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Network effects in mobile telecommunications markets: A comparative analysis of consumers' preferences in five Latin American countries[☆]

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ABSTRACT

It has been shown that the presence of demand-side externalities can induce the market to benefit the largest firms in terms of market share, usually named as network effect by the theoretical literature. On the one hand, macro-level approach in the empirical literature of network effects commonly use the assumption that a network's overall size matters more to consumers' decisions (global network effects). On the other hand, micro-level studies have suggested that social networks are more relevant to consumers' choices than the overall network size (local network effects). Based on microdata from five Latin American countries, we compare the choice of a particular operator over choosing the largest operator by individual consumers. Our research shows that country-level network size is one among a set factors that determine consumers' choices of mobile operators, once individual and operators' country presence heterogeneity are considered. We find that consumers' local network decisions are important for the choice of operator in the majority of cases considered, and that this result is conditional on the chosen operator's market share. Furthermore, network characteristics and consumer preferences, such as coverage, tariffs, and network importance also affect the choice of mobile network for the Latin American context.

1. Introduction

One of the most noteworthy features of mobile telecommunications markets is the fundamental role played by the network of users. In these markets, consumers obtain benefits not only from the product (or service) itself, but also from their mobile networks: lower uncertainty and informational spillovers (transfer of technical and non-technical information between members of the network), special tariffs, and compatibility of preferences between members of the network, among others (Maicas & Sese, 2011).[1] Moreover, the development of telecommunications markets in Latin America has followed a gradual liberal approach emphasizing the promotion of

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[1] Liebowitz and Margolis (2002) mention that network effects traditionally have been studied as positive, but they could also be negative: congestion is created by the negative impact of additional users on network performance as capacity constraints are approached.

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competition between incumbents and new firms, but only after a period of monopoly (Galperin & Mariscal, 2007; Mariscal, Bonina, & Luna, 2005; OSIPTEL, 2003). The development of Internet-based communication platforms could represent a challenge to mobile telephony in developing countries, but the fact is that Internet-based communications runs on mobile infrastructure. In this context, mobile infrastructure also has a significant potential as a tool for governments to deploy high-speed transmission networks, as well as to improve public service provision over applications that allow access to activities to contribute to people's wellbeing, and for poverty and inequality reduction. For mobile phone users, the existence and deployment of mobile infrastructure is critical as it allows operators to provide more alternatives and better services.

When looking at the demand side in mobile markets, it is key to understand how consumers choose mobile operators and the importance the former give to possible network effects. Given the past experience of strong monopoly incumbents, their mere size, i.e. market share, may heavily influence consumers' decisions. These choices may alter the way in which mobile operators compete which in turn may affect the way in which entrants grow in the Latin American context and the strength of competition in a particular market. By network effects we mean that consumer demand depends on other agents' decisions. An agent may either be expected to choose the larger network to obtain the benefits of being part of that network –"global network effects"- (Karaçuka, Çatik, & Haucap, 2012; Moore & Rutter, 2004), or may be influenced by the decisions and opinions of people she knows -"local network effects"- (Birke, 2013; Birke & Swann, 2006). If an entrant chooses to compete by luring in new mobile subscribers, and local network effects prevail over global network effects, market share growth by new firms could be sustained by subscribers switching operators, and a healthy competitive environment may greatly benefit consumers in the long-run.

The purpose of this paper is to analyze the role local network effects play in shaping consumers' choices in the telecommunications markets of five Latin American countries: Argentina, Colombia, Peru, Guatemala and Paraguay. Alongside, we study the influence of socioeconomic variables (such as age, gender, education, monthly income and mobile expenditures), consumer preferences (opinions and perspectives about mobile operators' characteristics), and supply side variables (market share and tariffs) in the consumers' decision-making process of selecting a particular mobile operator over the largest one. The global and local network effects examined are those that reflect the choice between the largest operator, in terms of market share, and any other.

To characterize the probability of operator choices by consumers, an alternative-specific conditional logit model is used. The set of explanatory variables includes those specific both to mobile operators and individuals' characteristics, including network effects. The dataset used is part of the *After Access* project,[2] developed since 2017 in the Global South, in Africa, Asia and Latin America by RIA (Research ICT Africa), LIRNEasia (Learning Initiatives on Reforms for Network Economies Asia) and DIRSI (Diálogo Regional Sobre Sociedad de la Información), respectively. The focus of this demand-side project is on access and utilization of new technologies, using nationally representative data. Policy implications derived by the present study reaffirm the need for stronger competition to ensure better consumers' choices.

This paper is organized as follows. Section 2 provides an overview of other theoretical and empirical studies focusing on network effects in mobile telecommunications. Section 3 introduces the mobile telecommunications market in five countries of the Latin American region: Argentina, Colombia, Peru, Guatemala and Paraguay. The methodology and the dataset are presented in section 4 and 5, respectively. Finally, results are presented in section 6.

2. Network effects: a literature overview

A number of empirical studies have analyzed network effects in mobile telecommunications markets (Liebowitz & Margolis, 2002; Rohlfs, 1974). Positive network effects are mostly observed and found to be highly significant in diffusion models of mobile telecommunications (see Kalba, 2008; Kumar, Baisya, Shankar, & Momaya, 2007; Laffont & Tirole, 1999). Gruber and Verboven (2001) analyze the features of the diffusion process in mobile telecommunications services in countries of the European Union between 1984 and 1997 and find that, along with network effects and per capita income, countries with stronger competitive markets have higher penetration rates. Similarly, Jang, Dai, and Sung (2005) find evidence for strong network effects, using data on 29 OECD countries from the 1980–2001 period. In another cross-country study, Liikanen, Stoneman, and Toivanen (2004) directly address network effects and confirm their relevance in technology diffusion for the 1990–1997 period. In summary, these studies support the hypothesis that network effects positively influence the adoption decision of technology (i.e. the consumers' decisions to acquire a particular product or service).

Single-country studies (intra-country) present similar findings. Doganoglu and Grzybowski (2007) find strong network effects for Germany between 1998 and 2003. Other studies that use market-level data support the existence of network effects in the technology diffusion process. For example, Fu (2004) states that tariff-mediated externalities (usually known as *on-net tariffs*) play an important role for competition in the Taiwanese market: networks with a large subscriber base attract more new consumers than other operators' networks, and the magnitude of the effect becomes larger when the price differential between on-net and off-net tariffs is taken into account. In Poland, Grajek (2010) finds that network effects are limited to each specific network and argues that this is due to the significant on-net discounts that generate operator-specific effects. Thus, several studies highlight the relevance of the cost gains related to network effects.

Nevertheless, in the analysis of network effects on consumer choice both at industry-level and firm-level, the majority of studies focus on "*macro empiricism*" (Greenstein, 1993; Karaçuka et al., 2012), which involves inferring individuals' preferences from the

[2] See https://afteraccess.net/.

Table 1
Mobile operators in Latin America (1995–2017).

Country	1995–2000	#	2000–2005	#	2017	#
Argentina	BellSouth, Telefónica, France Télécom, TIM, Agea/Clarín	5	Telefónica, América Móvil, TIM, Nextel	7	Telefónica (Movistar), Personal, América Móvil (Claro), Nextel, Tuenti	5
Colombia	Millicom, Cable & Wireless, Bell Canada, Telefónica, AT&T	5	América Móvil, Telefónica, Ola, Avantel	4	Avantel, América Móvil (Claro), ETB, Grupo Éxito, Telefónica (Movistar), Tigo (before Ola), UFF Mobile, Virgin Mobile	8
Peru	Telefónica, TIM	2	Nextel, Telefónica, América Móvil	3	Bitel, América Móvil (Claro), Entel, Telefónica (Movistar), Tuenti	5
Guatemala	Comcel, BellSouth	2	Comcel, América Móvil, Telefónica	3	Tigo (before Comcel), América Móvil (Claro), Telefónica (Movistar)	3
Paraguay	Telecel, Núcleo	2	Telcel, Núcleo, América Móvil, Vox	4	América Móvil (Claro), Vox (Copaco), Tigo (before Telcel), Personal	4

Adapted from Mariscal (2007). Authors' elaboration.

examination of aggregate market performance (Fu, 2004). The research previously discussed in this section shows that network effects are usually measured using the number of adopters as a lagged variable. Even if this method provides an advantage in the absence of detailed micro-level consumer data, criticism can arise. Measuring network effects with the number of adopters as a lagged variable lead to ignoring individuals' preferences for network specific characteristics such as coverage, quality, and tariffs, among others. In addition, the approach assumes that network effects are "global" (Karaçuka et al., 2012; Maicas & Sese, 2011): all connections inside the network are supposed to be equally valuable, even if social networks and influence of peers suggest the opposite in several studies.[3] Hence, the present research aims to measure network effects and other determinants of adoption (socioeconomic, usage intensity, and preferences) of a specific operator by using individual data. Besides these determinants of consumer choice, the extent of network effects is examined by looking at whether an individual's decision to join a specific network is affected by the choices made by other individuals on her surroundings, i.e. her social network.

Using micro-level consumer data in the analysis, some studies have recently started to assess mobile telecommunications demand and consumer choice. Kim and Kwon (2003) use a conditional logit model to examine the main determinants of consumers' choices, as well as switching costs between mobile operators, in the Korean mobile market. Their key result is that network size effects are both significant and positive, suggesting large networks guide consumers' preferences. They also find a positive relationship between individuals' mobile expenditure and the probability that the consumer chooses the incumbent operator network. The conclusion of the study is that consumers would have chosen an alternative operator (not the incumbent operator) if and only if network size is not included in the analysis. Another relevant study was carried out by Birke and Swann (2006), who analyze consumers' choices of mobile phone operators for the United Kingdom (UK).[4] They focus on the *relevant* subscribers (such as family and friends) within a network and propose a disaggregation analysis of network effects. One effect is explained by overall country level network size, and the other is attributed to the operator that another member of the household had chosen previously. Results show that network choice is affected in a much stronger way by the choices of other household members, while overall network size has a weak impact on consumers' choice.

The question on how network effects influence consumers' choice of mobile telecommunications operators has also been analyzed in a number of quasi-experimental and survey-based papers. These studies state that the number of people the consumer knows is more meaningful than the overall size of the network. Corrocher and Zirulia (2009) find that consumers' preferences are heterogeneous regarding the emphasis they place on the choices of other members in their social networks. For example, students that care about their friends' operator choice are typically more aware of their phone bill and use voice services more intensively. Srinuan, Srinuan, and Bohlin (2014) find that social network effects, considering only family members and friends, are more relevant than the whole country operator network size. Finally, based on a choice experiment for the Polish mobile telecommunications market, Sobolewski and Czajkowski (2012) support the strong positive network effects thesis, which is related to the ratio of the consumers' social network group using the same operator and to the magnitude of on-net price discounts (measured as a hypothetical change in the price level).

Literature review shows that there is a knowledge gap regarding the nature of network effects over consumers' preferences: a consumer may either be expected to choose the larger network to obtain the benefits of being part of that network –"global network effects"- (Karaçuka et al., 2012; Moore & Rutter, 2004), or may be influenced by the decisions and opinions of people she knows -"local network effects"- (Birke, 2013; Birke & Swann, 2006). With these considerations we are using both global and local effects perspective for the Latin American context so as to identify the real sources of consumers' choices.

3. The mobile telecommunications market in Latin America

An overview of firms and market shares in the five countries we study is presented in Table 1 and Fig. 1. A brief analysis of each country is provided. The order of presentation reflects per capita GDP.

[3] Chwe (2000) shows that it is more reasonable to assume that each person only knows the network of his/her neighbors, but not the entire network.

[4] Also, Birke (2013) generalized the analysis to the Netherlands, Malaysia and Italy, finding similar results.

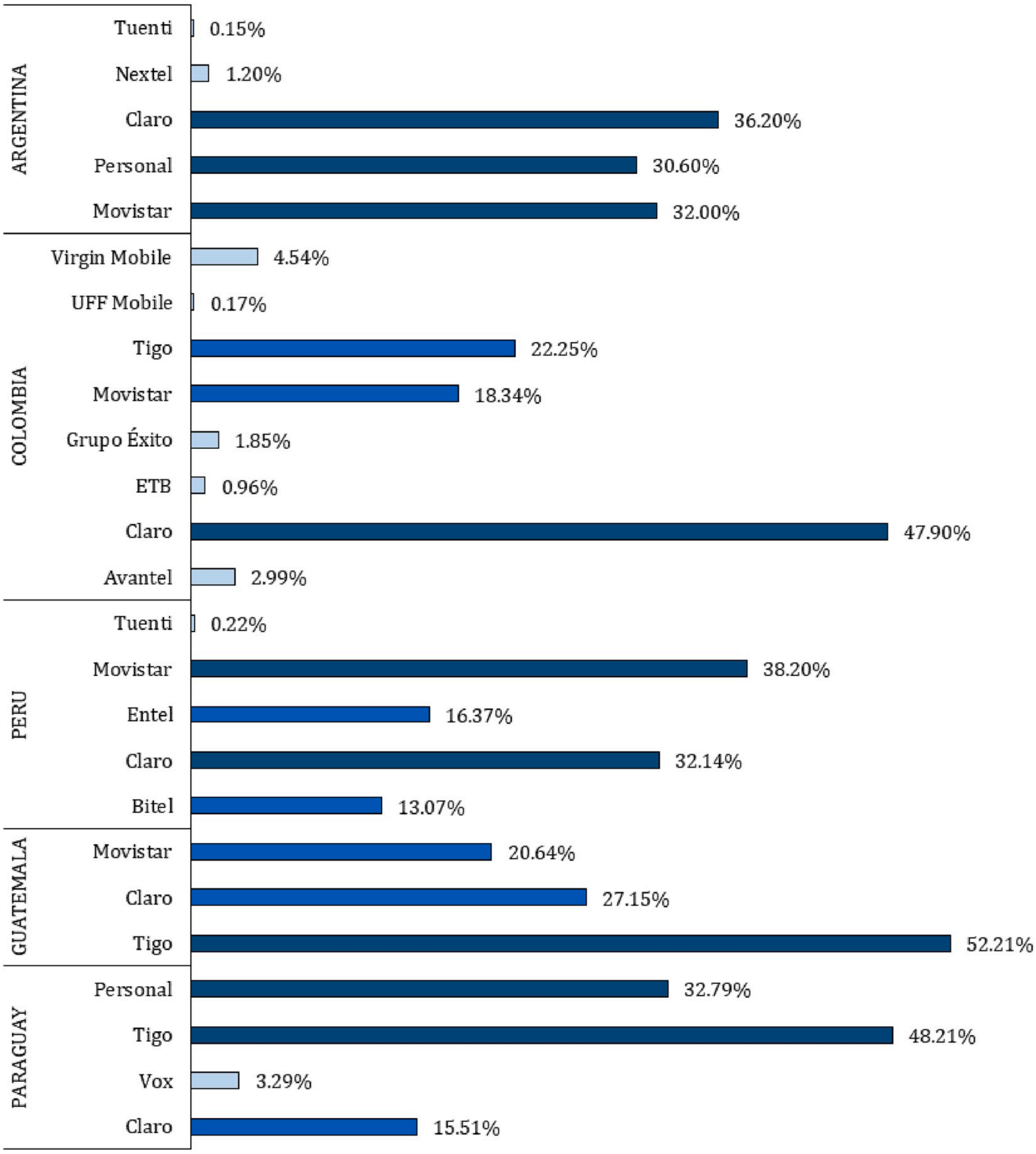

Fig. 1. Mobile market share, by operator and country (%) – 2017.Note: Market share data are based on total mobile subscribers. Source: ENACOM (2017), CRC (2017), OSIPTEL (2017), SIT (2017), CONATEL (2017). Authors' elaboration.

3.1. Argentina

Argentina represents a special case for the Latin-American mobile market. During the 1990s, in order to develop their mobile telecommunications services, the country was divided into three areas (Buenos Aires, North Zone and South Zone). Four private capital firms operated the market: Movicom (from BellSouth) and Miniphone (a mix between Telefónica and Telecom Personal) in the Buenos Aires zone, Telecom Personal in the North Zone, Telefónica Unifon in the South Zone, and CTI Company in both North and South Zones. At the end of the 1990s, two events changed the structure of the mobile market. In 1998, Nextel entered the market, but kept a low market share. A year later, new frequencies were tendered, allowing competition among mobile operators throughout the country. Later, in the early 21st century, there were two important moments for mobile market composition: América Móvil (known as Claro) bought CTI, and Telefónica (known as Movistar)[5] bought BellSouth.

[5] See Table 1.

Among the main regulations and laws, the 26.522 law,[6] published in 2009, established the rules for the operation of the audiovisual and advertising services and the licensing process.[7] Other relevant regulations are related to number portability[8] since 2010, and service quality[9] since 2013. Finally, it is worth noting that in Argentina mobile telecommunications tariffs were not regulated (Reategui & Perea, 2012) until 2014. As part of the "*Precios Cuidados*" program, benchmark rates were established for prepaid and postpaid plans in the mobile market.

In Argentina, there has been an upward trend in access to mobile telephony. Between 2014 and 2017, the number of mobile lines went from 60.6 to 64.1 million, while the mobile phone penetration rate went from 139 to 145.7 (ENACOM, 2017). Approximately 50% of the country's mobile lines are concentrated in the capital Buenos Aires and the Ciudad Autónoma de Buenos Aires (CABA),[10] while lines are distributed homogeneously in the rest of the country. Moreover, according to ENACOM (2017) more consumers are likely to choose prepaid plans: by mid-2017, 88% subscriptions were prepaid compared to 12% of postpaid ones.[11] The Argentinian mobile market is one of the most competitive ones in the region (IDB, 2018). Mainly, three companies compete with very similar market shares (see Fig. 1): Claro (36.2%), Movistar (32%), and Telecom Personal (30.6%).[12]

3.2. Colombia

In 1991, the new Colombian Constitution provided the basis for market liberalization and privatization. It was not until 1994 that the government granted operation rights to six companies in the mobile market. Since then, the country is divided homogeneously in three regions, where each one is split into two operation zones (A and B).

The results of these institutional changes were unexpected. The new mobile market turned into a duopoly formed by two multinational companies that gained significant market share in the region: América Móvil and Telefónica. América Móvil entered the market by buying Comcel in 2000, and later the remaining A zone companies 2004. The case of Telefónica was similar: it acquired BellSouth in 2004 after purchasing all of zone B operating companies. Hence, by the end of 2004, the Colombian mobile market ended up having only two competitors that controlled the whole market with national coverage: América Móvil (known as Claro) in the A operation zone, and Telefónica (known as Movistar) in the B operation zone (OECD, 2014). Nonetheless, it is noteworthy to say that a third mobile company entered the market through a public tender in 2002: Colombia Móvil SA ESP (known as Tigo Colombia).[13] Tigo Colombia began to take relevance in the national market through an aggressive advertising strategy, and nowadays is the company with the second highest market share (behind Claro). Finally, in 2010, MVNO companies, such as UFF Mobile, Virgin Mobile and Grupo Éxito, entered the mobile market when they won the 4G bidding process (OECD, 2014).[14]

Mobile telephony has had a positive growth rate over the years in Colombia. In fact, between 2014 and 2017, the number of mobile lines in service increased from 51.6 to 59 million (MINTIC, 2017). Moreover, there are nine companies operating in the mobile market. However, far from being competitive, the market share is concentrated mainly in three companies.[15] Claro has 48% of the market share, and Tigo Colombia and Movistar have 22.5% and 18.34% respectively.

3.3. Peru

The mobile telecommunications market in Peru has had a significant development since 1990, but in a context of high market concentration (Gallardo, 2000). Until 2004, two companies dominated the market (Telefónica and América Móvil), with a third company showing a negligible market share (Nextel).

The Telefónica concession agreement was renewed in 2013,[16] with new requirements such as the establishment of a *social rate* for prepaid mobile telephony. The same year, the number portability law was approved,[17] facilitating conditions that further reduced the cost of access and mobile number portability. In addition, regulations to promote entry of MVNO and Operators of Rural Mobile Infrastructure (OIMR) in the mobile market were enacted in 2013.[18] Finally, some regulations focused on the quality and tariffs of mobile services (Loaiza & Jáuregui, 2015).[19]

Only since 2014, three more companies entered the mobile market because of regulatory changes. The first entrant, Americatel

[6] *Ley de Medios*.

[7] In addition, this law created the Federal Audiovisual Communication Services Authority (AFSCA), the regulator of the audiovisual services market.

[8] Resolución 98 SC/10.

[9] Resolución 5 SC/13.

[10] CABA city has the highest penetration rate: it triples the national average penetration rate (ENACOM, 2017).

[11] In both modalities, the mobile plans are offered in a mixed form: voice minutes, messages (SMS and MMS) and Internet services.

[12] It is important to mention that Nextel was purchased by Telecom Argentina in 2015. Remarkable, since Nextel's services are focused on mobile digital radio for enterprises.

[13] Owned by Millicom International Cellular SA.

[14] See Table 1.

[15] See Fig. 1.

[16] Resolución Nro. 091-2013-MTC/03.

[17] Resolución Nro. 166–2013 CD/OSIPTEL.

[18] Ley Nro. 30083.

[19] For example, the "*Nuevo Reglamento de Calidad*" and "*Reglamento General de Tarifas*" norms.

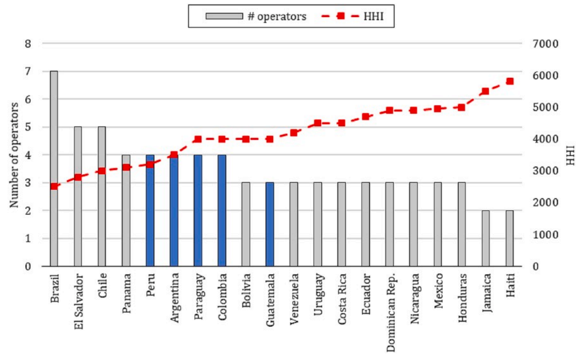

Fig. 2. Number of mobile network operators (MNO) and HHI, by country.
Source: IDB (2018).

(known as Entel), bought Nextel's market position in 2013. Similarly, Viettel (known as Bitel) and Virgin Mobile (a MVNO operator) entered the market in 2015 and 2016 respectively. Historical operators' market presence is shown in Table 1.

According to the Peruvian Telecommunications Regulator (OSIPTEL), the mobile market has grown from 32 million mobile lines in 2014 to 38 million in 2017, which are highly concentrated in the capital city of Lima. Until the first half of 2017, the most important companies in the mobile market are still Telefónica (known as Movistar) and Claro (with 38.2% and 32.14% of market share, respectively). However, due to the number portability law of 2013, Entel has increased its participation to reach 16.4% mainly due to aggressive pricing and product innovation services.[20] Finally, prepaid dominates the market with 70% of lines.

3.4. Guatemala

In 1986, a fifteen-year monopoly was granted to Comunicaciones Celulares S.A., known as Comcel. In 1999, América Móvil and Telefónica entered the Guatemalan market. That same year, Millicom International Cellular (an international conglomerate) increased its shares and investments in Comcel company, which led to Comcel taking the name of the conglomerate, Tigo.

As a result, the Guatemalan mobile market turned into a market of three mobile operators (SIT, 2017).[21] As of 2017, Tigo has more than half of the whole market share (52.21%), while Movistar and Claro share the rest (with 20.64% and 27.15% respectively).[22] It is worth mentioning that this may be a consequence of not having introduced number portability. Finally, the mobile market in Guatemala has grown only recently, just like the rest of the countries in the region. Between 2013 and 2017, mobile lines increased from 17.6 to 19.1 million, with 95% being prepaid (SIT, 2017).

3.5. Paraguay

In 1991, Telefónica Celular de Paraguay S.A. (known as Telcel) acquired the rights to operate in the Paraguayan mobile market. Tigo, the brand name of the Millicom International conglomerate, later purchased Telcel. Since then, América Móvil (operating as Claro), Personal (owned by Telecom Argentina), and Hola Paraguay (known as Vox) have entered the market, increasing competition in the sector. Later, in 2010, the state-owned company Copaco bought a share of Vox. The current Paraguayan context presents five mobile operators in a market with 7.5 million of mobile lines in service. Tigo (48.21%) and Personal (32.79%) control the market with the highest shares,[23] followed by Claro (15.51%), Vox (3.29%) and the state-owned company Copaco (0.20%).

3.6. Summary

The Latin-American mobile telecommunications market has changed from showing a highly concentrated structure to a more competitive one, due to pro-market policies undertaken in each country (IDB, 2018; Mariscal, 2007). However, an assessment of the number of firms does not assure an efficient analysis of market structure (Laffont & Tirole, 1999). To obtain a more precise perspective, Fig. 2 shows the number of operators as well as the Herfindahl-Hirschman Index (HHI) for the main countries of the region,[24] which measures market concentration. As many firms operate in each market, one would expect that shares might be similar and their HHI as a consequence. Even though Peru, Argentina, Paraguay and Guatemala have the same number of mobile operators, their HHI are

[20] See Fig. 1.
[21] See Fig. 1.
[22] This is not repeated in the fixed telephony market, because although the three companies have the largest market share, Claro has an 83% share. Therefore, it is undoubtedly a service with even greater concentration than the mobile market (SIT, 2017).
[23] See Fig. 1.
[24] This figure only analyzes MNO market shares by country.

Table 2
Definition of variables.

Variable	Definition	Source
Mobile operator	Dependent categorical variable. Endogenous choice of operator, depending of country	AA 2017
I. Network variables		
Local network effect	Takes the value of 1 if respondent belongs to the same operator as his/her most-called friend/relative; 0 otherwise	AA 2017
Intensity of use	Normalized index of intensity of mobile phone use relative to the social network. Greater values indicate respondents' contact with their social network through mobile has increased.	
Global network effect	Market share of the chosen operator at the national level	Country-specific regulator/operator
Tariff on-net	Price of 1-min on-net call in a standard tariff plan (prepaid or postpaid)	
Tariff off-net	Price of 1-min off-net call in a standard tariff plan (prepaid or postpaid)	
II. Respondent's Socioeconomic variables		
Age	1 if young (18–25); 2 if adult (26–59); and 3 if elderly (60 or more).	AA 2017
Female	1 if respondent is female; 0 otherwise	
Single	Marital status. Takes the value of 1 if single; 0 otherwise	
Education	Highest level of education achieved. Takes the value of 1 if lower than secondary; 2 if complete secondary; and 3 greater than secondary	
Rural	1 if respondent lives in a rural area; 0 otherwise	
Income	Logarithm of monthly net income	
Mobile expenditure	Logarithm of mobile monthly expenditure	
III. Usage variables		
Frequency of use	Normalized index of frequency of mobile phone use (daily, weekly, occasionally, never)	AA 2017
IV. Consumer preferences variables		
Coverage	Takes the value of 1 if respondent thinks that operator's coverage is an impediment to increase mobile use; 0 otherwise	AA 2017
Tariff	Takes the value of 1 if respondent thinks that operator's tariffs is an impediment to increase mobile use; 0 otherwise	
Network	Takes the value of 1 if the respondent thinks that a small network is an impediment to increase mobile use; 0 otherwise	

Note: AA 2017 means After Access 2017. Authors' elaboration.

different. Therefore, it is important to analyze why these differences in consumers' decisions exist in markets with similar historical patterns.

4. Methodology

In order to analyze the behavior of consumers when choosing a mobile operator, we consider a multiple discrete choice model with an unordered dependent variable. Discrete choice models are usually based on the assumption of the decision-maker's utility-maximizing behavior (McFadden, 1973; Cameron & Trivedi, 2010). The dependent variable in our model corresponds to the individual choice of mobile operator in each country.[25] For example, for the Peruvian case, the dependent variable can take only take five possible unordered values: Bitel, Claro, Movistar, Entel or Tuenti. Table 2 presents the definition of the explanatory variables: (1) network variables, (2) socioeconomic variables, (3) usage variables, and (4) consumer preferences variables. Since we have to include both the attributes of the alternative-specific variables (mobile operators) as well as the individual-specific variables (individuals characteristics), the appropriate methodological choice is an alternative-specific conditional logit model (ASCL) (Cameron & Trivedi, 2010). In particular, we report two kinds of ASCL's results: the relative-risk ratio (the effect of X explanatory variable over the probability to choose a specific operator rather than another operator) and the marginal effects (the effect of X explanatory variable over the probability to choose a specific operator).

The ASCL model was derived from McFadden (1973) and is described below. For the i-th user faced with J choices, the utility of choice j is:

$$U_{ij} = \beta^{'} X_{ij} + \gamma_j^{'} Z_i + \alpha_j + \varepsilon_{ij}, \tag{1}$$

Where X_{ij} is a vector of explanatory variables that describe the attributes of alternative j as faced by user i; Z_i is a vector of explanatory variables that describe the characteristics of users; α_j is a constant that is specific to alternative j; and ε_{ij} is the standard normal error term for both the alternative j and the user i. The alternative-specific constant for an alternative j captures the average effect of all

[25] Endogeneity problems regarding the relationship between market share (global network effect) and choice of mobile operator (where market share determines operator choice, which in turn increases its market share) are overcome because mobile infrastructure is already in place (capacity limits).

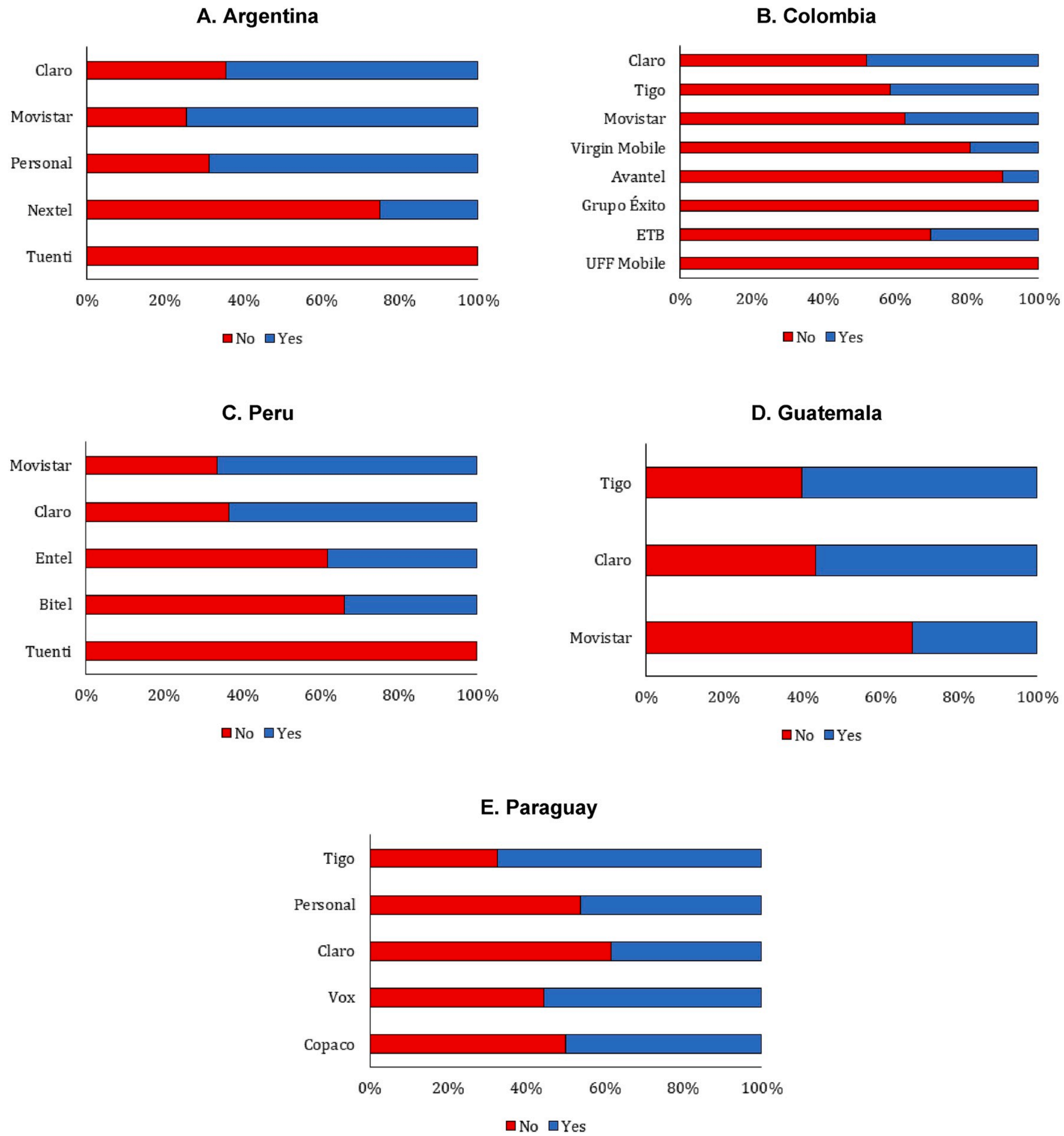

Fig. 3. Local network effects, by operator and country (%) – 2017.
Source: After Access 2017. Authors' elaboration.

factors that are not included in the model. Nevertheless, since only differences in utility matter, the difference in the alternative-specific constant is relevant. The usual procedure is to normalize one of the constants to zero (i.e. the baseline category)[26] and interpret the results relative to that category (the relative-risk ratio). In our case, we normalize the constant for the operator that has the higher market share, and set the results comparable to that category.

Let Y_i be a random variable that indicates the choice made. In the alternative-specific conditional logit model the probability that user i chooses alternative j (mobile operator) is:

[26] This normalization procedure to the baseline category is methodologically desirable because it makes comparison of the obtained results easier and ensures a better model identification (Cameron & Trivedi, 2010; McFadden, 1973).

$$\Pr(Y_i = j) = \frac{\exp\left(\beta^{'} X_{ij} + \gamma_j^{'} Z_i + \alpha_j\right)}{\sum_{j=1}^{J} \exp\left(\beta^{'} X_{ij} + \gamma_j^{'} Z_i + \alpha_j\right)}, \tag{2}$$

Then, the log-likelihood function of the model has the following form:

$$\ln L(\beta) = \sum_{i=1}^{N} \sum_{j=1}^{J} y_{ij} \ln Prob(Y_i), \tag{3}$$

Where y_{ij} is a dummy variable, which is equal to 1 if an individual chooses alternative j, and 0 otherwise. In addition to the relative-risk ratio where we can compare estimated parameters among different categories, independent estimated parameters of discrete choice models are generally not directly interpretable (Cameron & Trivedi, 2010). In particular, regardless of relative-risk ratio, a positive coefficient only reports the effect in sign, so the economically meaningful coefficients are the marginal effects. Thereby, for individual i, the marginal effects (ME) of a change in the kth regressor on the probability that alternative j becomes the outcome is:

$$\mathrm{ME}_{ijk} = \frac{\partial \Pr(y_i = j)}{\partial x_{ik}} \tag{4}$$

5. Data

The data set for the empirical analysis has been obtained from a survey conducted in 2017 by DIRSI (Diálogo Regional Sobre Sociedad de la Información). The data covers 6508 respondents dispersed in five countries in the Latin American region (1267 in Argentina, 1384 in Colombia, 1237 in Peru, 1265 in Guatemala, and 1355 in Paraguay). In this survey, among other topics, respondents are asked to state their real choice of mobile operators, depending on the country of analysis. Notably, the survey asks respondents if the person they contact the most (their social network) belongs to the same operator. This fact allows us to identify the local network effect described in the literature review, and to see the respondent's intensity of mobile phone use to communicate with their social network. This survey also contains information on the respondents' demographic and socioeconomic variables such as age, sex, marital status, education level, location (urban-rural), income and net income, and monthly expenditures for mobile telephony. Information on consumers' attitudes towards different characteristics of mobile operators' services such as coverage, tariff, and network are also available. Finally, the After Access 2017 survey allows the categorization of respondents according to their frequency of mobile phone usage. Variables are shown in Table 2.

Additionally, we collected information on specific characteristics of the mobile operators in the five countries under analysis, such as the operators' market share at the national level from regulators (ENACOM, CRC, OSIPTEL, SIT, CONATEL), as well as mobile operators' tariffs (from the operators' websites). Tariff information consists of the price of 1-min on-net and off-net call in a standard tariff plan (for prepaid and postpaid plans), and was collected through a criterion that allows comparisons of the services covered by the tariff plan, in order to make inferences about the choice of consumers under similar conditions and context.[27]

Fig. 3 shows local network effects by mobile operator and country. Local network effects are measured by the percentage of people who answered yes to the question *'Are the people that you call most often on the same network as you?'* The panels on Fig. 3 are organized considering the market share of the mobile operators for the five countries (operators with higher market shares, as shown in Fig. 1, are located at the top of each graph). It is important to notice that the majority of respondents stating that their contacts belong to the same operator picked operators with higher market shares. This clustering could be explained by the fact that the mobile market has been historically concentrated in one or two firms, which allowed them to expand their network through higher investment in infrastructure (IDB, 2018; Mariscal, 2007).

Furthermore, it is worth noting the relevance of network effects depending on market competition. We can compare the Guatemalan and Peruvian case as complete opposites in terms of market competition: the Herfindahl-Hirschman Index (HHI) for Peru is the lowest one among the five countries (2931), while the HHI for Guatemala is the highest (3889). Panel C shows that network effects decrease as the mobile operator's market share decreases, while panel D does not show big differences. The analysis confirms that there may be no relevant differences attributed to market structure in these five countries, highlighting the possibility that there may be other variables altering the consumer choice process, such as network effects.

6. Results

Results vary according to the specific context of each country and individual characteristics. Regarding the dependent variable (mobile operator choice), the mobile operator with the highest market share in each country (Claro for Argentina and Colombia, Tigo for Guatemala and Paraguay, and Movistar for Peru) is set as the baseline reference category (relative-risk ratio). This allows a better understanding of consumers' decisions based on the relative probabilities, considering the reference category as the "*best*" operator choice (similar to a benchmark). In addition, we use marginal effects of ASCL estimations in order to perform robustness-check tests. All results consider socioeconomic and usage variables as control regressors for each country. Standard errors are robust to allow for the possibility of heteroskedastic variance, where the variance of the errors is not only attributable to inter-individual differences, but

[27] Tariff information are in USD per minute to make the cross-country analysis easier.

Table 3
Estimations results (relative-risk ratios of the ASCL) – Argentina.

Variables	(1)	(2)	(3)	(4)
	Movistar	Personal	Nextel	Tuenti
I. Network variables				
Local network effect	0.533*	0.211***	−1.413**	−17.284***
	(0.310)	(0.181)	(0.709)	(0.560)
Global network effect	0.221**	0.522**	0.103*	1.860*
	(0.020)	(0.001)	(0.025)	(0.518)
Intensity of use	0.067***	0.508	−1.199***	−10.675***
	(0.021)	(0.096)	(0.063)	(0.129)
Tariff on-net	−0.044**	−0.173	−2.239**	−8.169***
	(0.020)	(0.098)	(0.025)	(0.065)
Tariff off-net	−0.004***	−0.068***	−0.046***	−1.763***
	(0.024)	(0.132)	(0.010)	(0.071)
II. Consumer preferences variables				
Coverage	−0.467	−0.544	−2.223*	−17.055***
	(0.363)	(0.343)	(1.282)	(0.909)
Tariff	−0.712***	−0.206	0.927	−16.399***
	(0.232)	(0.244)	(0.904)	(0.937)
Network	−0.222	0.738**	−15.464***	−14.496***
	(0.261)	(0.320)	(0.605)	(1.191)
Constant	0.944**	1.224	1.113	−2.441
	(0.443)	(0.896)	(4.305)	(1.896)
Socioeconomic variables	Yes	Yes	Yes	Yes
Usage variables	Yes	Yes	Yes	Yes
Locality fixed-effects	Yes	Yes	Yes	Yes
Pseudo R^2	0.043	0.043	0.043	0.043
LR χ^2	125.42	125.42	125.42	125.42
Prob > χ^2	0.000	0.000	0.000	0.000
Observations	1267	1267	1267	1267

Note: the referee category is set equal to Claro category (highest market share operator). Robust standard errors clustered by locality in parentheses. Standardized coefficients. ***p < 0.01, **p < 0.05, *p < 0.1.

also intra-individual ones (Cameron & Trivedi, 2010).[28] Finally, the standard errors for all results are clustered by locality (provinces or regions in each country), since we assume that people living in the same area share both the same mobile operator infrastructure and commercial strategies (tariffs and particular promotions).

6.1. Argentina

Argentina represents a special case among the countries under analysis. Claro is the dominant firm in this market (see Fig. 1), therefore it is selected as the base category for the empirical analysis. Results are shown in Table 3. First, network effects can be decomposed in two mechanisms. On the one hand, the local network effect is related to the influence of people that the respondent actually knows (see Table 2) and it is stronger when the analysis compares the highest market share and the lowest market share operators (Claro versus Nextel and Tuenti) as seen in columns (3) and (4). In these cases, the probabilities of choosing Nextel and Tuenti are negative relative to choosing Claro. Additionally, if the respondents' social network belongs to the same mobile network, it is 53.3% more likely that the respondent chooses Movistar as compared to Claro. Finally, the intensity of mobile phone use relative to the network is not relevant only for Personal.

On the other hand, the global network effect refers to the size of the national operator market share. Table 3 shows that the national market share variable increases the probability of choosing any operator other than Claro: these effects are always positive and statistically significant compared to the local network effect. The results of local and global network effects are different than those shown in Karaçuka et al. (2012).[29] Finally, supply side variables such as the prices of on-net and off-net tariffs plans are relevant only when choosing between Movistar and Claro: if Movistar decides to increase both types of tariffs (prepaid and postpaid), the probability that a consumer chooses Claro increases in 4.4% and 0.4%, for a positive variation in on-net an off-net tariff, respectively.

Consumer preferences variables are also relevant for the choices of mobile operators. Table 3 shows that specific characteristics related to mobile operators in the Argentinian market have a positive influence in the consumers choosing Claro. Respondents who think that a mobile operator's coverage creates a barrier for higher use strongly prefer Claro to Nextel. In fact, the coverage factor is

[28] Inter-individual differences represent differences observed between people *-individual-specific variables-* (e.g. socioeconomic variables), whereas intra-individual differences represent differences observed within the same person when they are assessed at different times or in different situations *-alternative-specific variables-* (e.g. decision of an operator choice).

[29] Additionally, the use of a local network effect variable in the present paper is the main difference with the research developed in Karaçuka et al. (2012).

Table 4
Estimations results (relative-risk ratios of the ASCL) – Colombia.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Tigo	Movistar	Virgin	Avantel	Éxito	ETB	UFF
I. Network variables							
Local network effect	−0.248	−0.395***	−1.236***	−1.874**	−16.330***	−0.464	−15.944***
	(0.243)	(0.143)	(0.207)	(0.800)	(0.565)	(0.567)	(1.018)
Global network effect	0.615*	0.555**	0.580**	0.036***	0.166***	0.148	0.178
	(0.122)	(0.110)	(0.113)	(0.012)	(0.040)	(0.035)	(0.037)
Intensity of use	−0.067	−0.107	−0.071	0.001**	0.007*	0.013	0.014*
	(0.090)	(0.080)	(0.082)	(0.009)	(0.008)	(0.007)	(0.007)
Tariff on-net	−0.945***	−0.672***	−0.841*	−0.066	−0.100*	−0.113*	−0.090**
	(0.208)	(0.183)	(0.187)	(0.024)	(0.036)	(0.032)	(0.033)
Tariff off-net	−0.130**	−0.095*	−0.108**	−0.005	−0.515***	−0.351	−0.400**
	(0.033)	(0.029)	(0.031)	(0.003)	(0.056)	(0.050)	(0.050)
II. Consumer preferences variables							
Coverage	−1.665***	0.164	1.329**	−16.039***	−14.629***	−15.317***	−13.046***
	(0.634)	(0.367)	(0.660)	(0.664)	(0.866)	(0.708)	(1.225)
Tariff	−0.207	−0.308*	0.188	0.311	−0.362	0.700	1.253***
	(0.187)	(0.181)	(0.399)	(0.566)	(1.427)	(0.479)	(0.104)
Network	−0.781	−17.153***	−16.441***	−15.715***	−13.170***	−16.652***	−13.941***
	(0.499)	(0.495)	(0.701)	(1.108)	(1.349)	(0.950)	(1.893)
Constant	−0.694	−2.685***	−3.825***	−7.259***	−5.879***	−8.793***	−26.934***
	(0.926)	(0.812)	(0.916)	(1.672)	(1.981)	(1.988)	(1.065)
Socioeconomic variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Usage variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Locality fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.067	0.067	0.067	0.067	0.067	0.067	0.067
LR χ^2	202.25	202.25	202.25	202.25	202.25	202.25	202.25
Prob > χ^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	1384	1384	1384	1384	1384	1384	1384

Note: the reference category is set equal to Claro category (highest market share operator). Robust standard errors are clustered by locality in parentheses. Standardized coefficients. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

more relevant between Claro and the companies with lower market participation, reflecting the advantages that the dominant firm has in infrastructure as well as in the mobile service itself. The effect of tariff level, and consumers' perceptions about network relevance are interpreted in a similar way. The probabilities of not choosing Nextel and Tuenti as compared to Claro are higher than that corresponding to Movistar.

6.2. *Colombia*

Table 4 presents the results for Colombia. As Claro is the dominant firm (highest market share operator), it is selected as the baseline category for the empirical analysis. For the local network effects, the probability of choosing Claro if your social network belongs to the same mobile network, is higher when compared to Grupo Éxito and UFF operators. Furthermore, the local network effects are not significant when the choice is Tigo, but they do so when characteristics of the offered mobile services are analyzed. In fact, Table 4 reveals that the key competition variables are the differences in coverage offered by both companies. Higher mobile coverage increases the probability of choosing Claro over Tigo by 166%.

The analysis also suggests that the global network effect is always relevant for consumers' decisions (positive and statistically significant), excluding ETB and UFF operators. An increase in the market share of any of the operators increases the probability of choosing an operator other than Claro (except for ETB and UFF, where estimated parameters are not significant). Finally, results show that an increase in the level of on-net and off-net tariffs negatively affect the probability of choosing an operator (except for Avantel). These results also imply that tariff levels are still an important competition variable, but service-related variables could also increase competition among operators in the Colombian market, particularly, coverage and network.

6.3. *Peru*

Table 5 shows the results for the Peruvian mobile market. The baseline reference category is Movistar. The magnitude of local network effects increases as we compare the mobile operator with the highest market share to the operator with the lowest one, reaffirming the idea that consumers' social network (local network effect) are determinants of the choice of operator conditional of the operator market share (global market share). It is important to note that local network effects do not influence consumers' choices between Movistar and Claro (the second most important operator in the Peruvian mobile market), revealing closer competition between these two operators. Moreover, the intensity of mobile phone use relative to social network reinforces the local network effect: the probability to choose an operator different to Movistar increases with a more intense mobile phone use to contact people of the

Table 5
Estimations results (relative risk-ratios of the ASCL) – Peru.

Variables	(1)	(2)	(3)	(4)
	Claro	Entel	Bitel	Tuenti
I. Network variables				
Local network effect	−0.109	−1.151***	−1.410***	−16.164***
	(0.206)	(0.268)	(0.290)	(0.569)
Global network effect	0.418***	0.123**	0.945**	10.256***
	(0.027)	(0.005)	(0.050)	(0.020)
Intensity of use	0.327	−0.141*	−1.217**	12.210
	(0.032)	(0.006)	(0.060)	(0.024)
Tariff on-net	−0.059***	−0.005***	−0.012*	−8.042***
	(0.008)	(0.002)	(0.016)	(0.006)
Tariff off-net	−0.039***	−0.010***	−0.006*	−10.067***
	(0.008)	(0.002)	(0.016)	(0.006)
II. Consumer preferences variables				
Coverage	−0.672***	−0.100	−1.106***	−15.176***
	(0.171)	(0.239)	(0.370)	(0.677)
Tariff	0.095	−0.078	−0.361	−14.967***
	(0.160)	(0.198)	(0.232)	(0.541)
Network	0.147	−1.431	0.016	−14.921***
	(0.496)	(1.161)	(0.471)	(0.614)
Constant	−0.218	−1.289***	2.275***	−2.461
	(0.493)	(0.411)	(0.503)	(2.471)
Socioeconomic variables	Yes	Yes	Yes	Yes
Usage variables	Yes	Yes	Yes	Yes
Locality fixed-effects	Yes	Yes	Yes	Yes
Pseudo R^2	0.075	0.075	0.075	0.075
LR χ^2	229.69	229.69	229.69	229.69
Prob $> \chi^2$	0.000	0.000	0.000	0.000
Observations	1237	1237	1237	1237

Note: the reference category is set equal to the Movistar category (highest market share operator). Robust standard errors are clustered by locality in parentheses. Standardized coefficients. ***p $<$ 0.01, **p $<$ 0.05, *p $<$ 0.1.

same social network (friends, relatives, coworkers, local community, among others), subscribed to the other operator.

Once more, global network effect estimations are always positive and relevant for consumer decisions, suggesting that being the largest operator overall is critical for consumer preferences. In addition, variations in tariffs plans (at the prepaid and postpaid) are also very relevant, which suggest that the key competition variable to attract consumers is guided by network variables. Finally, perceptions about mobile operators' coverage play a key role in the Peruvian market. Since the liberalization period in 90s, entrant mobile operators have had an aggressive commercial policy in the highlands and the jungle, both considered as "new" markets to "compete under the same conditions" (OSIPTEL, 2003). This event supports the obtained results of the study: coverage characteristics influence consumers' decisions for all mobile operators (except for Entel), with considerable differences for Bitel and Tuenti.

6.4. Guatemala

Since Tigo is the dominant firm in the Guatemalan market (see Fig. 1), it is selected as the baseline category for the empirical analysis. Table 6 presents the relative-risk ratios for each mobile operator different to the dominant firm. We can see that the local network effect is not important when the analysis focuses on the consumer's decision between Tigo and Claro (dominant and follower competitor operators, respectively). In addition, consumer preferences variables (coverage, tariffs or network) influence the choice decisions of Guatemalan consumers between Claro and Tigo. The only variable that changes consumers' preferences between these two operators is global network effect. If the national market share of Claro increases in one unit, the probability of choosing Claro as a mobile operator rather than Tigo increases in 31%. Conversely, positive variation in on-net or off-net tariffs increases the probability to choose Tigo instead of Claro by 4% and 9%, respectively.

Guatemalan consumers' characterization allows us to identify some competition variables between Tigo and Movistar. For competition between these operators, consumers with a social network in the same mobile network (local network effect) increases in the probability of choosing Tigo over Movistar by 107%, and the effects are more relevant when Tigo is compared to Movistar than to Claro (a large difference in operator market shares, i.e. global network effect). Since there are only three firms operating in the Guatemalan market, the local network effect reflects the strong level of competition (SIT, 2017). Likewise, Table 6 also reports the relevance of tariff and operator service variables as determinants of the choice between Tigo and Movistar. An increase in tariff levels of Movistar (on-net and off-net) diminishes the probability to choose Movistar as compared to Tigo, while network consumer preferences increased the probability to choose Movistar by 79%.

Table 6
Estimations results (relative-risk ratios of the ASCL) – Guatemala.

Variables	(1) Claro	(2) Movistar
I. Network variables		
Local network effect	−0.085	−1.075***
	(0.164)	(0.211)
Global network effect	0.310**	−0.047***
	(0.021)	(0.004)
Intensity of use	−0.150	−0.030*
	(0.025)	(0.005)
Tariff on-net	−0.044***	−0.003**
	(0.007)	(0.001)
Tariff off-net	−0.086***	−0.010***
	(0.007)	(0.001)
II. Consumer preferences variables		
Coverage	−0.511	−0.734*
	(0.359)	(0.429)
Tariff	−0.182	−0.153
	(0.161)	(0.289)
Network	0.362	0.795**
	(0.397)	(0.347)
Constant	−1.279**	−1.392***
	(0.609)	(0.498)
Socioeconomic variables	Yes	Yes
Usage variables	Yes	Yes
Locality fixed-effects	Yes	Yes
Pseudo R^2	0.057	0.057
LR χ^2	142.35	142.35
Prob > χ^2	0.000	0.000
Observations	1265	1265

Note: the reference category is set equal to Tigo category (highest market share operator). Robust standard errors clustered by locality in parentheses. Standardized coefficients. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

6.5. *Paraguay*

Results for Paraguay (reported in Table 7) are similar to the estimations presented before. Like Guatemala, Tigo is the baseline reference category, with 48.21% of the mobile market share. Similar to previous cases, the influence of the local network variable is significant in Paraguay, but conditional to the size of operators' market shares (global network effect). When choosing an operator, it is not only relevant that people you know belong to the same operator, but also the intensity of mobile phone use relative to that social network (*intensity of use* variable).

Compared to market conditions that Tigo faces in Guatemala, the Paraguayan mobile market represents an attractive scenario for the company, explained by the competition with its follower Personal. There is only a difference of 15.42% in the market share between Tigo and its closest competitor in Paraguay, as compared to the market share gap 25.06% in Guatemala. Finally, unlike all other cases, the network consumer preferences increase the probability to choose Tigo rather than Claro or Vox.

6.6. *Robustness-check analysis*

In order to verify the weakness of estimated parameters discussed above (focusing on the local network effect variable), we carried out two robustness-check exercises related to the marginal effects of ASCL results.[30] First, we reran regressions without considering MVNO operators or operators that might not be considered direct competitors, such as Nextel. The purpose was to focus the analysis in companies with comparable telecommunication infrastructure (MNO). In Argentina, we excluded Tuenti (MVNO) and Nextel from the analysis. [31] For the Colombian case, we excluded Virgin, Éxito, ETB and UFF (MVNO). In Peru, we excluded Tuenti (MVNO). Finally, for the Guatemalan and Paraguayan all operators are MNO, so none was excluded. Then, we performed a falsification exercise using market shares of 2015 to test the inertia of prior market position (or the incumbency advantages bias).

Fig. 4 plotted the estimations' marginal effects of the ASCL model.[32] This figure shows the marginal effects of the local network

[30] Marginal effects in discrete choice models (as ASCL) are directly interpretable, regardless any baseline reference category (Cameron & Trivedi, 2010).
[31] Although this company offer many mobile services (mobile Internet, SMS, etc.), traditionally focused on mobile digital radio market – *push-to-talk* calls.
[32] See figure A1 in the appendix for our main ASCL's marginal effects results (model 1).

Table 7
Estimations results (relative risk ratios of the ASCL) – Paraguay.

Variables	(1)	(2)	(3)
	Personal	Claro	Vox
I. Network variables			
Local network effect	−0.897***	−1.135***	−0.407
	(0.223)	(0.236)	(0.584)
Global network effect	0.098***	0.024***	0.255***
	(0.012)	(0.003)	(0.029)
Intensity of use	0.065***	0.009*	0.003
	(0.001)	(0.006)	(0.054)
Tariff on-net	−0.239**	−0.492***	−4.306***
	(0.012)	(0.055)	(0.506)
Tariff off-net	−0.196***	−0.004**	−0.001*
	(0.001)	(0.009)	(0.079)
II. Consumer preferences variables			
Coverage	−0.191	0.157	0.261
	(0.185)	(0.159)	(0.690)
Tariff	−0.257	−0.070	−0.309
	(0.232)	(0.247)	(0.686)
Network	1.009	−12.952***	−12.932***
	(0.863)	(0.772)	(1.283)
Constant	−0.627	−4.580***	−0.291
	(0.717)	(0.997)	(1.956)
Socioeconomic variables	Yes	Yes	Yes
Usage variables	Yes	Yes	Yes
Locality fixed-effects	Yes	Yes	Yes
Pseudo R2	0.074	0.074	0.074
LR chi2	167.86	167.86	167.86
Prob > chi2	0.000	0.000	0.000
Observations	1355	1355	1355

Note: the reference category is set equal to "Tigo" category (highest market share operator). Robust standard errors clustered by locality in parentheses. Standardized coefficients. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

effect variable of our main model (Model 1) and of the robustness-check tests: Model 2 excluded MVNO, and Model 3 uses 2015 market shares. First, Fig. 4 shows that the local network effect is consistent with the relative-risk ratios and marginal effects results reported. Except for Argentina, local network effects are positive for the largest operators and ratios are higher than the ones estimated in the main exercise, suggesting that local network effects are important in those operators with the largest market share (local network effect conditional to global network effect hypothesis). Furthermore, operators with lesser market participation in almost all countries analyzed show weak local networks, confirming our main results. Second, both Model 2 and Model 3 show robust results: variability of changes in the parameters magnitude is minimal.

7. Conclusion

It has been shown that the presence of demand-side externalities can induce the market to benefit the largest firms in terms of market share, usually called *network effect* by the theoretical literature (Liebowitz & Margolis, 2002). Macro-level approaches in the empirical literature of network effects commonly use the assumption that a network's overall size matters more to consumers' decisions (global network effects). On the other hand, micro-level studies have suggested that family and friends (local network effects) also matter for consumers' choices beyond the overall network size (global network effects). This study suggests that, based on individual level data for five Latin American countries, country-level network size is one among a set of different factors determining mobile operator consumers' choices, once individual and operators' regional presence heterogeneity are considered. Moreover, network characteristics and consumer preferences, such as coverage, tariffs, and network importance also affect the choice of mobile network in the five Latin American countries examined.

Our approach emphasized the comparison of global network effects versus local network effects. Specifically, local network effects were evaluated with respect to the largest operator in each country. In twelve out the twenty possible comparisons for the five countries selected, local network effects were larger, in absolute value, than global network effects, with two cases showing the opposite, when both coefficients were statistically significant. Four more comparisons showed that only global network effects were statistically significant; interestingly, three of these occurred when the individual chose the second largest operator in each country -Colombia, Peru and Guatemala; note should be taken that Colombia and Guatemala are among the ones with the highest HHI in our sample. The remaining two cases correspond to the smallest MVOs in Colombia: one where neither local or global effects are statistically significant, and the other one where only the local effect was statistically significant, but is of negative sign.

Our findings are particularly useful to explain recent market developments in the countries under analysis. The competition for new customers in Latin America triggered a continuous fall in mobile tariffs, which would have generally resulted in a more competitive market structure reflected in a more even distribution of market shares among market rivals. However, this scenario did not

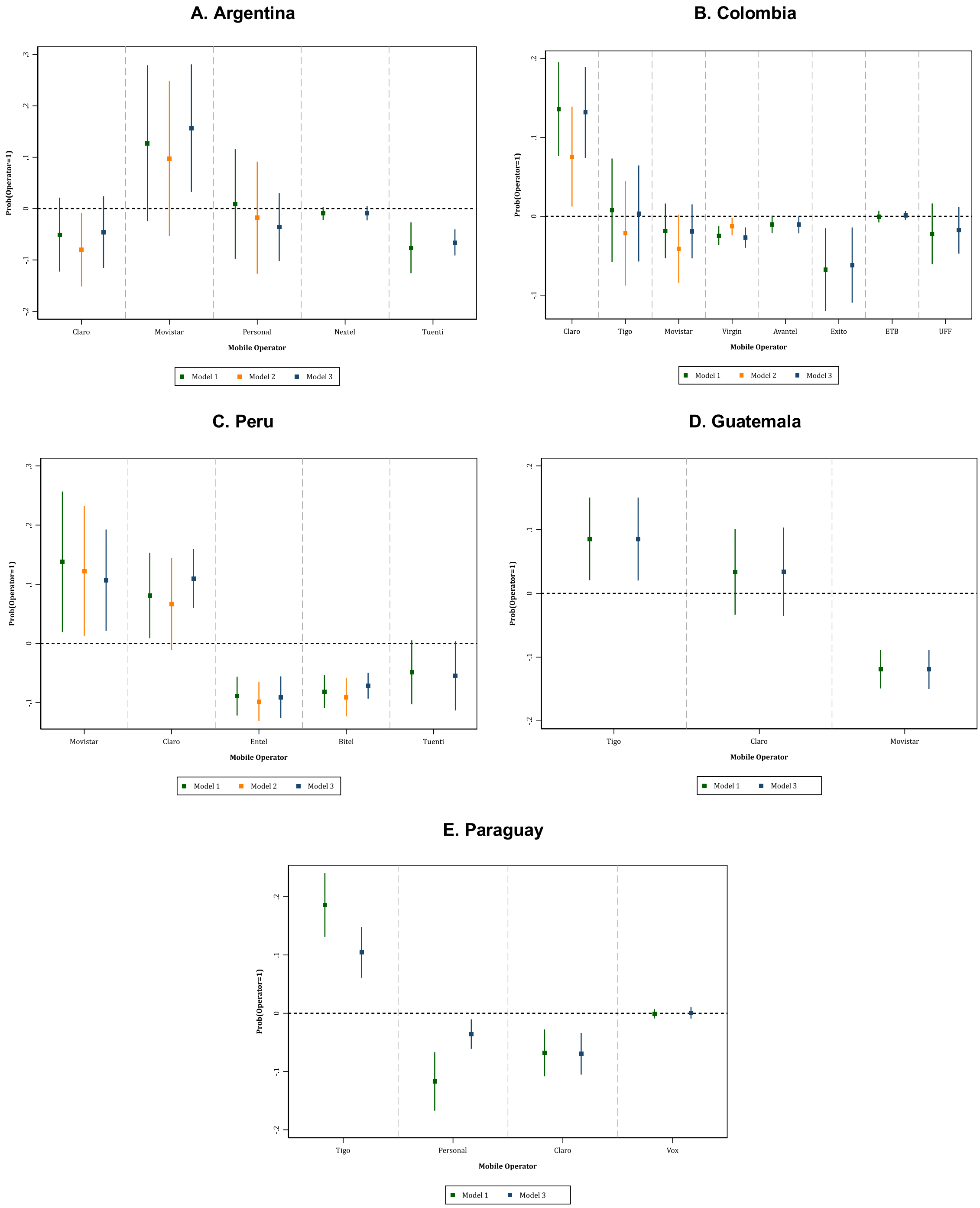

Fig. 4. Robustness-check analysis (marginal effects of local network variable). Source: After Access 2017. Authors' elaboration.

materialize. The mobile market in the region remained highly concentrated in spite of severe tariff competition. Such developments are typical for markets where network effects prevail (Laffont & Tirole, 1999; Viscusi, Harrington, & Vernon, 2005) coupled with entrants' strategies to target current subscribers instead of enlarging the market by subscribing new mobile consumers altogether. Furthermore, on-net prices and off-net prices still have a significant impact on the probability of choosing a mobile operator, but there are also other competition variables (such as network variables) that should be considered in the analysis. Birke and Swann (2006) argue that the reason for this may be that users have a choice among a set of different tariff variables, highlighting the network effects that are the focus of this paper.

The results strengthen the importance of local network effects for the Latin American mobile market, and are strongly significant for the dominant firm choice. We found that consumers' local network decisions are important for the choice of mobile operator, with two caveats. The first one is that the magnitude of the effect is conditional on the size of the operator market share, i.e. the smallest the mobile operator, the less important is the local network effect. The second caveat pertains our focus on evaluating the local network effect when choosing between any operator and the largest one.

Recently, regulators focused on tariff competition while overlooking operators' efforts to compete on loyalty programs characterized by offering customers even free communication to selected numbers or unlimited access to social networks (zero rating type of programs). Moreover, the existence of network effects, positive and significant global network effects reinforced by substantial local network effects, can enlarge and sustain monopolist positions bringing about antitrust concerns, and weakening entrants' efforts to establish a significant and sustainable position in the market. As we discussed in section three, less competitive countries (measured by HHI size) –Paraguay, Colombia and Guatemala – have similar regulatory strategies, all of them have three operators in their mobile markets, and the former monopoly was the pioneer in the industry as well as one the first to obtain the 3G license. Therefore, despite number portability programs introduced in each country, regulatory authorities should focus on implementing policies to further reduce switching costs, or supervise loyalty programs to avoid local network effects reinforcing global network effects, or promoting dynamic compatibility standards competition. Our results show that the regulatory focus may have been misguided, contributing therefore to explain the persistence of market share exhibited by the dominant firms.

Modeling consumers' preferences in markets with positive network effects, as is the case in mobile telecommunications, is particularly relevant. In the five Latin American countries analyzed, consumers might select a product they would not normally pick based on the expectation that their social network will choose the same product (local network effect). Thus, it is important to understand the mobile market through a demand-side approach in order to understand the consumers' reaction to the current market competition level (Knieps, 2015). Positive local network effects hinder the regulatory functioning, where policies go beyond regulation of network size. Therefore, the analysis must consider the choice of a network among competing alternatives based on the network composition more than on the differences in products.

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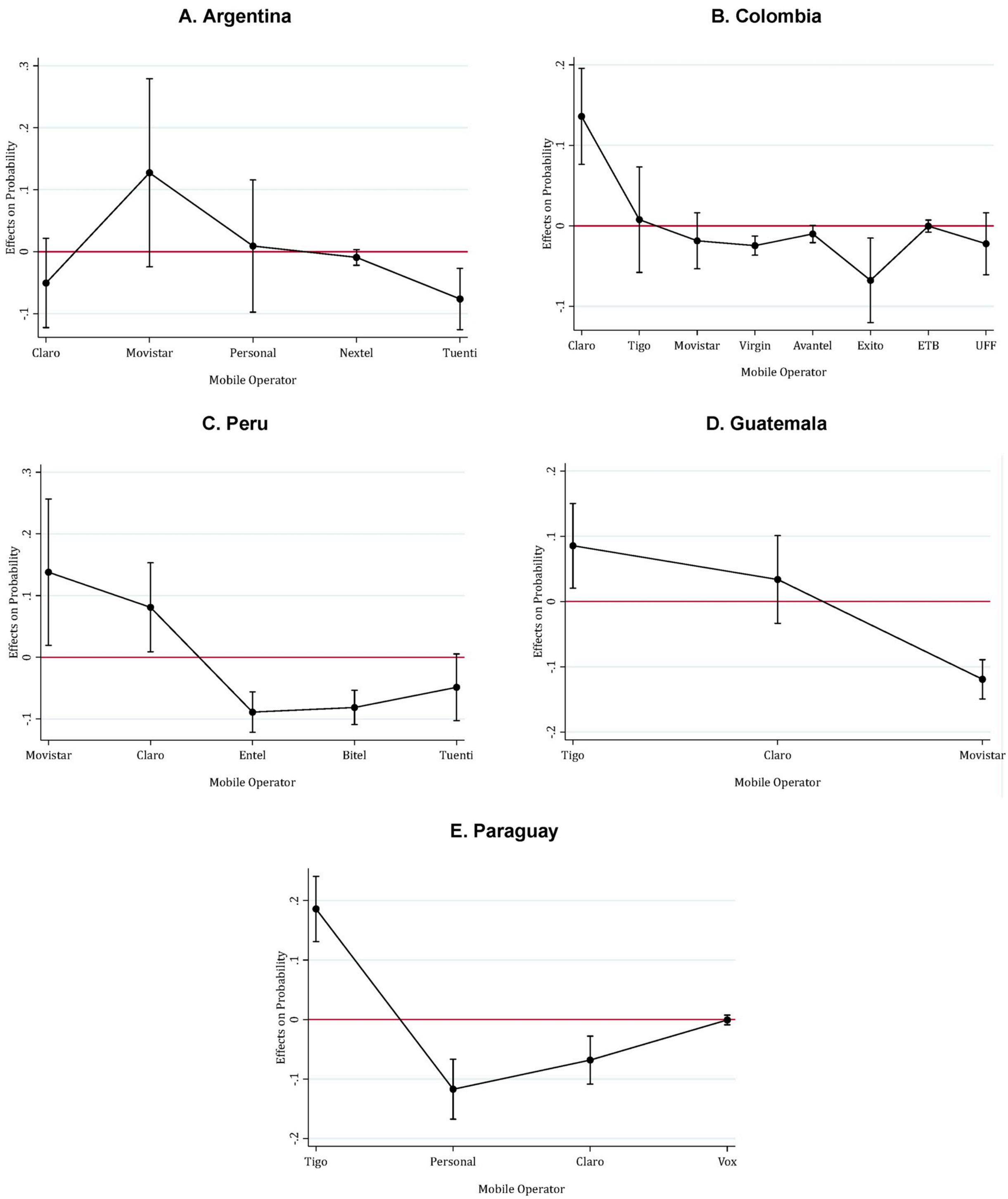
Appendix



Note: Standardized coefficients. Authors' elaboration.

Fig. A1. Local network effects, by operator (marginal effects of local network variable)

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