.4838)	-0.9711** (0.4838)	-0.9711** (0.4838)	-0.9711** (0.4838)
Espectro	-6.6768*** (1.5433)	-6.6768*** (1.5433)	-6.6768*** (1.5433)	-6.6768*** (1.5433)	-6.6768*** (1.5433)
Licitado	0.0098*** (0.0028)	0.0052*** (0.0004)	0.0033*** (0.0001)	0.0042*** (0.0001)	0.0015*** (0.0003)
%Urb		2,566.10*** (517.8606)			802.52* (432.9091)
lnIngpc		2.3751*** (0.2144)	2.3718*** (0.2140)		
lnMercado			2.1639*** (0.4367)	0.7158* (0.3668)	
lnPIBpc					3.6411*** (0.3287)
Constante	-373.79** (179.0959)	-2,349.77*** (443.6647)	-417.34** (179.5684)	-386.39** (179.7931)	-1,032.97** (392.9247)

Cuadro 3. Efectos en la inversión de los operadores móviles					
Variable dependiente	**Inversión (lnCapex)**				
Modelos	(1)	(2)	(3)	(4)	(5)
Chi2	5,617.30	1.07e+08	5,145.16	5,200.29	5,315.04
R2	0.993	0.993	0.993	0.993	0.993
Número de observaciones	48	48	48	48	48
Nota: Valores de errores estándar en paréntesis. Significancia a niveles *** 1%, ** 5%, * 10%					

Fuente: Elaboración propia.

Los resultados respecto al impacto que tiene la competencia económica sobre la inversión indican que existe una relación en forma de U invertida, pues la variable de participación de mercado (*PM*) es significativa y positiva, mientras que la participación de mercado al cuadrado (*PM2*) es significativa y presenta un signo negativo. Esto significa que a mayor intensidad de competencia económica mayor inversión; sin embargo, si la intensidad a la competencia es muy elevada la inversión disminuirá. Cabe señalar que este resultado es similar al encontrado por Houngbonon et al. (2016), quienes muestran que existen una relación en forma de U invertida entre competencia y la inversión en redes inalámbricas. La **Erro! Fonte de referência não encontrada.** muestra esta relación en forma de U invertida, utilizando los coeficientes estimados del modelo (1) de *PM* y *PM2*. El punto donde se alcanza el mayor efecto de la participación de mercado sobre la inversión es con una participación de mercado del 48.6%.

Considerando solo el efecto lineal de la participación de mercado, un incremento en un punto porcentual de la participación de mercado de los operadores móviles aumenta la inversión en 20.15%.



Gráfica 2. Efecto no lineal de la participación de mercado en la inversión

Fuente: Elaboración propia a partir de las estimaciones realizadas.

Adicionalmente, los resultados muestran que existe un efecto no lineal en el pago de derechos, pues el coeficiente de la variable *lnDerechos2* es significativo y negativo. Un aumento en el pago de derechos incrementará la inversión; sin embargo, si el pago de derechos por el espectro es muy elevado, dominará el efecto negativo sobre la inversión. En el caso del *lnARPU*, esta variable tiene un coeficiente significativo y positivo; indicando que a mayor ingreso promedio por usuario mayor será la inversión por parte de los operadores móviles. El porcentaje de conexiones 3G (*%3G*) presenta un impacto significativo y negativo sobre la inversión. Por su parte, la cantidad de espectro por suscriptor (*Espectro*) tiene un efecto significativo y negativo. La licitación de nuevas bandas del espectro radioeléctrico y mayor cantidad de espectro licitado posibilita e incentiva mayores inversiones.

Las variables relativas a las características de mercado o de control, como el porcentaje de personas que viven en zonas urbanas, el ingreso per cápita, el tamaño de mercado y el PIB per cápita son significativas y positivas. Otros autores como Cambinia, et al. (2017), Gutierrez et al. (2000), Jeanjean et al. (2017) y Jeanjean et al. (2019) han hallado impactos positivos de estas variables sobre la inversión.

Finalmente, del Cuadro 3 se puede advertir que las variables que mayor impacto generan en la inversión de los operadores móviles se encuentran el pago de derechos y la concentración de mercado (medida a través de la participación de mercado), seguido de la eficiencia (medida a través de cantidad de espectro por suscriptor).

CONCLUSIONES

Este artículo presenta evidencia empírica de la existencia de una relación en forma de U invertida entre competencia y la inversión, lo que es consistente con el resultado hallado por Houngbonon et al. (2016). La participación de mercado tiene un efecto positivo sobre la inversión; sin embargo, si la participación de mercado es muy elevada se desincentiva la inversión. El valor de la participación de mercado que maximiza la inversión es 48.6%.

Por su parte, si se considera solo el efecto lineal de la participación de mercado sobre la inversión, se encuentra que por cada 1% adicional en la participación de mercado, la inversión aumentará en un 20.15%. Esto es consistente con los hallazgos de Genakos et al., (2015) y Kang et al., (2012), quienes encuentran que mercados con una concentración mayor tendrán incentivos a invertir. Otros factores que afectan positivamente la inversión son el pago de derechos, la disponibilidad de espectro a través de las licitaciones, el ingreso promedio por usuario, el porcentaje de población urbana, el ingreso per cápita, el PIB per cápita y el tamaño de mercado, mientras el porcentaje de conexiones 3G y la cantidad de espectro por suscriptor impactan negativamente la inversión.

Cabe señalar que el presente estudio no aborda posibles problemas de endogeneidad que la literatura señala respecto a las variables de competencia. Tampoco estudia los posibles efectos de corto y largo plazo de los factores que influyen en la inversión. En este sentido, futuras líneas de investigación podrían abordar estos temas.

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ANEXO

El Cuadro 4 muestra las pruebas estadísticas. De acuerdo con las pruebas estadísticas se estima un modelo con efectos fijos y efectos temporales, como lo indican las pruebas de Breusch-Pagan, la prueba F estadística, la de Hausman y estadístico de Wald. Por su parte, no se presentan problemas de autocorrelación entre las variables independientes y el término de error de acuerdo con el estadístico de Wooldridge. Sin embargo, en los modelos (3), (4) y (5), se presentan problemas de heteroscedasticidad y correlación contemporánea, mientras que en el modelo (1) y (2) solo existen problemas de la última. Para solucionar esto, se utilizó el modelo de Errores Estándar Corregidos para Panel (PCSE).

Cuadro 4. Pruebas estadísticas de los modelos lineales

Pruebas estadísticas	Modelo (1)	Modelo (2)	Modelo (3)	Modelo (4)	Modelo (5)
Prueba de Breusch-Pagan (para Efectos aleatorios)	0.00	0.00	0.00	0.00	0.00
P-value	(1.0000)	(1.0000)	(1.0000)	(1.0000)	(1.0000)
Prueba F estadística para Efectos fijos	13.47	5.30	11.79	11.79	7.29
P-value	(0.0000)	(0.0097)	(0.0003)	(0.0003)	(0.0023)
Prueba de Hausman (efectos fijos vs efectos aleatorios)	28.33	8.60	12.65	12.65	14.83
P-value	(0.0002)	(0.0135)	(0.0055)	(0.0055)	(0.0625)
Prueba de efectos individuales (Wald F estadístico)	11.79	11.79	11.79	11.79	11.79
P-value	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Prueba de efectos temporales (Wald F estadístico)	18.34	20.26	13.09	14.05	18.43
P-value	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Prueba de Wooldridge (Autocorrelación)	6.978	9.889	3.376	6.199	5.364
P-value	(0.1184)	(0.088)	(0.2075)	(0.1305)	(0.1465)
Prueba modificada de Wald (Heteroscedasticidad)	2.57	2.650	8.61	8.61	6.89
P-value	(0.4636)	(0.4486)	(0.0350)	(0.0350)	(0.0756)
Prueba de Breusch-Pagan (LM de correlación)	22.352	22.305	15.628	15.628	15.085
P-value	(0.0001)	(0.0001)	(0.0014)	(0.0014)	(0.0017)
Diagnóstico de multicolinealidad (Media FIV)	2.61	4.57	6.23	3.35	3.62
Valores Eigen e índice de condición	(0.0722)	(0.0014)	(0.0009)	(0.0145)	(0.0053)

Fuente: Elaboración propia.

Concentración en las telecomunicaciones móviles

"La concentración es parecida al colesterol: hay concentración que es buena y concentración que es mala".

Thomas Philippon, *The Great Reversal, 2019*

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BIOGRAFÍA

Jesús Zurita-González es un economista mexicano educado en la Universidad Autónoma Metropolitana (UAM) y en la Universidad de Minnesota, con estudios de doctorado en economía. Ha trabajado en los sectores público y privado diseñando medidas y políticas públicas para mejorar la competitividad de empresas y gobiernos estatales y municipales, así como para impulsar la eficiencia de la economía. Como Director General del Centro de Capital Intelectual y Competitividad, institución socia en México del Foro Económico Mundial (WEF), contribuyó a elaborar el Plan Nacional de Competitividad de la República Dominicana y a asesorar al ex presidente de este país Leonel Fernández en el diseño de políticas públicas. Ha realizado consultoría en temas de subastas y competencia económica para Pemex y el Banco de México, y ha sido profesor del departamento de economía de la UAM desde 1987. Desde inicios de 2015 labora como Director General Adjunto de Investigación en Políticas Públicas en el Centro de Estudios del Instituto Federal de Telecomunicaciones de México.

RESUMEN

En este trabajo se analiza la concentración y sus efectos en las telecomunicaciones móviles. Con una muestra de cincuenta países tomada de la Matriz Inalámbrica Global de Merrill Lynch, se observa que entre 2010 y 2020 disminuye el número de operadores a nivel global, pero también el IHH. En un modelo de datos de panel con efectos fijos se encuentra que al aumentar el IHH también aumenta el ARPU, lo que beneficia a los operadores con mayor participación de mercado. Con un modelo de suavizamiento exponencial se calcula el contrafactual del precio real de la telefonía móvil en México entre 2014 y 2020, encontrándose que este precio es mayor en aproximadamente diez por ciento al efectivamente ocurrido con la reforma de telecomunicaciones de 2013, por lo que esta reforma ha contribuido a elevar el bienestar de los consumidores mexicanos de servicios móviles

Palabras clave

Telecomunicaciones móviles, México, precio, reforma de telecomunicaciones de 2013.

INTRODUCTION

En este trabajo se analiza la concentración y sus efectos, así como su relación con variables importantes que reflejan la evolución de la competencia en las telecomunicaciones móviles, como el ingreso promedio de los operadores (ARPU), que se utiliza en la literatura como una buena aproximación al comportamiento del precio[1], la inversión por suscriptor (capex por suscriptor), la penetración y el ingreso per cápita. Se utiliza una muestra de cincuenta economías avanzadas y emergentes tomada de la Matriz Inalámbrica Global de Merrill Lynch (Global Wireless Matrix, GWM) y se encuentra que la concentración, medida con el número de operadores, aumentó durante el período 2010-2020, mientras que medida con el índice Herfindahl-Hirschman (IHH) disminuyó en el mismo período. En un modelo econométrico de datos de panel con efectos fijos se observa que, controlando por el capex por suscriptor, la penetración y el ingreso per cápita, la variable IHH es significativa para explicar el ARPU, mientras

[1] Al dividir los ingresos entre el número de suscriptores, el comportamiento del ARPU es semejante al del precio.

que el número de operadores no lo es. En particular, se obtiene que al aumentar el IHH se eleva el ARPU, lo que indica que una concentración más elevada se refleja en mayor ARPU, beneficiando a los operadores que tienen una participación de mercado mayor. En un ejercicio econométrico de series de tiempo en el que se utiliza un modelo de suavizamiento exponencial (Holt-Winters exponential smoothing), se calcula el contrafactual del precio real de la telefonía móvil en México (esto es, el precio real que habría ocurrido si la reforma de las telecomunicaciones de 2013 no se hubiera realizado). Se encuentra que, entre 2014 y 2020, dicho precio se ubica siempre por encima del que efectivamente ocurrió, siendo superior en aproximadamente diez por ciento durante los últimos tres años, por lo que la reforma ha contribuido a incrementar el bienestar de los consumidores mexicanos de servicios móviles.

La concentración es un fenómeno que preocupa y ocupa a los analistas, académicos y autoridades relacionadas con la industria de las telecomunicaciones, por las posibles consecuencias que puede tener sobre el desarrollo de esta industria y en el bienestar de los consumidores.

Las consecuencias económicas de una concentración alta y creciente del mercado han sido objeto de un intenso debate político y académico durante los últimos años, principalmente en Estados Unidos y Europa. Por un lado, el aumento de la concentración (asociado con el surgimiento de las llamadas ’empresas superestrellas’) se ha interpretado como una señal de un entorno competitivo en el que el ganador se lo lleva todo, en el que los productores más eficientes e innovadores obtienen una mayor participación de mercado. Por otro lado, se ha considerado que una mayor concentración es el resultado de una menor competencia asociada con un mayor poder de mercado de las empresas, y que no es producto de los avances tecnológicos en las principales empresas.

En particular, las telecomunicaciones móviles exhiben economías de escala y economías de alcance, así como efectos de red. Debido a ello, a medida que transcurre el tiempo es probable que la industria tienda a concentrarse en pocos operadores. Y algunos de estos pueden tener una participación de mercado muy superior a los demás, así como poder sustancial de mercado. Sin duda, una preocupación permanente analistas, académicos y autoridades, ha sido como la concentración puede afectar la competencia y el bienestar de los consumidores.

El premio Nobel Selten captó el fenómeno de concentración que ocurre en algunas industrias en su famoso artículo *A simple model of imperfect competition, where 4 are few and 6 are many* (Selten, 1973). En un trabajo más reciente denominado *Two are few and four are many: Number effects in experimental oligopolies* (Huck y Oechssler, 2004), Huck et. al. propone que este fenómeno puede haberse profundizado, como parece estar ocurriendo ahora en las telecomunicaciones móviles.

Desde la realización de esos estudios, los mercados han evolucionado debido a las nuevas tecnologías, la mayor compartición de infraestructura, el cambio en los marcos regulatorios, el fortalecimiento de las plataformas sobre el Internet y la inversión en redes troncales, así como la creación de redes virtuales. En especial la red 5G es probable que cree una disrupción importante con relación a la evolución pasada de las redes previas, cuyo desarrollo fue gradual. Esta disrupción es posible que se acompañe de inversiones importantes para su despliegue, lo que sin duda puede afectar la concentración en la industria de las telecomunicaciones móviles.

En este trabajo se realiza un análisis de la evolución del número de participantes y de sus participaciones en la provisión de servicios móviles en diversas economías avanzadas y emergentes, explorando los efectos de la concentración a nivel internacional. Se revisa la evolución de los precios y de los ingresos de los operadores (ARPU).

El propósito es detectar si ha habido una reducción en el número de operadores en este conjunto de países, reportar cual ha sido la evolución, en la última década, de esta variable, al igual que de la medición más utilizada de concentración, el índice Herfindahl-Hirschman (IHH), así como analizar los efectos de la concentración sobre el ingreso promedio por usuario (conocido como ARPU por sus siglas en inglés) de los operadores, variable relevante asociada a la competencia. Esto se lleva a cabo a través de una exploración econométrica en que el número de operadores y el IHH aparecen como variables explicativas del ingreso promedio por usuario.

En el ejercicio econométrico realizado, se consideran como variables de control otros indicadores relacionados con la concentración, como el capex por suscriptor, la penetración de la telefonía móvil y el PIB per cápita. Se encuentra que al incrementarse el IHH el ARPU también aumenta, lo que sugiere que una mayor concentración eleva los ingresos de los operadores con mayor participación de mercado. El número de operadores, en contraste, no resulta una variable significativa para explicar el ARPU.

En la sección 2 se realiza una revisión bibliográfica sobre la concentración y sus posibles efectos en la competencia y el bienestar de los consumidores, particularmente en las telecomunicaciones móviles.

En la sección 3 se consigna la evolución del número de operadores y del índice de concentración más utilizado para medir esta variable, así como también se reporta la evolución de otras variables de las telecomunicaciones móviles relacionadas con la concentración y la competencia.

En la sección 4 se describe el análisis econométrico con datos de panel realizado para tratar de identificar el efecto de la concentración en una variable importante para la competencia[2]: el ARPU de los operadores. Para detectar con mayor precisión este efecto, se utilizan variables de control que pueden también afectar el ARPU, como la penetración de la telefonía móvil, el PIB per cápita y el capex por suscriptor.

Finalmente, en la sección 5 se plantean las conclusiones y recomendaciones.

REVISIÓN BIBLIOGRÁFICA

En Viscusi y Sappington, 2018 los autores presentan una importante discusión que es útil para enmarcar los análisis que se han realizado y continúan realizándose sobre la concentración y su importancia para la competencia y el bienestar de los consumidores, incluyendo los trabajos mencionados en esta sección. Ellos arguyen acerca de la correlación entre concentración y el margen precio-costo *(mark up*) y plantean la dificultad de distinguir entre correlación y causalidad en esta relación. Indican que en la literatura se ha encontrado una correlación positiva entre algún índice de concentración y el margen precio-costo (ver Cowling y Waterson, 1976, por ejemplo). Cuando un mercado está relativamente concentrado, tiende a registrar un margen precio-costo mayor respecto a cuando no lo está. La pregunta relevante, se cuestionan los autores, es qué debe concluirse de esta correlación; ¿debería intervenirse a las industrias que registran alta concentración, o tomar una actitud más laxa frente a esto?

Los autores señalan que existen dos posibles explicaciones a la correlación. Una de ellas la denominan la hipótesis de poder de mercado, en la que se considera que existe una relación causal entre una elevada concentración y un margen precio-costo significativo. Esta hipótesis parte de la idea de que entre más concentrada está una industria, menos agresivamente compiten las empresas y por ello más elevado es el margen precio-costo. Este resultado es consistente con lo que se señala en la siguiente sección sobre el modelo de Cournot. Entre menor sea el número de oligopolistas en un mercado, mayor será el margen precio-costo. Adicionalmente, es posible que conforme el número de productores disminuya se facilite la colusión y eso eleve la concentración. Así, un margen precio-costo alto se produce debido a que existe una elevada concentración.

La otra hipótesis que se propone como explicación de la relación entre concentración y margen precio-costo, es que la concentración observada no causa el margen precio-costo, sino que tanto la alta concentración como el margen precio-costo elevado se deben a un tercer factor. El argumento que sostiene esta hipótesis es que se considera que unas cuantas empresas tienen una ventaja por ser más eficientes que sus competidores, lo que Viscusi y Sappington llaman ventaja diferencial de eficiencia. La ventaja puede deberse a menores costos o a mejores productos y servicios. En algunas industrias existen firmas con la ventaja diferencial de eficiencia que tenderán a dominar el mercado, por lo que la concentración será considerable y tales firmas podrán fijar un precio significativamente mayor que el costo de producción, por lo que el margen precio-costo será elevado. Bajo esta hipótesis la concentración no causa el margen precio-costo, sino que ciertas condiciones de mercado hacen que simultáneamente se generen alta concentración y un elevado margen precio-costo. La correlación positiva entre el IHH y el margen precio-costo de la industria, que aparece en la solución de Cournot de la siguiente sección, es un ejemplo de la hipótesis de eficiencia diferencial. Si una industria tiene empresas con costos relativamente bajos, dichas firmas tenderán a fijar precios por debajo de sus competidores, lo que causará que logren una alta participación de mercado. Debido a esto, habrá una concentración significativa. Al mismo tiempo, como resultado de sus bajos costos de producción, estas firmas con ventaja diferencial de eficiencia registrarán un margen precio-costo importante que, cuando se pondere por su alta participación de mercado (como se establece en la sección que sigue), resultará en un margen precio-costo alto para la industria. Si la autoridad interviniera y esta hipótesis fuera la que rige, sería absurdo penalizar empresas por ser mejores y se impediría que continúen haciendo lo que la sociedad desea que hagan: producir mejores bienes y servicios a costos menores.

Como los autores comentan, determinar si el margen precio-costo considerable de una empresa o una industria es el resultado de ofrecer lo que desean los consumidores a un costo inferior, o si se debe a ejercer el poder de mercado anticompetitivamente, es un reto central para la política de competencia.

En Katz, 2019, el autor parece inclinarse por la ventaja diferencial de eficiencia, ya que plantea que un nivel de competencia excesivo en una industria intensiva en capital, como las telecomunicaciones, tiende a impactar tanto las eficiencias dinámicas como estáticas de la industria, afectando así el bienestar de consumidores. Señala que la inversión y la innovación se incrementan con el crecimiento de la competencia hasta un punto óptimo de

[2] En Faccio y Zingales, 2017 se utiliza información sobre la evolución del ARPU después de la reforma de las telecomunicaciones de 2013 para señalar la importancia de las medidas asimétricas tomadas por el IFT para mantener bajo control el poder de mercado del operador preponderante

competencia moderada, a partir del cual, si la competencia se intensifica, el incentivo para innovar comienza a disminuir.

Para este autor, si la expectativa de rentabilidad más alta es la causal del incentivo a innovar, el incremento indiscriminado de la competencia (y la consecuente reducción en rentabilidad) reduce el incentivo a innovar. Katz considera que en las telecomunicaciones existe un grado de concentración industrial óptimo que produce beneficios a consumidores al mismo tiempo que asegura la sostenibilidad del sector, al generarse importantes economías de escala, eficiencia operacional de grandes operadores y mayor capacidad de inversión y despliegue de infraestructura.

Después de revisar la literatura empírica sobre los efectos de la concentración en la industria de las telecomunicaciones, encuentra que existen eficiencias dinámicas, aunque con matices. Así, el aumento de la inversión en un inicio (que Katz denomina el primer orden) puede resultar en reducción de precios con posterioridad (en el segundo orden); en algunos casos, puede ocurrir un efecto compensatorio (*trade-off*) entre eficiencias estáticas y dinámicas, como reducciones de costos en el corto plazo que se trasladan a disminuciones de precios en el mediano plazo. Aunque no existe un modelo común a todas las concentraciones, en la literatura se identifican algunos efectos, según Katz:

Una consolidación de 4 a 3 operadores siempre genera una reducción de precios, pero no siempre un aumento de la inversión.

Una consolidación de 5 a 3 no genera una reducción inmediata de precios o aumento de la inversión, pero prepara a la industria para la migración a la nueva generación tecnológica.

Una concentración de 4 a 3, por la salida de un operador disruptor (*maverick*), resulta en un retorno temporal a la disciplina de precios, y luego en una reducción, pero conduce a un salto inmediato en la inversión.

En Cave, 2018, el autor plantea la hipótesis de que, después de tres décadas de estabilidad, ahora existe una perspectiva de cambio significativo en la estructura vertical y horizontal del mercado móvil. Del lado de la oferta, los factores importantes son, en primer lugar, la disponibilidad de una forma nueva y poderosa de conectividad móvil, la red 5G y, en segundo lugar, han surgido redes definidas por software (*software defined networks*) que permiten utilizar una red única para proporcionar una variedad de servicios heterogéneos (denominados *slices* en la literatura anglosajona). Por el lado de la demanda, la transformación digital de toda la economía (y no solamente del sector de las comunicaciones) crea la necesidad de diversas funciones de comunicaciones que operan en un universo mucho más amplio de servicios transformados digitalmente.

Los operadores móviles tendrán que enfrentar el hecho de que sus clientes contratan ahora servicios directamente con otras empresas que brindan los servicios transformados de manera integrada y, por lo tanto, estos operadores corren el riesgo de ser reemplazados en su vínculo directo con los usuarios finales, para convertirse en el proveedor mayorista de un producto de comunicaciones ampliado pero transformado en un servicio estandarizado (*commodity)*. Según Cave, también se podrían observar menos redes de acceso por radio (Radio Access Networks o RAN por sus siglas en inglés), así como la desintegración vertical (parcial) de los operadores de redes móviles. Los cambios regulatorios implícitos pueden incluir una regulación más estricta de menos RAN, así como la necesidad de que las autoridades de competencia realicen análisis de mercados en los cuales los operadores de redes venden cada vez más sus servicios a una variedad de proveedores heterogéneos de contenido y aplicaciones, algunos de los cuales pueden poseer poder de mercado significativo.

Para Cave, por las mayores frecuencias en que operará la red 5G se requerirá de mayores inversiones que en las redes anteriores, lo que es posible que conduzca a mayor concentración en la industria.

En WIK, 2015, los autores de este reporte para *Ofcom* elaboran un análisis basado en la evidencia del efecto de la competencia sobre la inversión y el bienestar del consumidor en el sector de telecomunicaciones móviles. Se explora la hipótesis respecto a si existe un círculo virtuoso entre competencia e inversión, o si una competencia más intensa puede afectar negativamente la inversión perjudicando el bienestar de los consumidores a largo plazo. La evaluación se basa en un análisis empírico de 12 países, ocho de los cuales son europeos (Reino Unido, Austria, Francia, Alemania, Irlanda, Italia, Países Bajos, España) y cuatro que no lo son (Australia, Japón, Corea del Sur y EE. UU.).

Sobre la base del análisis, incluida la evaluación econométrica, no se encontró relación entre la consolidación o una mayor concentración en los mercados móviles y un aumento de la inversión. Esto se debe, según los autores, a que la inversión tiende a seguir ciclos de largo plazo que parecen no estar relacionados en gran medida con la evolución de la estructura del mercado en los países analizados. La evidencia tampoco confirma que la consolidación y una mayor concentración en los mercados móviles están vinculados a una mejoría en el bienestar de los consumidores. Los autores consideran que las variables con el mayor potencial impulsor del bienestar del consumidor: velocidades de conexión notablemente más altas, penetración y mayor uso de datos, se encuentran en el lado de la demanda. Velocidades de conexión más elevadas se vinculan a una mayor penetración de los teléfonos inteligentes, y tanto la mayor penetración de la telefonía móvil como el mayor uso de datos están asociados a un uso intensivo de videos móviles. Por lo tanto, estos factores de demanda tienen un papel importante en la explicación de un mayor bienestar para el consumidor.

En Fruits, 2019, los autores revisan 18 análisis empíricos, publicados en los cinco años previos, que estudian los efectos de cambios en la concentración del mercado (posiblemente por fusiones) en el sector inalámbrico de la industria de las telecomunicaciones. De esos 18 estudios, ocho analizan los cambios en la concentración del mercado en múltiples jurisdicciones entre 2000 y 2015, mientras que diez se enfocaron en fusiones específicas.

De los diez estudios relacionados con fusiones específicas, aproximadamente en la mitad se encontró que los precios disminuyeron después de una fusión, mientras que en el resto sucede lo contrario ya que los precios aumentaron. Así, respecto al efecto de fusiones sobre el precio, incluidas las denominadas fusiones 4 a 3 operadores, los resultados resultan ambiguos. Incluso diferentes estudios de la misma fusión encuentran efectos marcadamente diferentes en los precios, que van desde disminuciones significativos hasta incrementos considerables[3].

De aquellos estudios que consideraron el efecto sobre la inversión en fusiones 4 a 3, se encontró que los gastos de capital o capex, un sustituto de la inversión, aumentaron después de la fusión. Según estos autores, varios estudios recientes que analizaron de manera más amplia los efectos de la concentración del mercado en la industria de las telecomunicaciones móviles indican que los niveles más altos de inversión ocurrieron en mercados con tres operadores (aunque la inversión no fue significativamente menor en los mercados con cuatro operadores).

En Baker, 2019, el autor provee el contexto para entender mejor la política de competencia implementada en Estados Unidos en las últimas décadas y, como consecuencia, en otros países que han adoptado, aunque sea parcialmente, su enfoque, lo cual ha tenido efectos sobre la concentración en varios sectores de la economía incluyendo las telecomunicaciones. Comenta sobre lo que denomina el fracaso del enfoque de la Universidad de Chicago que consideraba, a mediados de los años setenta del siglo pasado, que la política de competencia se había convertido en demasiado intrusiva y estaba afectando la productividad y la eficiencia de la economía estadounidense[4]. Según Baker, se esperaba que la relajación de las normas antimonopolio permitiera a las empresas lograr una mayor eficiencia, que se traduciría en una reducción de sus costos, lo que haría posible transferir parte de los ahorros a los consumidores a través de precios más bajos. También mejorarían sus productos y servicios e innovarían de manera más rápida y extensa, impulsando el crecimiento económico. Pero los proponentes de la escuela de Chicago estaban haciendo una apuesta. Consideraban que estas eficiencias compensarían con creces cualquier aumento del riesgo de que las empresas ejercieran poder de mercado. Si la apuesta funcionaba, los consumidores obtendrían mayor bienestar a largo plazo, lo cual contrarrestaría la pérdida en bienestar asociada con las prácticas anticompetitivas.

Según Baker, ahora es claro que los proponentes de la escuela de Chicago perdieron su apuesta. Desde la implementación de la desregulación antimonopolio, el poder de mercado se ha ampliado, sin que ello acompañe a las ganancias a largo plazo en el bienestar del consumidor. En cambio, el dinamismo económico y la tasa de crecimiento de la productividad han ido disminuyendo. Los daños derivados del ejercicio del poder de mercado se han extendido más allá de los compradores y proveedores directamente afectados, generando un crecimiento económico más lento y una distribución sesgada de la riqueza. Cualquier ganancia de eficiencia que puedan haber logrado los cambios inspirados por la escuela de Chicago, en su opinión, no han compensado los efectos de poder de mercado de la desregulación antimonopolio.

En Berry y Morton, 2019 los autores, basándose en diversos estudios de organización industrial, resumen algunas de las principales causas posibles de la expansión de los márgenes de ganancia. Las posibilidades incluyen un aumento en los costos fijos o hundidos, efectos de red, efectos de monopsonio en los mercados laborales, un comportamiento enfocado en la búsqueda de rentas, así como los efectos de la globalización. Por ejemplo, los costos fijos (o hundidos) más altos pueden conducir a menos empresas en un mercado, lo que puede resultar en una competencia más laxa, precios más altos y una reducción del bienestar del consumidor. Por otro lado, en algunos casos, los costos fijos (o hundidos) más altos pueden ser el resultado endógeno de productos o de tecnología de producción mejorados que reducen el costo marginal (Sutton, 1991). De esta forma, los márgenes más altos observados pueden o no estar asociados con precios más altos y menor bienestar del consumidor.

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[3] Los autores identifican una serie de factores que contribuyen a explicar los distintos resultados, incluyendo: falta de medidas homogéneas o comunes, entre los estudios, de precios y sus efectos; diferentes periodos elegidos, así como dificultades para incorporar variaciones en geografía, demografía y regímenes regulatorios entre jurisdicciones (lo que también puede crear un problema de sesgo de endogeneidad)

[4] Este enfoque se expresa en el famoso libro de Robert H. Bork, un juez federal de aquel tiempo (Bork, 1978).

Respecto a la aplicación de las leyes antimonopolio y la política de competencia, se examinan no sólo porque una política antimonopolio debilitada ofrece una posible explicación del aumento de los márgenes de ganancia, sino también porque la política de competencia ofrece herramientas para abordar el aumento en estos márgenes. Em virtud de la incertidumbre sobre si ha habido o no un aumento en márgenes así como sobre el tamaño de ese probable aumento, y debido a que estos márgenes varían en las distintas industrias, las recomendaciones de política de los autores se centran en aquéllas que son convenientes en diversas condiciones, por ejemplo, garantizar que la entrada al mercado no sea bloqueada, que las empresas predominantes no realicen acciones que pongan en desventaja a sus rivales y perjudiquen la competencia, y que la conducta anticompetitiva en los mercados laborales no debe permitirse. Además, los autores indican que las políticas regulatorias, comerciales y fiscales también pueden resultar valiosas para abordar los daños asociados con el aumento de los márgenes de ganancia.

En Faccio y Zingales, 2017 los autores estudian cómo los factores políticos dan forma a la competencia en el sector de las telecomunicaciones móviles. Tratan de mostrar que la forma en que un gobierno diseña las reglas del juego tiene un impacto en la concentración, la competencia y los precios. En su trabajo señalan que la regulación a favor de la competencia reduce los precios, pero no perjudica la calidad de los servicios o la inversión. Según ellos, los gobiernos más democráticos tienden a diseñar reglas más competitivas, aunque los operadores políticamente bien relacionados pueden distorsionar las reglas a su favor, restringiendo la competencia. De acuerdo con los autores, la intervención del gobierno tiene grandes efectos redistributivos. Según ellos, los consumidores de EE. UU. podrían ahorrar 65 mil millones de dólares al año si los precios de los servicios móviles de ese país estuvieran en línea con los alemanes, y 44 mil millones de dólares si estuvieran en línea con los daneses.

En este trabajo, los autores inician el artículo refiriéndose al caso mexicano. Señalan que, en 2014, el magnate mexicano de las telecomunicaciones Carlos Slim era la persona más rica del mundo según Forbes, con una riqueza estimada de casi 80 mil millones de dólares. Para 2016, Slim había caído al cuarto lugar de acuerdo con Forbes, con su riqueza alcanzando sólo 47 mil millones de dólares, al menos en parte porque las acciones de su operador de telefonía móvil, América Móvil, redujeron sustancialmente su precio en 2015 y principios de 2016 a raíz de nuevas normas mexicanas en las telecomunicaciones.

Señalan que, además, entre 2012 y 2016 el ingreso promedio por usuario (ARPU) en México se redujo en un 47 por ciento y el tráfico aumentó en un 59 por ciento. Al mismo tiempo, la riqueza de Carlos Slim disminuyó en más de 30 mil millones de dólares. Para los autores, este episodio plantea varias preguntas importantes. ¿Es esta asociación entre nuevas reglas para promover la competencia y la riqueza de Slim sólo una coincidencia? ¿Puede la intervención del gobierno generar mercados más competitivos? Si puede, ¿por qué no todos los gobiernos promueven la competencia? ¿Por qué el precio de la misma canasta de servicios de telefonía móvil varía mucho en todo el mundo, al igual que el precio de la banda ancha móvil? La reforma de telecomunicaciones mexicana fue, para los autores, un claro ejemplo de cómo se puede promover la competencia con modificaciones a la regulación y las normas de competencia.

CONCENTRACIÓN: NÚMERO DE OPERADORES E ÍNDICE HERFINDAHL-HIRSCHMAN

En esta sección utilizamos una muestra de economías avanzadas y emergentes para analizar la evolución, en el período 2010-2020, del número de operadores y del índice Herfindahl-Hirschman (IHH) a nivel global. La muestra seleccionada es la que la consultora Merrill Lynch utiliza en su reconocida publicación denominada Global Wireless Matrix (Matriz Inalámbrica Global). Esta muestra consta de 50 países, de los cuales aproximadamente la mitad son economías emergentes y el resto avanzadas. La lista de estos países se reporta en el Apéndice.

Posteriormente, utilizando el modelo de Cournot se muestra cómo el número de operadores y el IHH se relacionan con la competencia, ilustrando por qué representan mediciones útiles de la concentración.

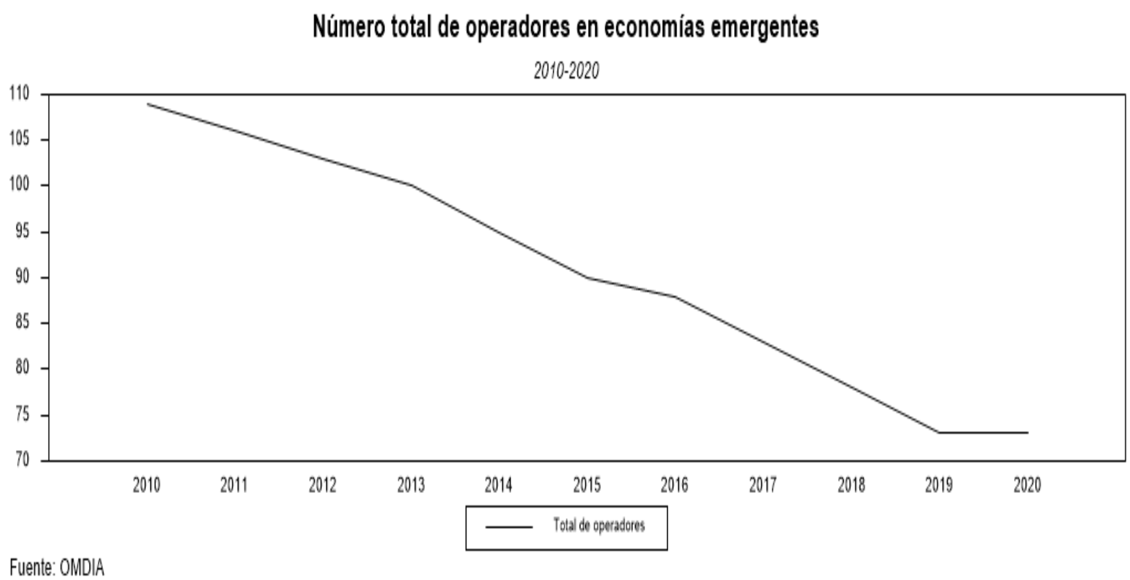
Evolución del número de operadores a nivel global

En las gráficas que se presentan en esta sección se observa la disminución en el número de operadores que ocurrió en la economía mundial, considerando la muestra utilizada, entre 2010 y 2020. Se manifiesta tanto para la muestra en general como para las economías avanzadas y las economías emergentes en particular.

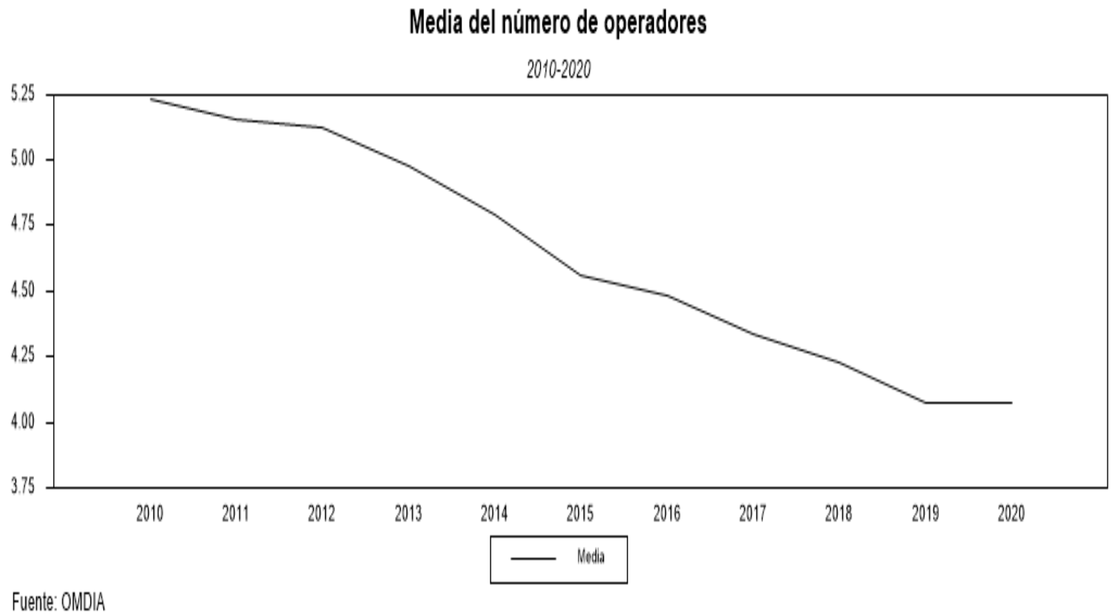
En las primeras dos gráficas se observa cómo en las economías avanzadas el número de operadores en las telecomunicaciones disminuyó a nivel global en la segunda década del siglo XXI. En la primera se muestra la evolución del número de operadores en las economías avanzadas y en la segunda en las economías emergentes.

En la primera gráfica se observa que el número de operadores aumentó ligeramente de 95 en 2010 a 97 en 2012, pero a partir de ahí registró una disminución continua hasta alcanzar 86 operadores en 2017, cifra que aumentó en un operador en 2018 para luego regresar a 86 en 2019 y 2020.

En la segunda gráfica, relativa al número de operadores en economías emergentes, se observa que tal número disminuyó continuamente desde 2010 hasta 2019. Iniciando en poco más de 105 operadores hasta alcanzar menos de 75 en 2019 y 2020.



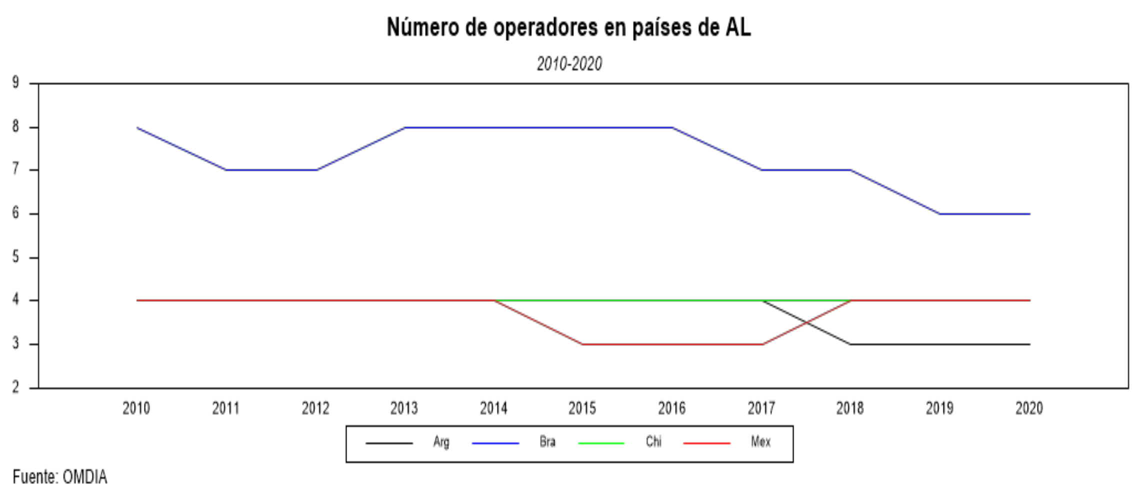
En la siguiente gráfica se muestra la evolución de la media del número de operadores, que pasó de poco más de 5 a cerca de 4 en el período considerado, registrándose una disminución continua a lo largo de la segunda década del siglo XXI.

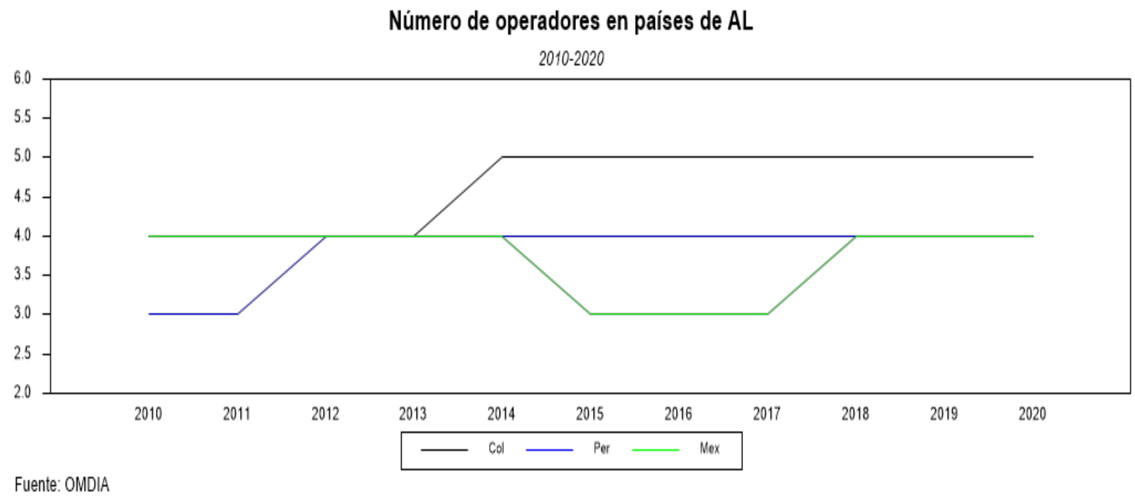


Finalmente, en las siguientes dos gráficas se reporta la evolución del número de operadores en las principales economías de América Latina. En la primera se reporta el comportamiento en Argentina, Brasil, Chile y México, mientras que en la segunda se muestra la evolución en Colombia, Perú y México.

En la primera gráfica se puede ver que Brasil registra el mayor número de operadores, aunque tal número disminuyó durante la década considerada. Chile y México registran el mismo número de operadores al inicio que al final de la década y Argentina disminuyó de 4 a 3 operadores al final.

En la segunda gráfica se observa que Colombia y Perú aumentaron en un operador en el período, mientras que México se mantuvo en los mismos 4 operadores.

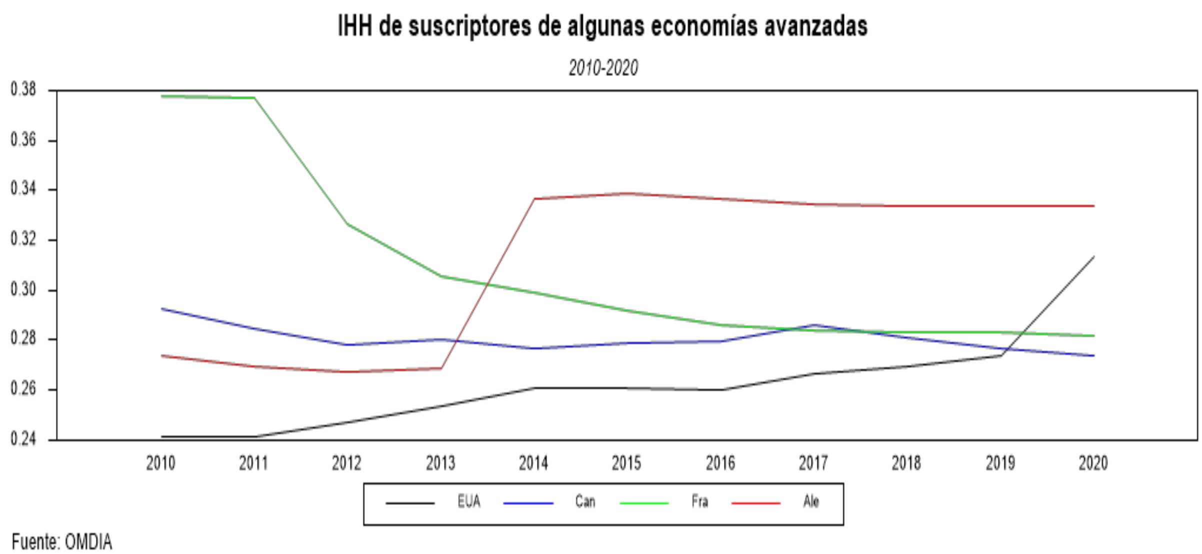




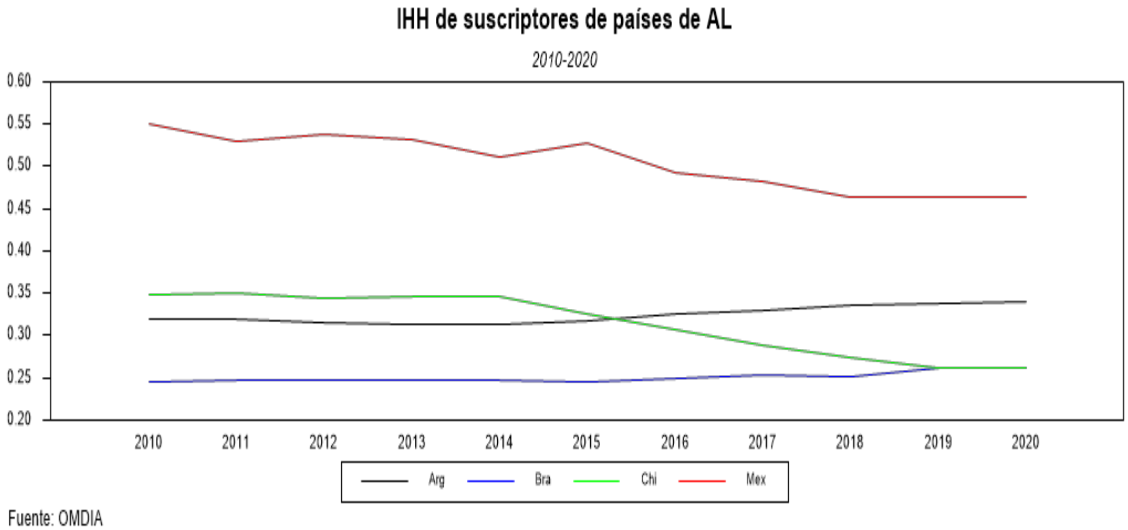
Evolución del IHH a nivel global

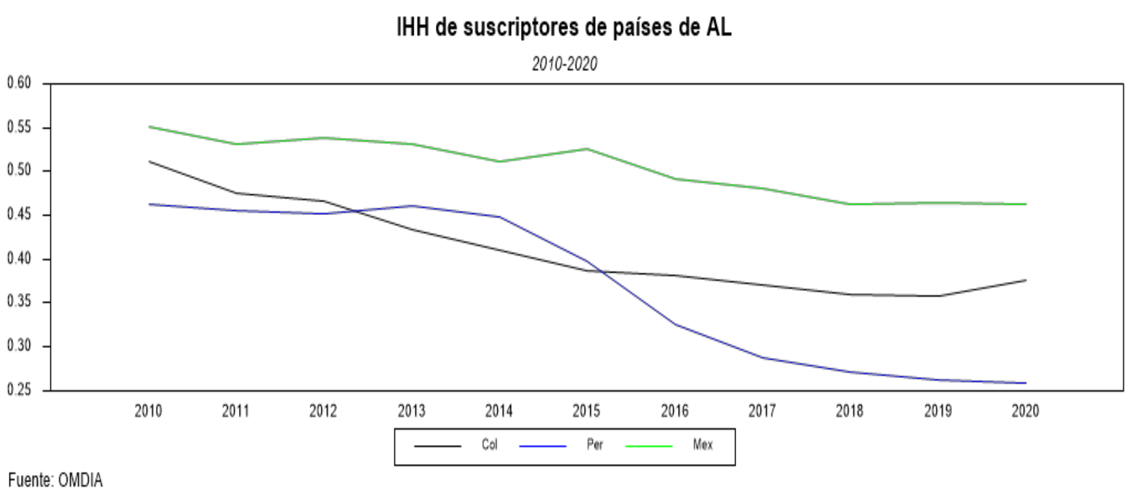
En las gráficas que se presentan en esta sección se observa que el IHH de suscriptores disminuyó, en el período entre 2010 y 2020, en la economía mundial. También se reporta que esto no ocurrió en todos los países, aunque haya sido así en términos generales. En el caso de América Latina se observa que México, Chile, Colombia y Perú disminuyeron su IHH, mientras que en el caso de Argentina y Brasil este índice aumentó ligeramente.

En la siguiente gráfica, la evolución del IHH en algunas economías avanzadas importantes, por su tamaño, es contrastante. Alemania y Estados Unidos registran un incremento del IHH, mientras que Francia muestra una disminución y en Canadá prácticamente se mantiene constante.

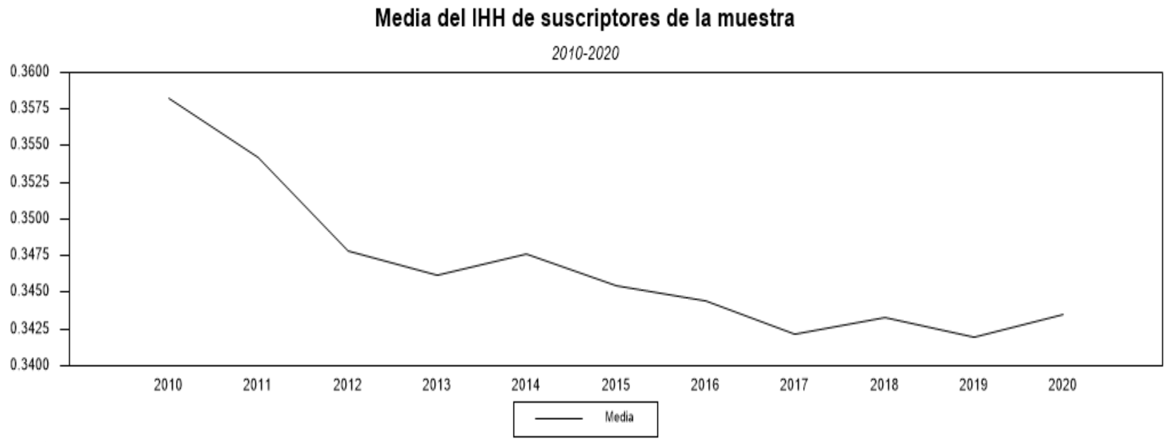


En América Latina, en las dos gráficas que siguen, se observa que México y Chile registran una disminución del IHH, mientras que Brasil y Argentina tienen un ligero aumento. Asimismo, que Colombia y Perú muestran una disminución, que en el caso de Perú es significativa.





Finalmente, considerando en la siguiente gráfica la media del IHH de la muestra, al igual que con el número de operadores se observa que ha habido una disminución en el IHH. Sin embargo, mientras que la disminución del número de operadores es un indicador de mayor concentración, la disminución del IHH revela una menor concentración.



Fuente: OMDIA

El modelo de Cournot: competencia y número de productores en una industria

En este apéndice se utiliza el modelo de Cournot en una versión simplificada para mostrar cómo el número de operadores es importante para la competencia. En los textos de introducción a la economía usualmente se señala que la competencia requiere de un número elevado de competidores, y el modelo de Cournot le da un sentido preciso a esta afirmación. Partimos de una función inversa de demanda lineal en la que $P = 100 - Q$, donde P es el precio del bien o servicio y Q es la cantidad de mercado demandada (nótese que para que $P > 0$ se requiere que $Q < 100$, lo cual se asume sin pérdida de generalidad). Suponemos que hay n productores, por lo que $\sum_1^n q_i = Q$. Si asumimos que el costo marginal de producción es igual a c para todas las empresas, entonces cada firma maximiza sus ganancias $\Pi_i = Pq_i - cq_i$ eligiendo el nivel de producción q_i.

En el máximo de ganancias de cada empresa i, donde $i = 1, 2, \ldots, n$, se obtiene que $100 - \sum_1^n q_j - q_i = c$, es decir que el ingreso marginal es igual al costo marginal. Si suponemos, como es usual en el modelo de Cournot, que $q_i = q$ para toda i, es decir que todas las empresas producen la misma cantidad del bien o servicio, entonces en el óptimo de una firma resulta que $100 - (n+1)q = c$, por lo que la producción de cada empresa es: $q_{Cournot} = \frac{100-c}{n+1}$, así que el nivel de producción total es $Q_{Cournot} = \frac{n}{n+1}(100 - c)$ y el precio es $P_{Cournot} = 100 - Q_{Cournot}$. De aquí obtenemos que cuando n es muy grande, es decir cuando el número de empresas es considerable, se tiene que (en el límite cuando n tiende a ∞), $Q_{Cournot} = 100 - c$ y con ello $P_{Cournot} = c$, es decir que el precio es igual al costo marginal, exactamente lo que ocurre bajo competencia. Es de destacar que, bajo el resultado del modelo de Cournot, el margen precio-costo, dado por $\frac{P-c}{P}$, disminuye conforme el número de productores aumenta, ya que P se aproxima cada vez más a c cuando esto ocurre.

Nótese que también la producción sería la misma que bajo competencia, dado este resultado. En este modelo sencillo se puede también notar que el precio y la producción bajo monopolio serían $P_{mon} = 50 + \frac{1}{2}c$, y $Q_{mon} = 50 - \frac{1}{2}c$, y si en el modelo de Cournot asumimos que hay un solo productor, es decir que $n = 1$, el precio y la cantidad producida serían los mismos que bajo monopolio. El modelo de Cournot representa así una solución intermedia entre monopolio y competencia. A medida que el número de productores aumenta la solución se aproxima cada vez más a la de competencia perfecta, y a medida que el número de productores disminuye la solución se acerca cada vez más a la de monopolio.

El IHH y el poder de mercado

El modelo de Cournot es también útil para establecer una relación teórica positiva entre el IHH y el poder de mercado de las empresas de una industria, lo que puede afectar negativamente la competencia.

El modelo de Cournot de la sección anterior se puede escribir de forma más general señalando que la función inversa de demanda es una función más general de Q[5]. De manera que el ingreso marginal de un oligopolista en el modelo de Cournot lo podemos escribir en forma más general como: $IMa = P + \frac{dP}{dQ} q_i$. También de forma más general podemos considerar que cada oligopolista tiene un costo marginal distinto e igual a c_i.

De tal manera que igualando el *IMa* al costo marginal, la condición de maximización de ganancias, tenemos que: $P + \frac{dP}{dQ} q_i = c_i$, de donde se sigue que $P - c_i = \frac{dP}{dQ} q_i$. Dividiendo ambos lados de esta ecuación entre *P*, se obtiene que: $\frac{P - c_i}{P} = -\frac{dP}{dQ}\frac{Q}{P}\frac{q_i}{Q}$. Nótese que el lado izquierdo de esta ecuación es el margen precio-costo de la empresa ***i***, mientras que en el lado derecho tenemos que $\frac{dP}{dQ}\frac{Q}{P} = \frac{1}{\varepsilon}$, lo que es igual al recíproco (o inverso) de la elasticidad de la demanda, ε, y $\frac{q_i}{Q}$ es la participación de mercado de la empresa *i*. Asumamos que $s_i = \frac{q_i}{Q}$. De esta forma: $\frac{P - c_i}{P} = \frac{s_i}{\varepsilon}$. Es decir que para una empresa típica del modelo de Cournot el margen precio-costo depende de su participación de mercado. Dada una cierta elasticidad de la demanda, si dicha participación se incrementa el margen precio-costo también. Si multiplicamos cada lado de la ecuación por s_i y luego sumamos para todas las empresas, obtenemos:

$$\boldsymbol{\Sigma_1^n \frac{P - c_i}{P} S_i = \frac{1}{\varepsilon} \Sigma_1^n S_i^2 = \frac{IHH}{\varepsilon}} .$$

De esta manera, el margen precio-costo promedio de la industria, donde el margen de cada empresa se pondera por su participación de mercado, es igual al IHH entre la elasticidad de la demanda. Así, un incremento en el IHH, dada la elasticidad de la demanda, implica un mayor margen precio-costo promedio para la industria. En el modelo de Cournot el IHH refleja la desviación de la competencia perfecta en promedio (competencia perfecta implica que el margen es cero, es decir que el precio es igual al costo marginal), es decir que indica la proporción promedio en que se viola la condición de que el precio sea igual al costo marginal. El resultado indica también que entre mayor sea la elasticidad de la demanda (en valor absoluto) menor es el margen precio-costo. La existencia de sustitutos cercanos limita el poder de mercado. El resultado obtenido, además, generaliza el índice de Lerner, que se utiliza para el monopolio. Este índice se refiere al poder de mercado del monopolio, a la capacidad que tiene para elevar el precio por encima del costo marginal. El índice de Lerner muestra que el poder de mercado del monopolio depende del recíproco de la elasticidad de la demanda ($\frac{P-c}{P} = \frac{1}{\varepsilon}$), lo que significa que entre menor sea la elasticidad de la demanda mayor es el poder de mercado del monopolio.

ANÁLISIS ECONOMÉTRICO SOBRE LOS EFECTOS DE LA CONCENTRACIÓN

En esta sección se presenta evidencia empírica relacionada con la competencia en las telecomunicaciones móviles, como la evolución de los precios de la telefonía móvil y del ARPU en las telecomunicaciones móviles. Posteriormente, se presenta una regresión de panel, utilizando datos de la muestra considerada obtenidos de OMDIA, en la que el ARPU aparece como variable dependiente. Adicionalmente, se presenta un ejercicio econométrico que permite comparar, para el caso de México, la evolución del índice real de precios de la telefonía móvil ocurrida a partir de la reforma de telecomunicaciones, comparándola contra un contrafactual que representa lo que hubiera ocurrido de no haber tenido lugar la reforma.

Evidencia sobre el comportamiento de los precios de la telefonía móvil y del ARPU en las telecomunicaciones móviles

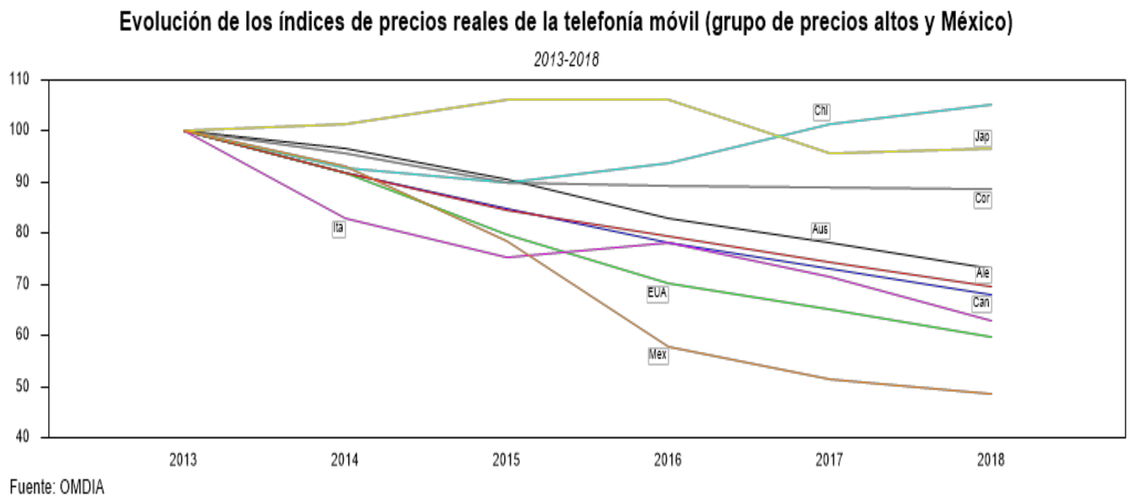
En las gráficas de esta sección se compara a México con otros doce países con respecto a la evolución en el precio real de la telefonía móvil. Se observa que México se ubica entre los países que registraron mayores reducciones en dicho precio. También se compara la evolución del ARPU en nuestro país respecto a la muestra de países de la GWM, reportándose que México registra una disminución claramente mayor que el promedio de la muestra en general y que el promedio de las economías emergentes y avanzadas.

En las siguientes dos gráficas se presenta la evidencia empírica que se pudo recabar de 13 países, incluyendo México, sobre el comportamiento de los precios reales en la telefonía móvil entre 2013 y 2018. México aparece con una

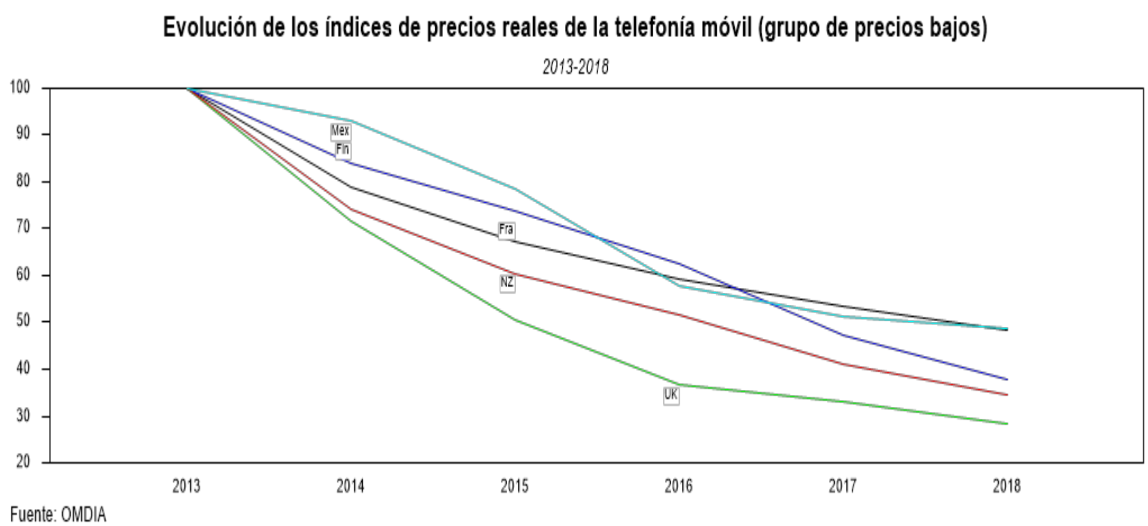
[5]Por ejemplo, una función lineal más general sería: P = A – BQ, donde A y B son constantes positivas. En el modelo de la sección anterior A = 100 y B = 1.

reducción del precio real significativamente mayor que la media (ver cuadro del Apéndice). La reducción en el caso de México, entre 2013 y 2018, es de 51.4 por ciento, en tanto que la del promedio de la muestra es de 36.8 por ciento.

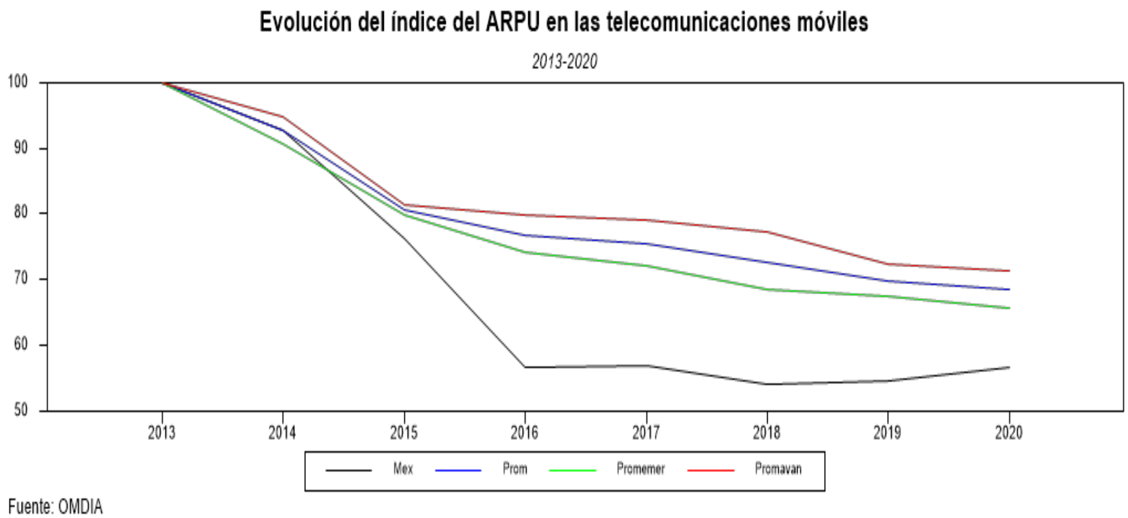
En la primera gráfica se muestra la evolución del índice real de precios en los países de la muestra con menores disminuciones de precios, y se incluye a México para mostrar que se redujo sustancialmente más el precio real de la telefonía móvil que en países asiáticos como Corea del Sur, Japón y China, con precios que casi no variaron. También se observa que la reducción del precio real de la telefonía móvil fue mayor en México que en países como Austria, Alemania, Canadá, Italia y Estados Unidos.



En la segunda gráfica se reporta el comportamiento del índice real del precio de la telefonía móvil en los países de la muestra que exhibieron los mayores decrementos de precios, observándose que México registra una reducción semejante a la de Francia y menor que las disminuciones registradas por el Reino Unido, Nueva Zelanda y Finlandia.



En la gráfica que sigue se observa el comportamiento de un índice (en dólares corrientes) del ARPU en las telecomunicaciones móviles entre 2013 y 2020, que se elaboró utilizando la muestra de países de la GWM. Se hicieron igual a 100 los valores de 2013 de cada país, para comparar más fácilmente la evolución del ARPU. Se observa que México registra una reducción mayor que el promedio de la muestra en este índice. México disminuye en 43.2 por ciento su ARPU, casi doce puntos porcentuales más de disminución que la muestra, cuyo ARPU disminuyó en 31.6 por ciento. Las economías emergentes disminuyeron su ARPU 34.2 por ciento y las avanzadas 28.6, por lo que ambas cifras reflejan una reducción menor a la que registró México en el mencionado período.



ANÁLISIS ECONOMÉTRICO

En esta sección se presentan los resultados de los modelos econométricos. El modelo de datos de panel con efectos fijos relaciona, como variable explicativa, el IHH, y como variable dependiente el ARPU promedio de cada país, obteniéndose que el IHH es una variable significativa y que hay una relación positiva entre el IHH y el ARPU: a mayor IHH mayor ARPU. El modelo de series de tiempo, de suavizamiento exponencial, permite construir, para México, una serie del precio real contrafactual de la telefonía móvil entre 2014 y 2020. Es decir, del precio que hubiera prevalecido en ausencia de la reforma de telecomunicaciones de 2013. Se observa que este precio es mayor que el precio ocurrido con la reforma, lo que indica que los consumidores mexicanos se beneficiaron con tal reforma.

El análisis econométrico se realizó utilizando la muestra de países de la GWM, pero para lograr un panel balanceado se incluyeron 39 países, con datos completos de las variables para el período 2010-2020. Los demás países tenían información incompleta de las variables y tuvieron que excluirse. Se realizó la prueba de Hausman para detectar si las regresiones de panel se debían llevar a cabo con efectos aleatorios o con efectos fijos. La prueba rechazó el modelo con efectos aleatorios en todos los casos y las regresiones se hicieron con efectos fijos. Se realizaron también regresiones de mínimos cuadrados en dos etapas y de mínimos cuadrados ordinarios, pero el mejor ajuste fue el de una regresión de panel con efectos fijos.

Los modelos empleados consideraron el ARPU como variable dependiente. Las variables de control utilizadas fueron la penetración de la telefonía móvil (pen), el PIB per cápita (PIBpc) y el capex por suscriptor (capps), así como dos variables binarias: la dummy1 para detectar el efecto del inicio de la recuperación de la economía después de la crisis financiera, y la dummy2 para detectar el efecto de la pandemia. Para medir la influencia de la concentración sobre el ARPU se usaron tanto el IHH de suscriptores de telefonía móvil como el número de operadores. Excepto por la penetración y las variables dummies, las variables se utilizaron en logaritmos.

En las regresiones con el número de operadores como variable explicativa, esta variable no resultó significativa en ningún caso. En contraste, al utilizar el IHH como variable explicativa en el modelo de datos de panel con efectos fijos, ésta resulta significativa. Los resultados de la regresión de panel con efectos fijos indican que las dos variables binarias resultan no significativas, aunque tienen los signos esperados. La dummy1 registra signo positivo, por la recuperación de la economía mundial luego de la crisis financiera, y la dummy2 negativo, al estar asociada a la pandemia de COVID. Las tres variables de control son significativas al 95 por ciento, al igual que el IHH.

El IHH registra signo positivo, lo que significa que a mayor IHH, es decir a mayor concentración, mayor ARPU (o también que a menor concentración menor ARPU, lo que significaría que el ARPU disminuye con la competencia).

Esto parece haber ocurrido en varios países de la muestra, incluido México, como se consigna en Faccio y Zingales, 2017.

Por su parte, aumentos en el PIB per cápita y en la inversión (capex por suscriptor) producen un incremento en el ARPU. Mayor crecimiento económico implica mayor demanda de servicios de telecomunicaciones móviles, y más infraestructura genera mayores posibilidades de ingreso para los operadores. La penetración resulta con signo negativo porque al aumentar el uso por cada 100 habitantes de teléfonos móviles la escala de operaciones de los servicios de telecomunicaciones móviles se eleva y eso tiende a disminuir los costos de producción y el precio de estos servicios. Es decir que el signo negativo se debe a que la disminución de los costos unitarios se refleja, al menos en parte, en menores precios de los servicios móviles.

Regresión de Panel: Estimación con efectos fijos

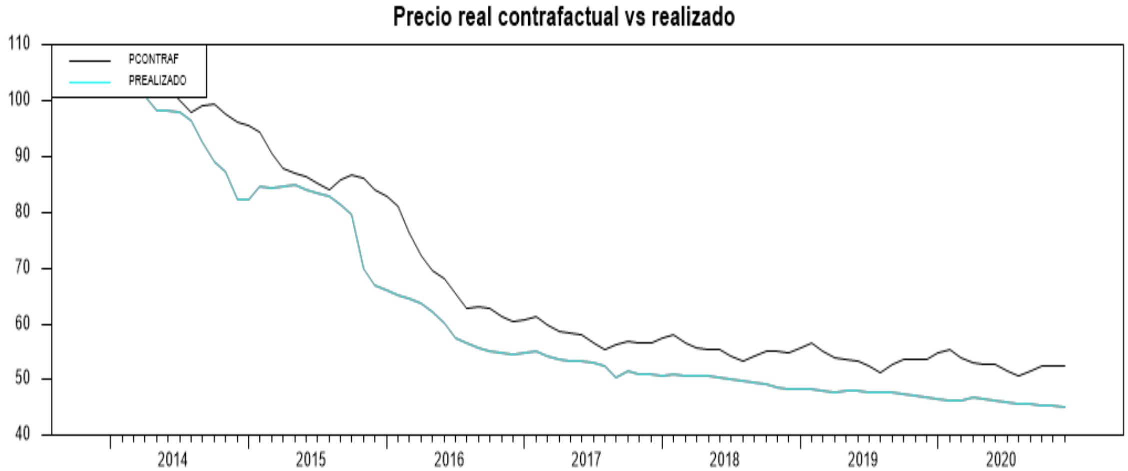
Variable dependiente LOGARPU	
Observaciones	426
Grados de libertad	371
R cuadrada centrada	0.94
R cuadrada	0.94
R cuadrada no centrada	0.99
Media de la variable dependiente	2.56
Error estándar de la estimación	0.23
Suma de errores al cuadrado	19.12
Estadístico F de la regresión	115.18
Valor p de la F	0.001
Log Likelihood	56.61

Variables explicativas	**Coeficiente**	**Error estándar**	**Estadístico t**	**Valor p**
LOGIHHMOB	0.113	0.053	2.136	0.033
LOGCAPPS	0.350	0.033	10.720	0.000
PEN	-0.002	0.000	-5.199	0.000
DUMMY1	0.036	0.155	0.231	0.817
DUMMY2	-0.061	0.244	-0.250	0.803
LOGPIBPC	0.553	0.026	21.024	0.000

Fuente: OMDIA.

La gráfica que sigue se obtuvo a partir de otro ejercicio econométrico, cuya intención es detectar cual hubiera sido la evolución del precio real de la telefonía móvil en ausencia de la reforma de telecomunicaciones, es decir el contrafactual, de manera que se pueda comparar este precio real contrafactual con el que ha ocurrido con la reforma. El ejercicio se realiza con un modelo de series de tiempo de suavizamiento exponencial. Este ejercicio permitió construir un contrafactual del precio real de la telefonía móvil desde 2014.

La gráfica muestra que el precio real contrafactual resulta mayor que el precio ocurrido con la reforma. De manera que en 2020 se encontraba poco más de diez por ciento por encima de éste. Es decir que en ausencia de la reforma los consumidores estarían pagando, por el servicio de telefonía móvil, un precio más elevado, en poco más de diez por ciento, que el actual.



Fuente: BIT e INEGI

CONCLUSIONES Y RECOMENDACIONES

En la literatura analizada, ya sea de organismos internacionales, consultorías o de la academia, se reportan resultados ambiguos acerca de la concentración y sus efectos. En este trabajo, utilizando la muestra de 50 economías avanzadas y emergentes de la GWM de Merrill Lynch, se encuentra que el número de operadores disminuyó en la segunda década del siglo XXI, lo que sugiere un aumento en la concentración, al menos en el promedio de los 50 países de esta muestra. Sin embargo, si se mide la concentración con un índice más completo, el IHH de suscriptores, que contempla no solamente el número de los operadores sino también la participación de mercado que tienen se obtiene que la concentración disminuyó en este período. El número de operadores en las economías avanzadas disminuyó cerca de 10 por ciento entre 2010 y 2020, mientras que en las emergentes en aproximadamente 30 por ciento. La media del número de operadores pasó de 5.25 a 4 en la muestra completa de países. Por su parte, el IHH disminuyó en aproximadamente 4 por ciento en la muestra completa.

Naturalmente, como estos resultados representan un promedio, al interior de la muestra existen muy diversos resultados para distintos países. En algunos países estos dos indicadores se mueven en el mismo sentido y en otros en sentido contrario. Un ejemplo sencillo ayuda a ilustrar esto. Supongamos que existe un país A en el que hay 5 operadores, todos con la misma participación de mercado (20 por ciento). En este caso el IHH es de 2000. Ahora consideremos un país B que tiene 6 operadores, 4 con 20 por ciento de participación de mercado y dos con 10 por ciento.

En el país B aumenta el número de operadores respecto al país A y el IHH disminuye a 1800. Finalmente, pensemos en un país C que tenga 8 operadores con las siguientes participaciones de mercado. Uno con 50 por ciento, tres con 10 y cuatro con 5. En este caso el IHH es de 2900, 45 por ciento mayor que el del país A, a pesar de que el número de operadores es 60 por ciento superior al del país A, lo que se debe a que la participación de mercado de uno de los productores es muy elevada.

Utilizando un ejemplo del modelo de Cournot, se muestra que conforme el número de operadores aumenta el precio se acerca al costo marginal. Es decir, a mayor número de operadores mayor competencia y menor concentración. Con el modelo de Cournot también se muestra cómo un aumento del IHH significa que el margen precio-costo promedio de una industria aumenta. Es decir que mayor IHH significa menor competencia y mayor concentración.

Al comparar a México con una muestra de 12 países de los cuales se logró obtener información para el período 2013-2018, se observa que México registra una disminución significativamente mayor del precio real de la telefonía móvil que la muestra. La reducción de México es de 51.4 por ciento, mientras que la de la muestra es de 36.8.

Se construyó un índice nominal (en dólares) del ARPU en las telecomunicaciones móviles. Este índice muestra que entre 2013 y 2020 el ARPU en México disminuyó en 43.2 por ciento, casi doce puntos porcentuales más de reducción que la muestra, cuyo ARPU disminuyó en 31.6 por ciento. Las economías emergentes disminuyeron su ARPU 34.2 por ciento y las avanzadas 28.6, por lo que ambas cifras reflejan una reducción menor a la que registró México en el mencionado período.

En el ejercicio econométrico en el que el ARPU es la variable dependiente, se encuentra que el número de operadores no resulta ser una variable significativa en ninguna de las regresiones. El IHH, por su parte, resulta una variable significativa para explicar el ARPU en la regresión de datos de panel con efectos fijos, controlando por el PIB per cápita, el capex por suscriptor y la penetración. El resultado más importante es que existe una relación positiva entre el ARPU y el IHH. A mayor concentración mayor ARPU (o a menor concentración menor ARPU), lo que significa que el ARPU aumenta con la concentración y falta de competencia y disminuye con la mayor competencia y menor concentración.

Se utilizó un modelo de series de tiempo, de suavizamiento exponencial, para estimar el contrafactual del índice del precio real de la telefonía móvil en México a partir de 2014. Es decir, este modelo se emplea para predecir el índice del precio real de los servicios de telefonía móvil en ausencia de la reforma de telecomunicaciones de 2013. Al comparar la serie de tiempo del precio real contrafactual versus el precio real realizado (el precio actual, con la reforma) se encuentra que, de no haberse realizado la reforma, los consumidores en la actualidad estarían pagando un precio mayor, en aproximadamente 10 por ciento, al que pagan. Es de destacar que durante el período de 2014 a 2020, el precio contrafactual es siempre mayor al ocurrido con la reforma, lo que significa que a través del tiempo ha habido un ahorro importante para los consumidores.

Los efectos de la concentración, cuando son nocivos, pueden limitarse con la política regulatoria y de competencia. Lo importante es no permitir el bloqueo de la competencia, las prácticas exclusionarias y el abuso de dominancia.

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APÉNDICE

La lista de países considerados en la muestra de la Matriz Inalámbrica Global (GWM) es la siguiente:

1. Argelia
2. Argentina
3. Australia
4. Austria
5. Bangladesh
6. Bélgica
7. Brasil
8. Canadá
9. Chile
10. China
11. Colombia
12. Dinamarca
13. Egipto
14. Finlandia
15. Francia
16. Alemania
17. Grecia
18. Hong Kong
19. India
20. Indonesia
21. Iraq
22. Israel
23. Italia
24. Japón
25. Malasia
26. México
27. Holanda
28. Nueva Zelanda
29. Nigeria
30. Noruega

31. Perú
32. Filipinas
33. Portugal
34. Catar
35. Rusia
36. Arabia Saudita
37. Singapur
38. Sudáfrica
39. Corea del Sur
40. España
41. Marruecos
42. Suecia
43. Suiza
44. Taiwán
45. Tailandia
46. Emiratos Árabes Unidos
47. Reino Unido
48. Ucrania
49. Estados Unidos
50. Turquía

Indicadores Internacionales de Precios Reales de Telefonía Móvil

	2013	2014	2015	2016	2017	2018
Australia	100.0	96.5	90.6	83.0	78.1	73.2
Canadá	100.0	91.9	84.7	78.1	73.2	68.1
China	100.0	92.7	90.0	93.8	101.5	105.1
Francia	100.0	78.7	67.1	59.3	53.4	48.3
Alemania	100.0	91.8	84.4	79.4	74.3	69.6
Italia	100.0	82.9	75.4	78.2	71.5	62.9
Japón	100.0	101.3	106.0	106.1	95.7	96.5
Corea del Sur	100.0	95.5	89.9	89.3	89.0	88.6
Nueva Zelanda	100.0	74.1	60.5	51.5	41.1	34.5
Reino Unido	100.0	71.7	50.5	36.8	33.1	28.3
Estados Unidos	100.0	91.8	79.7	70.2	65.0	59.9
Finlandia	100.0	84.0	73.9	62.7	47.4	37.9
México	100.0	93.1	78.5	58.0	51.3	48.6
Promedio	100.0	88.2	79.3	72.8	67.3	63.2

Fuente: Institutos de estadística nacionales.

Pagamento na entrega: comércio eletrônico B2C de pequenas empresas no Brasil

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RESUMO

O artigo tem como objetivo evidenciar algumas características do comércio eletrônico no Brasil, com atenção às formas usadas por empresas e indivíduos para realizarem transações comerciais. Destacam-se as diferentes formas com que empresas de grande e pequeno porte aproveitam sua presença no ambiente digital para comercializar seus produtos e serviços. Ademais, discute-se o aumento do comércio eletrônico entre usuários de Internet durante a pandemia, revertendo alguns hábitos de consumo centrados na preferência pela presença física e superando obstáculos oriundos da falta de confiança no ambiente digital. Conclui-se discutindo os desafios para a ampliação do comércio eletrônico no Brasil, salientando os problemas enfrentados por pequenas empresas e indivíduos para aumentar sua conectividade e presença *on-line*.

Palavras-chave

Comércio eletrônico, pequenas empresas, Brasil, pandemia.

INTRODUÇÃO

Os efeitos da transformação digital vêm afetando a economia e a sociedade brasileira. Estamos diante de um ecossistema cada vez mais conectado, no qual as transações entre empresas, indivíduos e governos se dará cada vez mais por meios digitais. À medida que mais indivíduos, organizações e dispositivos se conectam à Internet, mais as condições básicas da economia digital se estabelecem (UNCTAD, 2019).

O ambiente digital vem, progressivamente, assumindo a posição de principal meio em que ocorrem as transações econômicas, gerando oportunidades para pequenas empresas de aumento do alcance de mercado, fortalecendo a integração econômica local e gerando novas formas de criação de valor e geração de emprego via comércio eletrônico (OECD, 2019).

Esse cenário, contudo, ainda é incipiente em muitos países, sobretudo nas economias emergentes (Conferência das Nações Unidas sobre Comércio e Desenvolvimento [UNCTAD], 2019). Embora tenhamos avançado no acesso às TIC, ainda persistem barreiras ao uso e apropriação das TIC, incluindo capacidade financeira para contratar pacote de dados móveis e diferenças nas habilidades digitais, bem como a falta de confiança nos ambientes *on-line* para a realização de transações financeiras (Comitê Gestor da Internet no Brasil [CGI.br], 2019).

Para o comércio eletrônico, há barreiras tanto do lado da oferta quanto da demanda. Do lado da demanda, além das questões já levantadas envolvendo o uso e apropriação das TIC, a baixa penetração de cartão de crédito, sobretudo entre a população de menor renda, dificulta que as transações sejam 100% digitais, do pedido ao pagamento (Banco Central do Brasil [BCB], 2021). Estudos recentes indicaram um aumento da bancarização da população brasileira durante a pandemia impulsionado, principalmente, pela vinculação de programas de assistência social, como o pagamento de auxílio emergencial e vouchers destinados a consumo de produtos específicos (BCB, 2021). No entanto, estima-se que 31 milhões de brasileiros ainda não possuam relacionamento bancário, sendo que os grupos sociais que estão menos bancarizados são mulheres jovens e moradores de cidades localizadas no interior (Instituto Locomotiva, 2020).

Do lado da oferta, principalmente no caso das empresas de pequeno porte, as organizações enfrentam dificuldades em manter uma estrutura própria de *e-commerce* e, por vezes, contam com acesso precário à Internet e falta de habilidades e recursos para a manutenção de canais próprios de presença *on-line*, sobretudo um website próprio, apoiando-se em plataformas de venda (*e-marketplaces*) e outras formas de pagamento (p. ex., pagamento na entrega).

Esse quadro de baixa intensidade tecnológica das pequenas empresas, em especial no setor de varejo, ficou ainda mais evidenciado com o início da pandemia da COVID-19, em março de 2020. Entre as medidas de restrição adotadas para conter a transmissão da doença, diversas atividades presenciais foram suspensas ou tiveram seu funcionamento reduzido em diversas partes do país. Para seguir operando, o pequeno comércio teve que se adaptar rapidamente a esse novo contexto, e contar com diversas soluções tecnológicas a seu alcance para mediar a relação com os consumidores no ato da venda e na entrega dos produtos. A extensão da crise sanitária e as transformações em hábitos e expectativas dos consumidores em relação ao comércio eletrônico apontam para novos desafios na transformação digital das pequenas empresas do país.

Diante disto, este artigo analisa o perfil do comércio eletrônico no Brasil nos anos recentes a partir de duas perspectivas: das empresas e dos indivíduos/consumidores. O objetivo é entender como as tecnologias de informação e comunicação (TIC) têm afetado os negócios de pequenas empresas, as principais diferenças em relação a empresas de maior porte e as barreiras para o crescimento do comércio eletrônico nesse segmento. Ademais, busca-se também compreender o impacto da pandemia da COVID-19 sobre as pequenas empresas do setor de comércio considerando o papel das TIC para a manutenção das atividades dessas empresas, sua adaptação ao novo contexto e a intensificação do comércio eletrônico durante esse período, devido às medidas de restrição às atividades presenciais adotadas para conter a transmissão da doença.

Para tanto, analisaremos dados de survey sobre comércio eletrônico das pesquisas TIC Empresas (CGI.br, 2020) e Domicílios (CGI.br, 2019) realizadas pelo Comitê Gestor da Internet no Brasil. Neste artigo está sendo adotada a classificação do porte das empresas segundo o número de pessoas ocupadas utilizando como referência as faixas de 10-49 pessoas ocupadas para pequenas empresas, de 50-249 pessoas ocupadas para médias empresas e mais de 250 pessoas ocupadas para grandes empresas. Esta classificação é a adotada pela Pesquisa sobre uso das tecnologias de informação e comunicação nas empresas brasileiras – TIC Empresas, realizada pelo Comitê Gestor da Internet no Brasil, da qual serão utilizados os dados para análise. As microempresas não fazem parte do escopo de análise do artigo.

USO DE TIC POR PEQUENAS EMPRESAS NO BRASIL

No Brasil, a principal fonte de informações sobre o uso das TIC entre as empresas brasileiras é a pesquisa TIC Empresas, produzida pelo Comitê Gestor da Internet no Brasil (CGI.br, 2020). A pesquisa aponta um cenário com conectividade entre as empresas disseminada, mas um nível baixo de adoção estratégica da Internet nas rotinas da maioria das organizações, sobretudo as pequenas empresas. A versão mais recente da pesquisa, com dados coletados em 2019, já mostrava essa dualidade no âmbito do comércio eletrônico: observa-se que as grandes empresas realizam com mais frequência a venda de produtos e serviços via website, extranet e intercâmbio eletrônico de dados, enquanto as pequenas empresas vendem mais por aplicativos de mensagens instantâneas e pelas redes sociais (Figura 1). Portanto, de um lado temos um comércio eletrônico com uso de ferramentas desenhadas para realizar transações *on-line*, geralmente entre empresas, e de outro, o uso adaptado de ferramentas digitais gratuitas para realização de vendas para os indivíduos consumidores.

Outros canais de venda também foram utilizados em proporções semelhantes por empresas de diferentes portes, como o e-mail, as redes sociais, aplicativos e sites de venda, como Mercado Livre, OLX, Submarino, Americanas.com etc. Esses últimos, também chamados de *e-marketplaces*, são plataformas que reúnem diversas empresas e as conectam diretamente com consumidores, sem a necessidade de as empresas terem que desenvolver um website e sistema próprios para a realização de suas transações *on-line*. Além da economia em comparação com os custos de implementação e manutenção de uma loja virtual tradicional, essas plataformas permitem que produtos e serviços de pequenos negócios tenham maior visibilidade, poupando também os esforços de propaganda e marketing. Ainda que apenas 14% das empresas brasileiras que venderam pela Internet tenham utilizado essas plataformas para vendas (CGI.br, 2020), o fato de elas serem usadas em proporções semelhantes por empresas de diferentes portes mostra a oportunidade que oferecem a negócios de diferentes escalas.

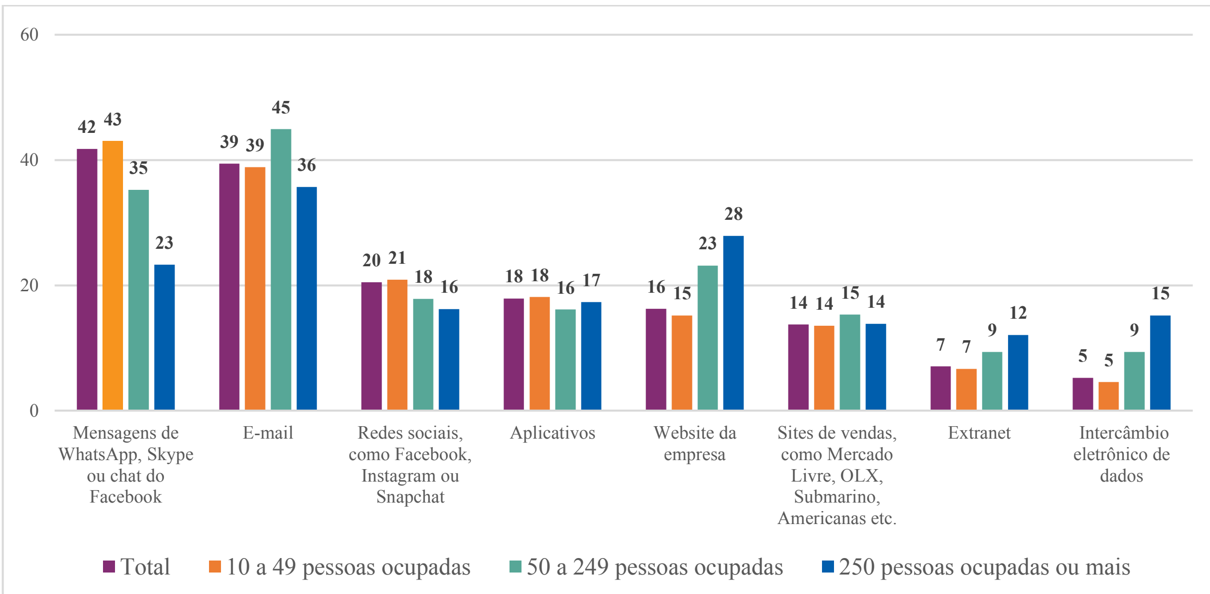

Figura 1. Proporção de empresas que venderam pela Internet nos últimos 12 meses, por tipo de canal online em que ocorreu a venda.
Fonte: CGI.br (2020).

As diferenças de porte da empresa também aparecem em relação às formas de pagamento. Entre as pequenas empresas, observa-se uma maior frequência do pagamento na entrega, enquanto entre as grandes empresas há uma predominância entre formas de pagamento mediadas por instituições bancárias, tais como débito *on-line* ou transferência bancária e boleto bancário. Desta maneira, vislumbra-se a presença de um comércio eletrônico mais estruturado, contando com um número maior de transações *on-line* e automatizadas e contato mais direto entre a empresa e o cliente, com pagamento realizado ao final do serviço ou entrega do produto ou serviço.

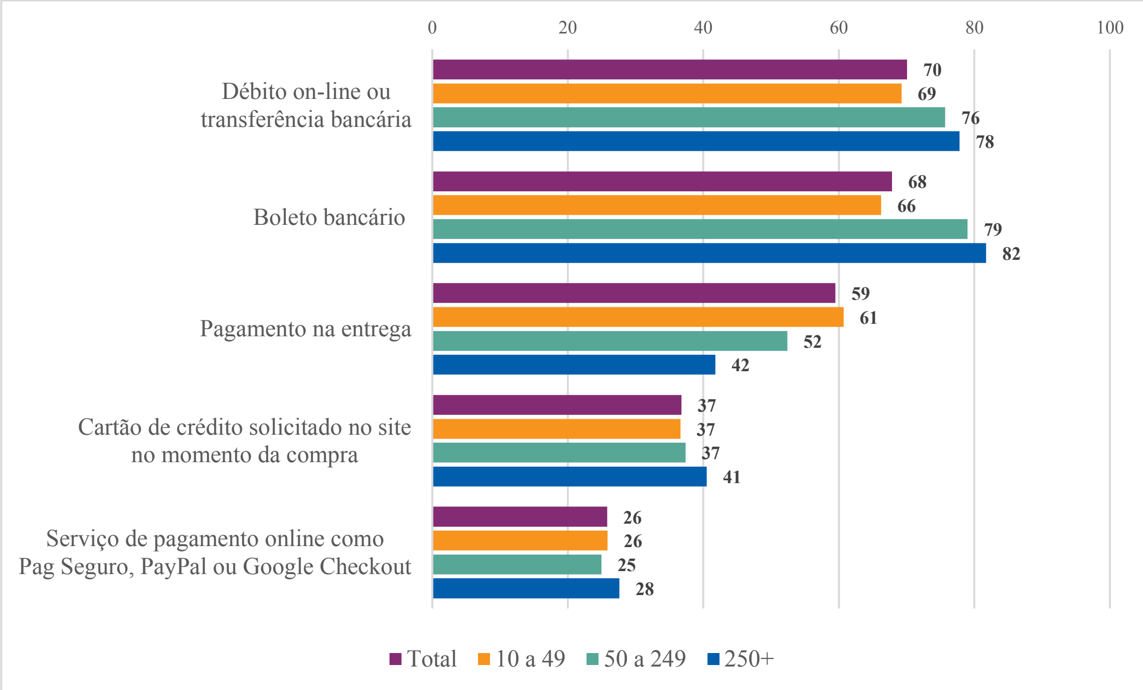

Figura 2. Proporção de empresas que venderam pela Internet nos últimos 12 meses, por forma de pagamento.
Fonte: CGI.br (2020).

Portanto, é possível caracterizar o comércio eletrônico das pequenas empresas como de menor escala, atuando de maneira local e com um raio de atuação mais reduzido, visto que boa parte delas aceita pagamentos na entrega. Com ferramentas disponíveis de forma gratuita, aliado à baixa presença de websites neste porte, é possível entrever que o uso das mensagens instantâneas cumpriu o papel de ferramenta à mão para que empresas menos estruturadas pudessem adentrar no ambiente digital e realizar transações comerciais. Ainda que o uso dessas aplicações não tenha sido idealizado exclusivamente para o comércio eletrônico, é evidente que o efeito de rede que elas possuem seja fator atrativo para que as empresas busquem adaptar suas rotinas para receber pedidos e promover seus produtos e serviços por meio delas. Desta forma, para empresas que lidam de forma direta com a clientela, é necessário saber usar aplicativos de mensagem instantânea e redes sociais de forma eficiente, visto que, na medida em que esses meios se consolidam como mais frequentes entre os clientes, a reputação da empresa também vai ser avaliada a partir da experiência dos consumidores com a medição digital. No entanto, tudo leva a crer que o cenário aqui não é de um uso profissional dessas ferramentas digitais, mas, sim, um uso adaptativo e restrito, que não necessariamente faz uso das opções mais avançadas oferecidas pelas empresas controladoras dessas plataformas[1].

Com a consolidação do comércio eletrônico, é importante que haja aprimoramento da presença *on-line* por parte das empresas, sobretudo as pequenas. As formas de lidar com os clientes no meio eletrônico necessitam de tratamento especializado. Segundo a TIC Domicílios 2018, 83% dos usuários que não compraram pela Internet justificaram o fato porque gostam de ver o produto, 62% afirmaram que não confiam que irão receber o produto e 59% não compraram pela Internet por questões relacionadas a segurança e privacidade (CGI.br, 2019). Portanto, os motivos informados pelos usuários de Internet para não comprar pela Internet indicam a necessidade de que a presença *on-line* da empresa garanta um ambiente seguro para dados pessoais, bem como forneça uma experiência ao usuário que supra a necessidade de presença em loja física, com informações claras e precisas, tratamento profissional de fotos e vídeos, canais de comunicação eficientes, entre outros.

[1] Na China, a presença de empresas em plataforma de compra e venda de produtos e serviços é usada como forma de oferecer serviços e qualificações para que empresas menores melhorarem sua atuação no ambiente digital (Banco Mundial & Alibaba, 2019).

COMÉRCIO ELETRÔNICO NA PANDEMIA

A pandemia da COVID-19 provocou diversos efeitos sobre a economia, tanto do lado da oferta quanto da demanda. Do lado da oferta, a crise sanitária afetou a cadeia de suprimentos global, com efeitos na disponibilidade de componentes e produtos e consequentes reflexos inflacionários sentidos ainda no fim de 2021. O fechamento de setores considerados não essenciais provocou inúmeros desafios para as empresas manterem suas operações, seja pela necessidade de implantar o trabalho remoto, seja pelos efeitos de redução da demanda verificados no período.[2]

Do ponto de vista dos consumidores, o comércio eletrônico se apresentou como uma importante alternativa para o cumprimento das medidas de distanciamento social. Houve nesse período um avanço do consumo de bens e serviços por meio da Internet, acelerando um movimento que já vinha ocorrendo entre os usuários de Internet e as empresas ao longo dos últimos anos. Os dados do Painel TIC COVID-19, pesquisa realizada em 2020 para medir o uso da Internet no Brasil durante a pandemia, confirmam essa tendência. A proporção de usuários de Internet que afirmaram ter feito compras *on-line* nos últimos três meses anteriores a realização da pesquisa foi de 66% em 2020 (CGI.br, 2021a). Isso representa um aumento de 22 pontos percentuais em relação à população de referência da pesquisa TIC Domicílios 2018 (44%).[3] Além disso, 55% dos usuários informaram que passaram a comprar mais pela Internet durante a pandemia.

A pandemia também afetou os padrões de consumo dos brasileiros usuários de Internet. O levantamento realizado durante a crise sanitária revelou que a proporção de usuários que compraram comida ou produtos alimentícios pela Internet foi de 54%, mais do que o dobro do registrado na população de referência em 2018 (22%). Também houve aumento no consumo de cosméticos ou produtos de higiene pessoal, passando de 25% para 44%, de medicamentos, que passou de 15% para 31%, e de itens de papelaria, que variou de 10% em 2018 para 17% em 2020 (Figura 3).

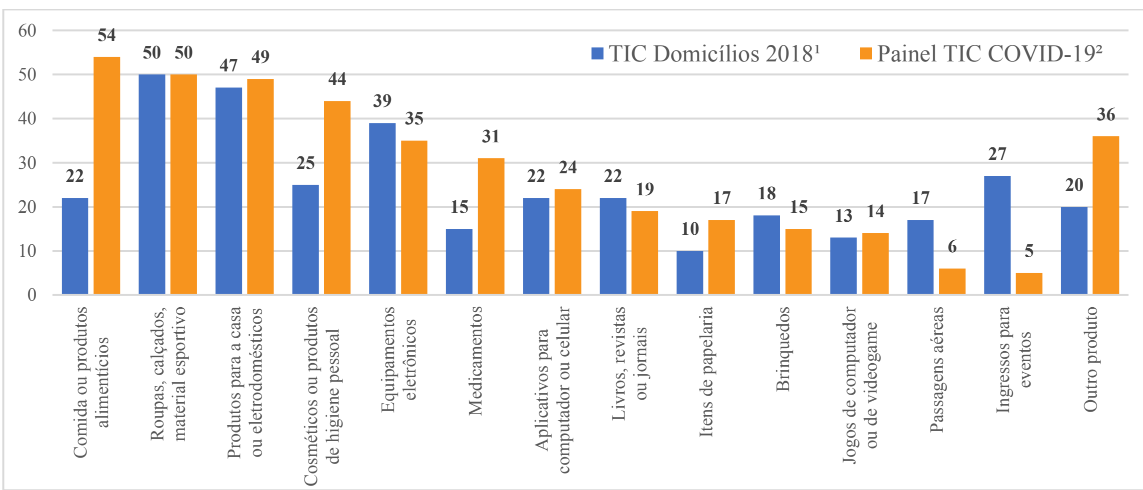

Figura 3. Proporção de usuários de Internet com 16 anos ou mais, por tipo de produto comprado pela Internet
Fonte: CGI.br (2021a).
Notas: 1. Base reprocessada com recorte populacional (ver relatório metodológico da pesquisa). 2. Períodos de referência diferentes (Painel TIC COVID-19: últimos três meses; TIC Domicílios: últimos doze meses).

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[2] Nos primeiros doze meses da pandemia, entre março de 2020 e março de 2021, houve uma redução de aproximadamente seis milhões de pessoas de 14 anos ou mais de idade ocupadas no país e uma perda da massa salarial da ordem de 15 bilhões de reais (IBGE, 2021). Segundo estimativas do Instituto de Pesquisa Econômica Aplicada – Ipea, a partir de dados da PNAD COVID19, em agosto de 2020, mais de 6% dos domicílios brasileiros (cerca de 4,25 milhões) sobreviveram exclusivamente com os rendimentos recebidos por meio do programa de auxílio emergencial do governo federal (Carvalho, 2020).

[3] Neste indicador, o período de referência adotado pela TIC Domicílios 2018 é de 12 meses anteriores a realização da pesquisa, considerando a sazonalidade na realização de compras pela Internet. Já no Painel TIC COVID-19, cuja coleta foi realizada em meados de 2020, por se tratar de pesquisa sobre uso da Internet durante a pandemia, o período de referência adotado foi de três meses.

Ainda segundo o Painel TIC COVID-19, 67% dos usuários de Internet com 16 anos ou mais que compraram produtos ou serviços pela Internet ou que realizaram serviços pela Internet afirmaram ter passado a comprar mais de produtores locais e pequenos comércios durante a pandemia. Para que isso fosse possível, o pequeno comércio de bairro teve que se adaptar rapidamente às recomendações de distanciamento social e adotar canais digitais de comunicação com o consumidor para a realização das vendas.

De acordo com a pesquisa TIC Domicílios 2020, o celular é o principal dispositivo usado no Brasil para acessar a Internet, usado por 99% dos usuários, e é o único dispositivo usado para acessar a rede por 58% dos usuários da classe C e 90% dos usuários das classes D e E (CGI.br, 2021b). A maioria dos indivíduos que possuem telefone celular contam com planos pré-pagos (57%), que oferecem pacotes de Internet limitados por uma franquia de dados, acima da qual a Internet é bloqueada ou é necessário pagar pelo consumo excedente. Exceção é feita para os chamados “apps patrocinados” ou zero-rating, cujo consumo de dados para seu uso não é contabilizado na franquia de dados. Os apps patrocinados mais comuns nos planos pré-pago no Brasil são aplicativos de mensagens instantâneas e de redes sociais, como WhatsApp e Facebook. O WhatsApp está instalado em praticamente todos os celulares dos usuários de Internet das classes C, D e E (95%), enquanto o Facebook está presente em 85% deles (Idec & Instituto Locomotiva, 2021).

O Painel TIC COVID-19 apontou que essa forma de contato direto com o cliente foi usada de forma mais intensa na pandemia: 46% dos usuários de Internet que compraram pela Internet afirmaram que o fizeram por aplicativos de mensagens instantâneas, como WhatsApp, Skype ou Telegram, proporção que era de 26% em 2018 (Figura 4). Como mostramos na seção anterior, esse esforço das empresas brasileiras para ampliar o uso da Internet em suas operações, com destaque para o uso de aplicativos de mensagens instantâneas, já havia sido registrado pela pesquisa TIC Empresas 2019.

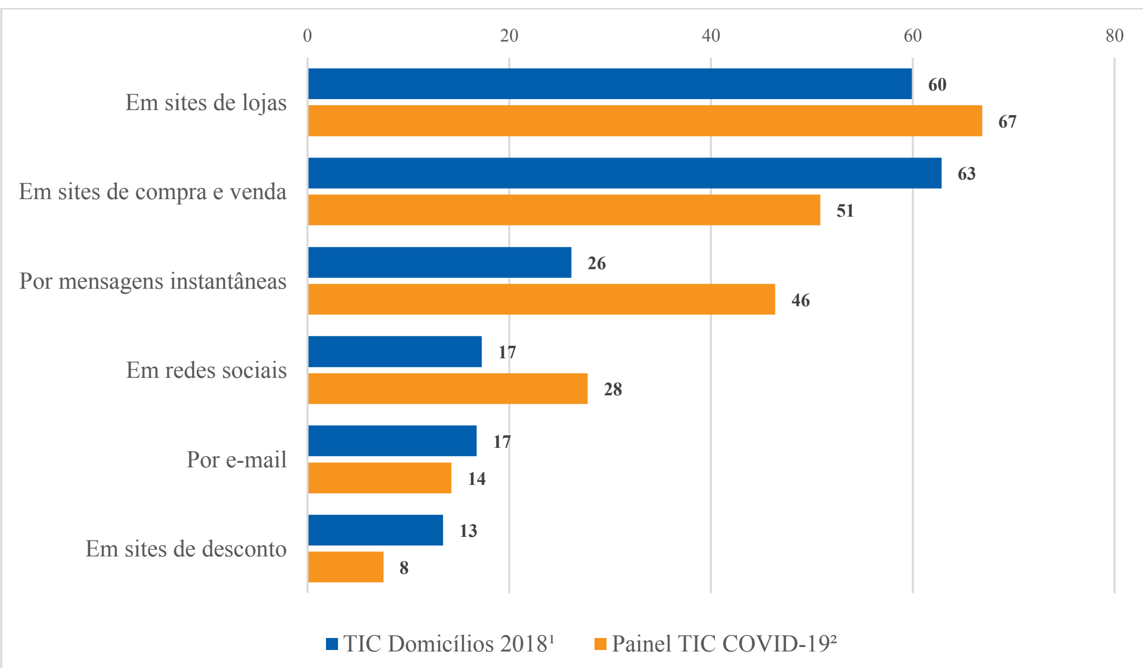

Figura 4. Usuários de Internet com 16 anos ou mais que compraram pela Internet, por canal de compra utilizado.
Fonte: CGI.br (2021a).
Notas: 1. Base reprocessada com recorte populacional (ver relatório metodológico da pesquisa). 2. Períodos de referência diferentes (Painel TIC COVID-19: últimos três meses; TIC Domicílios: últimos doze meses). Ver nota de rodapé n. **Erro! Indicador não definido.**.

O uso de aplicativos de mensagens para compra avançou mais nas classes mais altas: em 2018, 40% dos usuários de Internet das classes D e E afirmaram comprar por aplicativos de mensagens instantâneas, indo para 43% durante a pandemia; em relação às classes A e B, em 2018, 24% dos usuários afirmaram comprar por meio desses aplicativos, passando para 50% durante a pandemia.

A forma de pagamento mais utilizada pelos usuários de Internet para compras *on-line* foi o cartão de crédito (74%), seguido por boleto bancário (60%) e débito *on-line* ou transferência bancária (45%). O pagamento na entrega foi realizado por quatro em cada dez usuários que compraram pela Internet. Neste aspecto, verifica-se uma diferença de cerca de 10 pontos percentuais no uso de cartão de crédito a favor dos homens (80% deles e 70% de mulheres) e no pagamento na entrega em favor das mulheres (43% delas e 34% dos homens). Entre as classes sociais, verifica-se uma maior utilização do cartão de crédito pelas classes A e B (81%) contra 68% da classe D e E (CGI.br, 2021a).

Esse cenário de meios de pagamentos digitais no Brasil passou por uma recente transformação. No final de 2020, o Banco Central do Brasil lançou o Pix, uma modalidade de pagamento e transferência *on-line* gratuita, instantânea, disponível 24 horas por dia, todos os dias da semana. Entre os seus objetivos está o incentivo à adoção de formas de pagamento eletrônicas pela população. Em novembro de 2021, o Pix já contava com 115 milhões de usuários registrados e mais de um bilhão de transações liquidadas mensalmente. Pelo fato de ser instantânea e gratuita, essa ferramenta tem o potencial de facilitar as relações financeiras e o comércio *on-line*, já sendo, inclusive, aceita por diversos aplicativos de compras e serviços (BCB, 2021).

CONCLUSÃO

Este artigo revela avanços e desafios para a consolidação da economia digital no Brasil. Se, de um lado, as empresas brasileiras evoluíram em termos de infraestrutura de acesso à Internet, de outro, o uso da Internet como parte da estratégia das empresas ainda não é um fato consolidado, e a presença de tecnologias avançadas relacionadas à economia digital ainda é incipiente.

É importante destacar a forma multifacetada que o comercio eletrônico vem assumindo no Brasil. Com a possibilidade da troca imediata de mensagens com clientes, as empresas vêm usando aplicativos de mensagens instantâneas para negociar preços, agendar horários e buscar clientes, no que foi entendido pelos respondentes com uma modalidade de venda pela Internet, sobretudo pelas pequenas empresas.

Os dados apresentados por este artigo mostram que o uso de plataformas de mensagens instantâneas para a negociação de venda e o relacionamento com os clientes foi maior entre empresas pequenas em comparação com as empresas de médio e grande porte, dados que apontam o importante papel que essas aplicações vem cumprindo para inserção dos pequenos negócios no contexto de desenvolvimento do comércio eletrônico no país. Esse papel acentuou-se durante a pandemia.

De fato, a troca de mensagens pela Internet tem sido a principal atividade realizada pelos usuários de Internet brasileiros, o que revela o potencial dessas plataformas como canais de negociação entre empresas e consumidores, em especial para as empresas de pequeno porte. A proporção de usuários de Internet das classes D e E que compraram produtos ou serviços pela Internet por aplicativos de mensagens instantâneas foi superior aos das classes A e B, mostrando a importância dessa plataforma para a população de mais baixa renda no Brasil.

O uso de plataformas de venda (*e-marketplaces*) em proporções semelhantes por empresas de diferentes portes mostra a oportunidade que oferecem a negócios de diferentes escalas. Para além da exposição dos produtos no *frontend*, essas plataformas oferecem ao pequeno varejo uma estrutura tecnológica, incluindo pagamentos *on-line*, e de logística de entrega, incluindo rastreamento do pedido, que seria muito custosa para as pequenas empresas oferecerem aos consumidores por conta própria.

Há espaço para políticas públicas que ajudem a fomentar a transformação digital da economia e da sociedade brasileiras. As pequenas empresas enfrentam dificuldades em temas como logística, infraestrutura digital e segurança da informação. Facilitar a logística de última milha, ampliar o acesso à Internet e a outras infraestruturas digitais e promover a adoção de boas práticas de segurança da informação e proteção de dados (aumentando a confiança dos consumidores) seriam, portanto, importantes objetivos de política pública a serem perseguidos para que as empresas de pequeno porte possam tirar melhor proveito das oportunidades oferecidas pelo comércio eletrônico.

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