Market Entry and Adoption of Internet Services in Colombia

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Abstract

This paper analyzes (i) how changes in market structure affect welfare and consumer choices, and (ii) how the overall effect can be decomposed into two components: the price effect and the product variety effect. I address this analysis in the context of the Internet services market in Colombia and exploit the entry of a large telecom operator in 2007. I estimate a discrete-choice demand model and use a two-stage model with endogenous product and pricing decisions to conduct various counterfactual predictions. The empirical findings indicate that market entry increased the take-up of Internet services by 7.3 percentage points and rose consumer surplus by $10.3 million (32% of the post-entry sales). The decomposition of the overall effect reveals that, on average, the price effect accounts for 61% of the total effect whereas the remaining of the overall effect can be attributed to the change of the menu of products offered by incumbent firms.

Keywords: Entry, market structure, product variety, Internet services, digital gap.
JEL Codes: L13, L96

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1 Introduction

By the end of 2023, nearly one-third of the global population (2.6 billion people) remained without Internet access (ITU, 2023). This lack of Internet connectivity has the potential to hinder economic growth and exacerbate inequalities, especially in an increasingly digital-dependent society. While policy discussions on connectivity have re-emerged, especially after the COVID-19 pandemic, there is still a long way to achieve universal access to Internet.[1]

One of the main hurdles for adopting Internet services is the lack of competition, which holds unaffordable high prices for almost one billion people living in low- and middle-income countries (A4AI, 2021; Bamford et al., 2021). Promoting market entry might improve competitive conditions. A new entrant not only has the potential to intensify price competition but can also increase competitive pressure along other dimensions, such as product variety. However, high entry barriers, such as the lack of transparency on licensing requirements and delays to spectrum allocation, have deterred the entry of new firms into Internet markets. In light of this issue, it is important to understand the extent to which entry improves the competition conditions in Internet markets, particularly in developing economies, and how this can lead to higher Internet adoption rates. In this paper, I study entry in Internet markets and evaluate its impact on the adoption of Internet services, with an emphasis on the incumbents' responses to market entry. In doing so, I expect to provide conclusive evidence of the need to lower entry barriers in order to achieve universal Internet access.

I conduct this analysis in the context of the market for Internet services in Colombia. In particular, I leverage the entry of the large telecom operator Telmex in 2007 to evaluate the impact of entry on the adoption of Internet services and to examine the incumbents' response to the new entrant. This entry event was highly disruptive, and likely to generate responses by incumbents, as Telmex has been traditionally one of the largest telecom operators in Latin America. Colombia (with a GDP per capita of $6,600) has been characterized by low levels of internet adoption, especially among low-income households (OECD, 2014). As of 2023, there were 17 fixed Internet subscriptions for every 100 inhabitants in Colombia.[2] Despite the prevalence of mobile Internet (with relatively high uptake), home (or fixed) Internet services remain crucial for activities requiring high bandwidth levels (e.g., video conferences, file sharing, cloud services, streaming, among others) and are still the focus of policy initiatives.[3]

[1] One of the United Nation's Sustainable Development Goals is to provide **universal** and **affordable** access to the Internet in the least developed countries by 2030.

[2] To obtain more information on the current status of the digital and Internet market in Colombia, check the quarterly report by the Ministry of Information and Communication Technologies (MinTIC).

[3] In this paper, I use data for a time period during which the mobile Internet services were not affordable and only targeted towards well-off individuals (OECD, 2014).

The first objective of this work is to analyze how consumers make choices in the market for Internet services in Colombia. Given the low adoption rates, it is first-order to understand the decisions of whether or not to subscribe to Internet services, i.e., to analyze the extensive margin of demand. This involves identifying the parameters that govern consumers' preferences to understand the key factors influencing adoption decisions. The second objective is to empirically quantify the impact of entry on welfare and adoption rates. Finally, the third objective is to closely study the response of incumbents to market entry and determine how much of the total impact of market entry can be attributed to the price reaction and the adjustments of product portfolios.

To address these objectives, I use data on the universe of Internet plans offered in Colombia from 2005 to 2011. The data contain information on prices, plan characteristics, and the number of subscribers across local markets in Colombia. Using this dataset, I combine descriptive analyses with a model of demand and supply to assess the impact of market entry.

Two findings arise from the descriptive analysis. First, I show that, following market entry, the adoption rate in municipalities experiencing market entry became higher relative to markets without entry. Although descriptive, this result suggests that entry promoted the adoption of Internet services. Second, I conduct an event-study analysis to closely examine the competitive mechanisms through which entry might affect adoption decisions. I find that the entry of Telmex exerts significant competitive pressure in local markets, leading to a price reduction and changes in the number of Internet plans offered by the large incumbents. To compete with the entrant, incumbents reduce prices by 20 percent and expand their menu of Internet plans by 60 percent.

While the descriptive evidence sheds some light on the impact that market entry can produce, it still leaves many questions unanswered. For instance, it does not provide evidence on the importance of the price reaction relative to the adjustment of product portfolios, and it says little on the welfare implications of market entry. To answer these questions, I estimate a structural model of demand and supply of Internet services.

The demand model shows that consumers care about price, connection speed, last-mile technology, firm seniority and the quality (broadband) labels of the Internet plans. On the supply side, I estimate a two-stage model where Internet providers first decide on product portfolios and then simultaneously set prices. The demand parameters together with the supply-side model allow me to recover information on the cost structure of the Internet providers. For instance, I find that the fixed costs associated with Internet plans are positively correlated with the size of the local markets. For the smallest municipalities the fixed costs fall between $420 and $1,550, whereas for the largest cities in Colombia, these fixed costs range between $50,000 and $229,000.

The entry of Telmex prompts responses from incumbents in two ways. Market entry not only intensifies competition leading to a price reaction in the market, but also leads incumbents to adjust their product portfolio. To quantify each of these effects, I use the the structural model to simulate various counterfactual scenarios, each representing different entry status and portfolio of Internet plans.

The main finding shows that, after entry, the adoption rate of Internet services goes from 13 to 20.3 percent, representing an effect of 7.3 percentage points. In terms of surplus, market entry increases consumer surplus by $10.3 millions which amounts to 32 percent of the total post-entry sales. The decomposition of the total effect of market entry on adoption and consumer surplus reveals that about 61 percent arises from the price effect, while the remaining 39 percent can be attributed to the adjustments in product variety.

Finally, I compute the effect of entry on welfare accounting for the fixed costs of product adjustments. Overall, the net welfare gains are positive. Yet, I show that the gains in large cities drive these results, whereas for other small municipalities the net welfare gains are rather small or even negative. This finding, however, corresponds to just one month of Internet services. Unlike other products or one-time services, Internet plans involve subscription and monthly fees intended to last for years. Hence, extrapolating the welfare analysis over a year (or more) would exhibit gross welfare increases while keeping the fixed costs constant. As a result, in the short/medium term, I could expect the net welfare gains to be positive for all the municipalities.

Related Literature. This paper mainly contributes to two strands of the literature. First, it is connected to both empirical and theoretical works that have analyzed the effect of changes in market structure on the strategic reaction of incumbents and market coverage. The theoretical literature includes papers by Johnson and Myatt (2003) and Nocke and Schutz (2018) for competitors' choices; and Yang and Ye (2008) and Foros and Kind (2003) for market coverage. As for the empirical literature, this paper builds on previous works that examine how changes in market structure may affect conduct and, in particular, the strategic responses of incumbents in terms of product offerings and prices. Several papers have investigated this in the telecommunications industry including Berry and Waldfogel (2001), Economides et al. (2008), Seim and Viard (2011) and Boik and Takahashi (2020). In particular, Seim and Viard (2011) evaluate the impact of the entry of new personal communication services providers in the U.S. and decompose the effect into two sources: the competitive interaction effect (direct); and the launch of new services and discontinuation of old ones (indirect). In line with this work, the current investigation attempts to measure the total effect of entry and decompose it into the pure entry and product variety effects for the Internet services market in Colombia.

The empirical analysis of the current study is perhaps closest to Bourreau et al. (2021, henceforth BSV) in several ways. Firstly, BSV estimate a structural demand model, along with a two-stage supply-side model, to study how the entry of a new competitor can trigger the use of fighting brands strategy in the mobile telecommunications market in France. Similar to BSV, the current paper uses the estimates from a structural demand model, jointly with an oligopolistic model, to analyze, and decompose, the effects of market entry. Secondly, the current investigation complements BSV in that it analyzes a market that is at an early stage of the diffusion process, whereas BSV consider a telecommunications market that was already saturated before entry. Thirdly, the findings of BSV ascertain the relevance of accounting for the existence of market expansion, cannibalization, and business stealing effects when studying market entry with multiproduct firms. The aim of the current investigation is to shed some light on the nature of these effects in the market of residential Internet services in a developing country.

This work is also related to a second strand of the literature that has extensively studied the market of Internet services and the digital gap. Rappoport et al. (2003) and Cardona et al. (2009) analyze the intra- and inter-platform substitution patterns of residential Internet services in the US and Austria, respectively. Rosston et al. (2010) estimate an empirical model to study the household demand for Internet services in the US. The findings determine that the valuation for the service increases with service reliability, transmission speed, and household ICT experience. More recently, Nevo et al. (2016) postulate a dynamic model of decision-making subscribers to estimate the demand function for Internet services. Exploiting the dynamic variation arising from the monthly consumption under a three-part tariff, they find that consumers are heterogeneous in the willingness to pay for data transfer rate and that usage-based pricing is effective at lowering usage without affecting consumer welfare. The current investigation can be seen as complementary to these papers in that it also estimates a demand model to identify the parameters characterizing consumers' choices. However, one of the contributions of this paper to the existing literature is to analyze the Internet market for the case of a developing country.

As for the digital gap, Goolsbee (2002) studies and compares two policies focused on boosting the adoption of broadband services, namely: subsidized prices of broadband access, and investment tax credits for the expansion of the service in underserved areas. Using individual-level data on willingness-to-pay, the analysis shows that, given the presence of fixed costs, the total benefits arising from the supply-side intervention are expected to be larger than the gains obtained from the subsidy intervention. In Galperin and Ruzzier (2013), the authors attempt to identify the effect of price reductions on the adoption of fixed broadband services in Latin America and the Caribbean. The results imply that an average price reduction of \$10 would raise the penetration rate by approximately 22%. Ackerberg et al. (2014) estimate a demand model for telephone services in order to understand the economic factors driving adoption choices. Using the demand estimates, they assess the effectiveness of two universal service policies aiming at increasing the penetration rate of low-income households. The results determine that the policies raised the penetration rate of poor households by 6.1 percentage points in 2000 in the US. This work is most closely related to Hidalgo and Sovinsky (2022) and Hidalgo and Sovinsky (2023), which study the impact of the Colombian subsidy policy on switching behavior and Internet adoption.

This paper adds to the above literature in that it gauges the effect on adoption rates of changes in market structure, instead of specific interventions. Hence, the policy objective of this paper is, ultimately, to show how the digital divide in less developed countries can be overcome by increasing competition (through market entry).

The remainder of the paper proceeds as follows. The next section presents an overview of the Internet industry in Colombia and discusses the dataset. Section 3 provides descriptive evidence related to market entry. I introduce the empirical model and outline the approach to conduct the counterfactual analyses in section 4. Section 6 reports the empirical results and section 7 shows the welfare effects of market entry and the implications for adoption of Internet services. Finally, Section 8 presents the concluding remarks.

2 Industry Background and Data

This section provides an overview of the Internet services industry in Colombia with a focus on the entry of the large telecom operator Telmex. Next, I present a brief description of the available datasets used in the empirical analysis.

2.1 Internet market and the entry of Telmex

The market for fixed Internet services in Colombia is characterized by a highly fragmented telecommunications network, with many local and regional fixed operators that own the infrastructure. According to the review of the wholesale Internet market by the Colombian telecom authority (CRC, 2017a,b), there are 16 operators that possess their own networks (local or national) and provide access to other Internet providers. Out of those 16 operators, 11 are vertically integrated companies serving also the retail market. This market configuration raises concerns as there might be market foreclosure. To address these concerns, the Colombian regulatory framework has set the economic and technical terms and conditions for the interconnection and provision of access to essential facilities in the telecommunications sector.[4] Prior to 2012, even though the regulatory framework included the instruments to set the conditions to access the local markets, there were no legal obligations (e.g. local loop unbundling or wholesale broadband access) to enforce acess and interconnection agreements. As a result, there was limited access to existing local telecommunication networks which had direct implications on the expansion and take-up of fixed Internet services (OECD, 2014).

Instead of relying on the traditional telecommunications network and their owners, Telmex entered the Colombian telecommunications market leveraging existing TV cable infrastructure. This market entry constituted a disruption of the telecom market and an increased head-to-head competition (specially with the large incumbents) as the entrant has been traditionally one of the leading telecommunication operators in Latin America. [5] Initially, in early 2006, Telmex attempted to enter the market by pursuing the acquisition of the state-owned telecom incumbent but failed to beat the spanish bidder Telefonica. Later, by the end of 2006, Telmex changed the entry strategy, focusing on the acquisition of various regional and local TV cable operators. In doing so, the aim of the company was to offer Internet services using hybrid fiber-coaxial networks (cable technology henceforth).[6]

For the purpose of this paper, the entry of Telmex into the Internet market is marked by two time periods. The first period is the last quarter of 2007 (2007:4) which marks the inorganic entry into the market, with operations through TV cable subsidiaries competing in both TV and Internet markets. Among these subsidiaries, TV Cable was the only company providing fixed Internet services. Given that the company was taken over in the second quarter of 2007, one can assume a buffer period of one-quarter to allow the full integration of the company. During this time period, Telmex operated in 20 out of 260 local markets. The second period, starting in the first quarter of 2008 (2008:1), marks the consolidation of the operations of all the cable operators and the onset of the Telmex brand. During this

[4] The Decree 2870 of 2007 obliges operators with dominant position in the wholesale market to provide access to network infrastructure under non-discriminatory and transparent terms. Further, the ICT Law of 2009 traces the principles for access and use of essential facilities, indicating that the terms and conditions must be set by the regulatory authority. Accordingly, the CRC Resolution 3101 of 2011 provides a new regime of access and interconnection of wholesale networks. In particular, the regulatory authority specifies a listing of essential facilities for both access and interconnection, which can be used by any ISP by paying the respective cost-oriented charge.

[5] Telmex was part of the conglomerate company Carso Global Telecom which was acquired by America Movil in 2010. Its operations expand over 15 countries throughout the Americas. This company is ultimately owned by the businessman Carlos Slim.

[6] The acquisition wave started in October 2006 with the purchasing of the Bogota-based cable operator Superview for $37 millions. Subsequently, in April 2007, the company took over TV Cable for $123 millions and the Medellin-based operator Cable Pacifico for $113 millions. Next, in October 2007, Cablecentro and Satelcaribe were acquired for $345 and $51 millions, respectively. By the end of 2007, Telmex consolidated the operations of all acquired TV cable operators and started offering Internet services under the Telmex brand. Finally, in August 2008, the company acquired Teledinamica and Organizacion Dinamica for $31 millions.

time period, Telmex increase its market presence from 20 local markets to 56 (out of 369) by 2011.[7]

To conclude the brief description of the market and the regulatory framework in Colombia, there have been two regulatory decisions aimed to mitigate information asymmetries by setting a broadband quality standard, i.e., a standard that separates high-quality (broadband) from low-quality (narrowband) services. The regulation in 2007 defined broadband services in terms of data transmission speed. More specifically, an Internet connection is considered as a broadband service if it provides download and upload speed of at least 512 kbps and 256 kbps, respectively. If those requirements are not met, the service is labeled narrowband. This quality standard was then updated in 2010 by raising the thresholds to 1024 Kbps and 512 Kbps.[8]

2.2 Data

The main data source comprises the universe of residential Internet plans offered in Colombia. The data cover the period from 2005:4 to 2011:1, with a semi-annual frequency for the initial three years and quarterly frequency from 2009 onwards (16 periods in total).[9] The unit of observation is defined by the combination of period-municipality-firm-product and includes information related to the characteristics of the service (connection speed and last-mile technology) as well as the monthly fee and number of subscribers. The Internet plan is defined accordingly by the combination of firm, technology and connection speed.

The structure of the dataset is unbalanced in terms of municipalities and providers over the sample period. Since the Colombian Internet market is at an early stage, the dataset shows a constant geographic expansion, covering 51 municipalities in 2005:4 and extending to 369 municipalities by the end of the sample period.[10] Regarding Internet providers, there is little variation in the number of competitors and it is only associated with non-large providers. Each period contains, on average, information of 16 non-large providers and 4 large providers. The latter includes three incumbents (Colombia Telecom, UNE and ETB) and the entrant (Telmex). In the Appendix, Table 5 provides further details of the structure of the dataset. The Internet data consist of 36,293 observations.

Table 1 presents the summary statistics. On average, the representative Internet plan

[7]Figure 5 in the Appendix provides an overview of the evolution of the number of markets with Internet services and the entry of Telmex.

[8]See the CRC Resolution 1740 of 2007 and CRC Resolution 2352 of 2010 for further information.

[9]The database is publicly available and regularly updated by the Colombian ministry of Information Technologies and Communications.

[10]There are a some municipalities with too few subscribers that show up sporadically in the dataset. I exclude them from the analysis and work mainly with the municipalities having an established Internet service market.

provides a connection speed of 1.3 Mbps and is offered at a monthly fee of $37.7. There are 28 different Internet providers throughout the sample who jointly offer, on average, 8 distinct Internet plans within a market.

Table 1. Summary statistics

	Price	Speed	Plans	Firms	Market Share (%)
Total	37.7	1.3	8.3	28	
Large	32.5	1.6	8.7	3	37.8
Other	44.9	1.0	3.6	15	7.6
Telmex	39.3	3.3	6.4	1	17.6

Notes: Prices are in US dollars and connection speed is measured in Mbps. Plans refer to the number of Internet plans offered within a municipality, while market shares denote the average share of Internet subscribers across municipalities. The top row shows the averages from 2005:4 to 2011:1, whereas the bottom rows show the statistics for markets with market entry, spanning from 2008:2 to 2011:1.

The bottom rows in Table 1 show the summary statistics by groups of Internet providers for municipalities experiencing market entry. Non-large (other) incumbents offer Internet plans that are at a competitive disadvantage with respect to their competitors. On average, these providers offer plans with the lowest connection speed (1 Mbps) and the highest monthly fee ($44.9). As a result, this group of providers has the smallest average market share. As for the large incumbents (Colombia Telecom, UNE and ETB), the representative Internet plan is offered at an effective price of $20 per Mbps which is almost twice as high as the effective price offered by the entrant ($ 11.9 per Mbps). These statistics suggest sizeable competitive pressure arising from the entrant and the need of a strategic response by the incumbents. In the Appendix, Figure 7 displays the evolution of average prices, speed and the number of plans. Over the sample period, these variables have drastically changed: average prices have decreased by around 56%; average speed has seen a six-fold increase; and the number of plans duplicating has doubled. Interestingly, there seems to be moderate shift in these variables around the entry of Telmex, specially for the large incumbents. I explore this relationship further in Section 3.

I augment the Internet dataset with population and demographic information at the municipality level. The purpose of adding this information is two-fold. On the one hand, the total number of households (population divided by the average number of people per household) in every municipality is used as a proxy of market size, which is employed to measure the adoption rate and to estimate the demand model (Section 6.2). On the other hand, demographic information (e.g., income) can be used to control for taste heterogeneity in the estimation of the parameters governing consumers' preferences. These additional sources of information are collected from the National Department of Statistics (DANE) and the household survey Gran Encuesta Integrada de Hogares (GEIH)[11]. The main limitation of adding demographic variables to the dataset is that this information is collected only for the main metropolitan areas in Colombia. In Section 6.2, I use information from the income distribution by areas to link incomes to each municipality.

3 Descriptive Evidence

This section provides descriptive evidence of the effect of market entry on the take-up of Internet services and on incumbents' behavior. First, I analyze the evolution of the adoption rate and subscribers by comparing markets with and without entry (section 3.1). Second, I quantify the effect of market entry on various equilibrium outcomes by using an event-study design (section 3.2).

Three key facts emerge from the evidence presented in this section. First, the take-up of Internet services is higher and increases at a faster rate in markets with entry than in markets without entry. Second, the incumbents response to market entry involves not only price reduction but also an increase in the number of Internet plans. Third, the response seems to be associated solely with large incumbents.

3.1 Adoption rate of Internet Services

To analyze whether market entry has any effect on the take-up of Internet services, I plot the predicted municipality-level adoption rate by entry status. The predicted adoption rate is estimated after controlling for market characteristics (average connection speed, last-mile technologies and number of Internet plans) and municipality fixed effect.

Panel (A) of Figure 1 reports the results. Two aspects of the graphical analysis stand out. First, prior to Telmex acquisition of TV cable operators, there seems to be a steady difference in adoption rate between markets with and without entry. On average, the adoption rate in markets experiencing entry is 5 percentage points higher than in those without the presence of Telmex. Second, following the entry of Telmex, both group of markets exhibit increasing adoption rates. While the upward trend seems to be stable for markets without entry, the trend becomes steeper for the group of markets with entry. The initial 5-percentage-point difference in adoption rate increases to 17 percentage points by the end of the sample period.

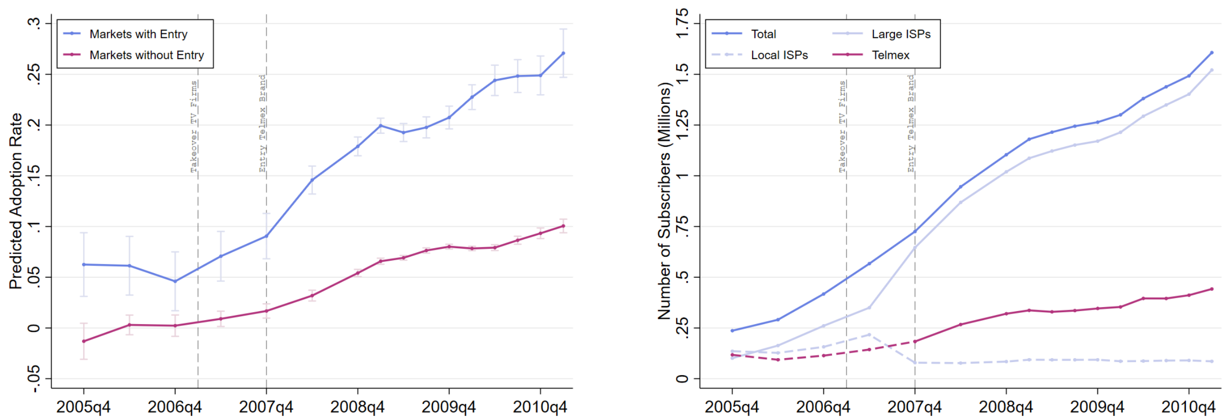
[11]This survey is the analog of the Current Population Survey conducted in the US.

These patterns suggest that market entry boosted the adoption of Internet services within local markets.

Figure 1. Evolution of Adoption Rate and Subscribers

(A) Adoption rate by entry status

(B) Subscribers by firms



Notes: Panel (A) displays the predicted adoption rate after controlling for market characteristics (including average connection speed, technologies and number of Internet plans) and municipality fixed effects. Vertical lines indicate 95% confidence intervals based on robust standard errors. Adoption rate indicates the proportion of households (potential subscribers) with Internet subscriptions. Panel (B) displays the evolution of Internet subscribers for a restricted sample of markets experiencing Telmex entry in 2008:2. The dashed segment related to the Telmex curve (solid pink) represents the number of subscribers of companies taken over by Telmex. In panels (A) and (B) the dashed vertical lines denote periods related to market entry. The first dashed line in 2007:1 represents the acquisition of TV cable operators, whereas the second one in 2007:4 denotes the introduction of Internet services under the Telmex brand.

In Panel (B) of Figure 1, I zoom in on the evolution of Internet subscribers in markets where Telmex entered for the first time in 2008:2. The dashed segment along the entrant curve denotes the number of subscribers of acquired firms prior to acquisition. Notice that after entry, there is a moderate increase in the number of Telmex subscribers relative to the pre-entry subscriber base of the acquired firms. Interestingly, the change in the number of subscribers is more pronounced, albeit of opposite direction, among large and local incumbents. This seems to suggest that the response of incumbents to market entry is heterogeneous and reinforces the dominant position of the large incumbents. The next subsection investigates further the reactions to market entry by type of incumbent.

3.2 Changes in Equilibrium Outcomes: Event Study

I exploit the entry of Telmex in 2007:4 to evaluate its effects on various market outcomes. Let f index Internet providers, m index municipalities and t index time periods (year and quarter combinations). I quantify the effects of market entry on the outcome Y_{fmt} by employing an event-study design. For this analysis, I aggregate data to the firm-municipality-period level and estimate the following specification:

$$\log(Y_{fmt}) \;=\; \sum_k \beta_k \, entry_m \cdot \mathbb{1}\{k = t\} + \gamma^1_f + \gamma^2_m + \gamma^3_t + \boldsymbol{\tau} \boldsymbol{X}_{fmt} + \varepsilon_{fmt}, \qquad (1)$$

where the outcome variable is either price, number of Internet plans or connection speed.[12] The parameter of interest is β_k which is associated with the indicator variable $entry_m$ that takes the value of one if the market experiences entry of Telmex. I normalize the coefficient $\beta_{2007:2}$ equal to zero, so the interpretation of the other treatment coefficients is relative to the pre-entry period. The specification also includes provider fixed effects γ^1_f to account for persistent differences across Internet providers; market fixed effects γ^2_m to account for time-invariant characteristics of the municipalities; and time fixed effects γ^3_t to account for aggregate changes or trends in the outcome variable. $\boldsymbol{X}_{fmt}$ is a vector of control variables, including firm markets coverage, number of providers competing in the market, number of different technologies used to provide the service, among others.[13] Standard errors are clustered at the municipality level.[14]

The entry of Telmex affects the decisions of the large incumbents. Figure 2 shows the results for prices and the number of Internet plans. Panel (A) shows that the prices set by incumbents decrease after the entry of Telmex. The estimates imply that one year after market entry, the prices drop by 20 percent. Similarly, Panel (B) shows that after entry, the incumbents increase the number of Internet plans offered in markets with entry relative to markets without it. In particular, the menu of Internet plans increases by almost 60 percent one year after entry. The immediate and large effect seems to last one year for both prices and product variety. After that, the effect halves and stays steady throughout the remaining post-entry periods.

In the Appendix, I show additional the analyses for other equilibrium outcomes. Figure 9 reports the effect of market entry on the number of broadband (high-quality) and

[12] I define the firm-market-level outcome variables as the average across all Internet plans offered in a particular market. I do not use shares to compute the weighted average as the outcome variable should reflect the firm's decision and should be driven by changes in the variable itself and not to changes in market shares (or consumers choices).

[13] Depending on the outcome variable, I use a different vector of control variables. For instance, for price, I control for (log of) speed, the number of products offered by the Internet provider, the number of broadband products (high-quality), the number of last-mile technologies, and a dummy variable indicating whether the provider is a subsidiary. To estimate this specification, I make the assumption that characteristics as well as the menu of products are decisions pre-determined and were chosen at a period before.

[14] For the main analysis, I use a sample of municipalities that show up in 2006:4 (or before) and in all periods after entry. In the Appendix, I provide results using a balanced sample of markets that show up in every period of the dataset. Also, I fully saturate the model as I include all pre-entry and post-entry periods.

Figure 2. Relative changes in prices and product variety (large incumbents)

(A) Prices (B) Number of Internet plans

Notes: This figure displays the coefficients of the event study regressions for large incumbents, where the coefficient for the period 2007:2 is normalized to 0. The dashed (pink) lines correspond to the upper and lower bounds of the 90% confidence interval which is based on robust standard errors clustered at the municipality level. For panel (A) the outcome variable is the (log) price and for panel (B) the outcome is the (log) number of Internet plans. The sample consists of municipality-firm pairs that show up in the pre- and post-entry periods. In panels (A) and (B) the dashed vertical lines denote periods related to market entry. The first dashed line in 2007:1 represents the acquisition of TV cable operators, whereas the second one in 2007:4 denotes the introduction of Internet services under the Telmex brand.

narrowband (low-quality) plans. The findings suggest that, following market entry, large incumbents increase the number of products in both market segments. These estimates should be interpreted with caution for the narrowband plans (Panel B) as there is no pre-entry parallel trends and one cannot attribute this change solely to market entry. With respect to the connection speed, Figure 10 shows that there is no clear pattern related to the timing of entry. This is most likely due to the fact that there is an increase in high- and low-speed plans after entry. Finally, in Figure 11, I show that there is no clear evidence that non-large incumbents react to market entry.

The main identification concern is the existence of unobserved determinants of the equilibrium outcomes that drive also entry decisions. If this is true, the parameters of interest would confound the effect of market entry on incumbents outcomes with trends in outcomes that lead to the entry of Telmex. The evidence of parallel pre-trends for both prices and product variety suggest that this is not an identification threat in this setting.

3.3 Summary of Descriptive Evidence

The analysis in this section has shown that the entry of Telmex exerts significant competitive pressure in local markets, leading to a price reduction and changes in the number of Internet plans offered by large incumbents. This improved competitive landscape prompts households to take-up Internet services, driving up the adoption rate across local markets. The findings, however, do not reveal how much of the total effect of market entry can be attributed to the reaction in pricing versus the reaction in product variety. Moreover, while lower prices and higher variety suggest potential welfare gains, the broader implications for total welfare are not clear. The incumbents may incur in large fixed costs to expand their menu of Internet plans. In the next sections, I develop and estimate a structural model (i) to decompose the total effect of market entry into the price and variety components, and (ii) to quantify the net welfare effects.

4 The Empirical Model

This section presents the structural model used to analyze the market of Internet services in Colombia. First, I introduce the demand model for differentiated products. Second, I present a two-stage supply model, where the firms first decide on product offerings and then set simultaneously prices. This model serves three purposes. First, the demand estimates allows us to better understand the decision-making process of consumers in the Colombian Internet market. Second, the structural model is used to recover information on the, otherwise unobserved, underlying cost structure of the firms (i.e., marginal and fixed costs). Third, I utilize the estimated structural model to conduct the counterfactual predictions in Section 7.

4.1 Demand model

To model the demand for residential Internet services, I use the discrete choice framework proposed by Berry et al. (1995). The demand model consists of consumers, indexed by $i \in I$, who make a discrete purchasing decision in market m at time t. The consumer i faces $J_{mt}+1$ alternatives: J different Internet plans and the outside option ($j = 0$). The indirect utility consumer i obtains from purchasing j is given by

$$U_{ijmt} \;=\; \alpha \log(y_{imt} - p_{jmt}) + \boldsymbol{x}_{jmt}\beta + \xi_{jmt} + \varepsilon_{ijmt}, \tag{2}$$

where y_{imt} denotes the income of the consumer, $\boldsymbol{x}_{jmt}$ is a vector of observable product characteristics, p_{jmt} is the price of the product and ξ_{jmt} denotes unobserved (to the researcher) product characteristics. The individual income is assumed to follow an underlying probability distribution $\mathcal{P}_{mt}$ that is specific to each market. The term ε_{ijmt} is an idiosyncratic taste parameter which is modelled as a i.i.d random variable with a Type I extreme-value distribution.

The outside option is mainly dominated by the non-purchasing choice as potential substitutes for fixed Internet services (e.g., mobile Internet) are underdeveloped during the sample period (OECD, 2014). The utility from the outside option is assumed to be $u_{i0mt} = \alpha \log(y_{imt}) + \varepsilon_{i0mt}$.

Following Berry et al. (1995), I split the utility from purchasing j into three components:

$$U_{ijmt} \;=\; \delta_{jmt} - \mu_{ijmt} + \varepsilon_{ijmt}. \tag{3}$$

The first term of equation 3 is the mean utility, δ_{jmt}, which is common to all consumers. This component is a function of (observed and unobserved) product characteristics. The second element of equation 3 is the individual specific deviation from the mean utility μ_{ijmt}. This component depends on income and the disutility derived from price $\alpha \log(y_{imt} - p_{jmt})$.

A consumer chooses the product j if and only if $U_{ijmt} > U_{ij'mt} \forall j' \neq j$. Given the distributional assumption of ε_{ijmt}, I obtain the logit choice probability of product j for consumer i as (I omit the index for market and time):

$$s_{ij}(\alpha, \beta) \;= \frac{\exp\big(\delta_j(\beta) \;+\; \mu_{ij}(y_i;\alpha)\big)}{\sum_{k=0}^{J} \exp\big(\delta_k(\beta) \;+\; \mu_{ik}(y_i;\alpha)\big)} \tag{4}$$

and the aggregate market share of product j is given by

$$s_j(\alpha, \beta) \;= \int s_{ij}(\alpha, \beta) d\mathcal{P}(y_i). \tag{5}$$

For a given market and time period, the demand for the product j is equal to $\mathcal{M} s_j$, where $\mathcal{M}$ is the number of households.[15] The details of the specification, estimation and potential identification issues are discussed in Section 5.2.

4.2 Supply model

This section presents a two-stage model where prices and product offerings are endogenous decisions. In the first stage, Internet providers decide simultaneously which Internet plans to offer in each market taking into account the fixed costs arising from these decisions. In the second stage, the Internet providers set simultaneously prices. I now turn to a formal description of the supply model.

[15] For each municipality, I compute the number of households as the total urban population divided by the average number of individuals per household.

4.2.1 Stage 1: Internet Plan Decisions

In the first stage, the Internet providers make product offering decisions.[16] For a given market and time period, the provider decides whether or not to offer the product j taking into consideration that (i) the product must be part of the set of feasible products $\mathcal{J}_f$ (i.e., the firm must have the technical capabilities to offer the product), and (ii) the firm must incur a fixed cost to introduce the product into the market.[17]

To introduce a new product into the market, each firm incurs fixed costs. These costs include various factors, including equipment costs (e.g., routers required to support the features of the plan), inventory management expenses, and investments in marketing. For instance, when launching a new Internet plan, the provider must initially purchase the necessary equipment and store it in warehouses, resulting in inventory management costs. On top of that, the Internet provider incurs in one-time marketing expenditures so as to inform consumers about the existence and characteristics of the new product. These marketing activities usually involve placing ads on local TV channels and radio stations.

For a given market and time period, the fixed cost of introducing a new product j by firm f is

$$F_j = F_f + \nu_j, \quad \text{with } E[\nu_j | j \in \mathcal{J}_f] = 0. \tag{6}$$

The term F_f represents a firm-specific cost and ν_j denotes a mean-zero product-specific cost shock. Notice that the cost shock is mean-zero conditional on the set of potential products. This set includes all products that are being offered in the market as well as those products that could be offered but were not introduced by the firm.

The firm makes product portfolio decisions based on the information available at the moment of making such decisions. At the beginning of stage 1, firms observe the realization of the current fixed cost shocks ν_j and know the distribution of stage 2 demand and marginal cost shocks $e_j = (\xi_j, \omega_j)$. Given this information set, the firm chooses the optimal product portfolio by trading off the expected variable profits and the total fixed costs. Formally, the firm chooses a product portfolio J_f to solve the problem

$$\max_{J_f \subseteq \mathcal{J}_f} \Big\{ \pi_f = E_e[\pi_f^V | J_f] - \sum_{j \in J_f} F_j \Big\}, \tag{7}$$

where the expected value of the variable profits, denoted as π_f^V, is computed over the joint distribution of the demand and marginal cost shocks. As the selection of an optimal prod-

[16] The exposition of the first stage follows closely the ones in Eizenberg (2014) and in Montag (2023).

[17] I assume that at the beginning of the stage, each Internet provider is endowed with a set of potential Internet plans. In practice, this set varies over time and contains all Internet plans that are being offered by at least two providers in one particular time period.

uct portfolio involves discrete choices, the first-order conditions of the profit maximization problem are satisfied only as inequalities.

4.2.2 Stage 2: Oligopoly Pricing

In the second stage, the Internet providers simultaneously set prices for consumers. This decision is made after observing the realizations of demand and marginal cost shocks (e_j) and product offerings. Given this information set, I assume that market competition is characterized by a multi-product Nash-Bertrand equilibrium, where each firm sets prices to maximize variable profits over all its products offerings, taking as given the prices set by competitors.

For a given market and time period, each firm f offers the product portfolio J_f. The firm f's variable profits π_f^V are given by

$$\pi_f^V = \sum_{j \in J_f} (p_j - c_j) s_j(\mathbf{p}) \mathcal{M}, \tag{8}$$

where c_j is the constant marginal cost of plan j, $\mathcal{M}$ denotes the total number of potential consumers, and s_j is the market share of plan j, which is a function of the J_f-dimensional price vector $\mathbf{p}$. In the Internet market, the marginal costs refer to the increase in total costs required to provide the service to one additional consumer. These costs mainly consist of setup expenses, which involve consumer-specific equipment, wiring the dwelling to provide the service, installation costs, among others.

Assuming the existence of a pure-strategy Nash equilibrium, the system of first-order conditions is defined as:

$$s_j(\mathbf{p}) + (p_j - c_j)\frac{\partial s_j(\mathbf{p})}{\partial p_j} + \sum_{\substack{k \in J_f \\ k \neq j}} (p_k - c_k)\frac{\partial s_k(\mathbf{p})}{\partial p_j} = 0, \qquad j = 1, ..., J.$$

This set of conditions involves three terms, which reflect the tradeoff made by a profit-maximizing multi-product firm. First, a small unit price increase for product j raises the price-cost margin. This gain is proportional to the market share at current prices. Second, a unit price increase also reduces the demand for product j and this implies a profit loss which is proportional to the current price-cost margin. Third, the price increase also affects positively the demand for other products served by the same firm. More specific, a unit price increase raises the market share of other products k and this implies gains that are proportional to the margins of these products. At equilibrium, all effects offset one another. I express this system of first-order conditions in matrix form as follows:

$$s(\mathbf{p}) + \left(\theta^{\mathcal{F}} \odot \Delta(\mathbf{p})\right)(\mathbf{p} - \mathbf{c}) = 0. \tag{9}$$

The term $s(\mathbf{p})$ is a $|J_f| \times 1$ market share vector and $\theta^{\mathcal{F}}$ is a $|J_f| \times |J_f|$ ownership matrix, where the element $\theta^{\mathcal{F}}_{jk}$ is equal to 1 if Internet plans j and k are served by the same Internet provider, and 0 otherwise. The matrix $\Delta(\mathbf{p}) = \frac{\partial s(\mathbf{p})}{\partial \mathbf{p}'}$ is a $|J_f| \times |J_f|$ derivative matrix, and $\odot$ represents elementwise multiplication.

I use equation (9) to back out product-specific marginal costs $\hat{\mathbf{c}}$ which depend linearly on cost shifters and on an additive marginal cost shock:[18]

$$\log(mc_j) \;=\; w_j\gamma + \omega_j \tag{10}$$

Solution concept For the two-stage game, I assume the existence of a pure-strategy subgame perfect Nash equilibrium (SPNE). This equilibrium consists of product portfolio decisions and their prices. To estimate the parameters of the two-stage model, I require the existence but not the uniqueness of the SPNE. I provide details of the estimation in the next section. Finally, to ease the presentation of the model, I omitted municipalities and time period indices. However, the two-stage game is assumed to be played every quarter and municipality.

5 Estimation and Identification

This section is divided into two parts. First, I discuss the identification and estimation challenges related to the demand model. Next, I describe the approach to estimate the fixed cost parameters. Overall, the estimation strategy initially obtains estimates of the demand parameters $\Theta = \{\alpha, \beta\}$. These parameters are used jointly with the conduct assumption to back-out marginal cost and compute total variable profits. Necessary equilibrium conditions of the product offering decisions are then used to partially identify the fixed costs parameters F_j for every period, municipality and Internet provider.

5.1 Demand

Specification The empirical analysis is based on the demand model (equation 4.1). The vector of observed characteristics, $\boldsymbol{x}_{jmt}$, consists of connection speed, the broadband (high-

[18]Given the lack of data on supply-side shifters, I set $w_j = \boldsymbol{x}_j$ which means that the observed characteristics affect both utility and marginal costs. Data on cost shifters would help to discipline the recovered marginal costs and would improve the identification in the demand model. Gathering these additional data is work in progress.

quality) label and indicator variables denoting the last-mile technology[19]. It also includes a set of features characterizing the business strategy of each Internet provider, including a subsidiary dummy, markets coverage and seniority. The latter denotes the number of time periods that the provider has been operating in each municipality. In addition, I control for the number of Internet centers for public institutions (Compartel) and the number of commercial Internet points (Internet Cafes).

Similar to Bourreau et al. (2021), I specify the log price term as $\alpha \log(y_{imt} - p_{jmt}) \approx \alpha\log(y_{imt}) - \alpha_{imt}\, p_{jmt}$, where $\alpha_{imt} = \alpha / y_{imt}$. This formulation allows price sensitivity to depend on income y_{imt}. In doing so, an individual with a low-income draw has a stronger reaction to price changes than a high-income individual. I treat y_{imt} as a random variable with a known parametric distribution resembling the distribution of income in each municipality. For a given municipality and period, $y_i \sim \max\{\underline{y}, N(\bar{y}, \sigma_y^2)\}$, where the moments and the minimum income are estimated from household surveys. Under this specification, y_i can be seen as a form of unobserved heterogeneity that is to some extent related to income.

I specify the term of unobserved characteristics as $\xi_{jmt} = \xi_{mf(j)} + \xi_{f(j)t} + \xi_t + \Delta\xi_{jmt}$. The municipality-firm fixed effects $\xi_{mf(j)}$ capture time-invariant unobserved characteristics of the service provided by firm f in municipality m. To capture the unobserved features of firm f in period t (e.g., national marketing campaigns and firm-level technological capabilities), I control for firm-period fixed effects $\xi_{f(j)t}$. Finally, I capture seasonality in demand by including period fixed effects.

Identification To identify the demand parameters, I need to address issues related to sample selection and endogeneity.

First, I do not observe a random sample of product offerings but rather a set of products that are endogenously chosen by firms. This creates sample selection issues in the demand model as there might be unobserved characteristics that are correlated with the product portfolio decision. I follow Eizenberg (2014) and address this concern using the timing of the structural model and the assumptions regarding the information set. Intuitively, firms only observe the realization of the structural error ξ_{jmt} after they have decided the optimal product portfolio. This implies that the product selection does not depend on the error term ξ_{jmt}.

It could be the case that firms forecast the unobserved structural errors, leading to a correlation between product choices and ξ_{jmt}. As long as these forecasts are based on systematic and observed characteristics (which are controlled for in the model), the timing and information assumptions hold. Specifically, for identification I assume that the (non-

[19]The technology has three mutually exclusive and exhaustive categories. The wireless technology is the reference group.

systematic) demand shocks are independent of the observed characteristics and the fixed costs, i.e., $E[\Delta\xi_{jmt}|\boldsymbol{x}_{jmt}, F_{jmt}] = 0$ for each $j \in \mathcal{J}_f$.

The second identification concerns involves endogeneity issues. The main challenge is to identify the parameters of the model as there are unobserved characteristics (by the econometrician) that may be correlated with observed attributes of the Internet services. Is is primarily a concern associated with the price coefficient. The endogeneity issue arises since pricing decisions depend on unobserved quality characteristics of the Internet services (included in the structural error term $\Delta\xi_{jmt}$). If firms set optimal prices accounting for all product characteristics, then p_{jmt} may be correlated with $\Delta\xi_{jmt}$. For instance, the structural error term can be associated with the quality features of the Internet services that affect positively both price and consumers' utility. If the demand model were to be estimated using OLS, one could expect then the price coefficient to be (in absolute value) underestimated.

To overcome this, I employ instrumental variables that are in the spirit of Berry et al. (1995). I use the sum of observed product characteristics of the other plans offered by the same provider and the sum of characteristics of plans served by competitors in the same market. More specifically, the demand instruments are given by the number of plans and the number of broadband (high-quality) plans offered by the Internet provider. I also use the sum of the connection speed of the competitors and a quadratic term associated with this variable. In the Appendix, I show results using different combinations of the above-mentioned instrumental variables.

The identification of the demand parameters requires the set of instrumental variables to satisfy two conditions. First, the instruments must be excluded from the demand equation (exogenous). On this point, the identifying assumption is that the location of the Internet plans in the characteristics space is exogenous. Second, the set of instruments must be relevant (i.e., correlated with the endogenous variables). This is indeed the case under the assumption that firms optimally choose characteristics before setting prices[20]. In the empirical analysis, I test the validity of the second assumption using the weak identification test.

Estimation I follow the estimation approach proposed by Berry et al. (1995). I estimate the two-step feasible generalized method of moments (GMM) using the above-discussed set of instruments to define the orthogonality conditions. I use robust standard errors that allow serial correlation and heteroskedasticity. These standard errors are clustered at the municipality-firm level as it is likely to find unobserved correlations across different Internet plans offered by a firm in a specific municipality.

[20]These assumptions are valid if we consider the characteristics as predetermined variables at the pricing stage and with a slow adjustment over time (Verboven, 2002).

To approximate the implied market share, I use Monte Carlo integration with 500 quasi-random draws generated by Latin hypercube sampling. The market share simulator is then the average over individual choice probabilities. To find the vector δ that equates simulated and observed market shares, I use the SQUAREM method to accelerate the fixed-point approach (Varadhan and Roland, 2008) with an error tolerance of 1e-12.

5.2 Fixed Cost Bounds

The observed product offerings and prices are assumed to support an SPNE.[21] The resulting equilibrium condition implies that any unilateral deviation from the first-stage product decisions should not lead to an increase in expected profits. This deviation from the equilibrium can be either to introduce a new product in the market or to remove an existing one. Using these no profitable single-product deviations, I can derive bounds on the fixed cost parameters. Below, I formally describe the equilibrium conditions and the procedure to set-identify the fixed costs.[22]

Bounds on the fixed cost Let $\mathcal{J}_f$ represent the set of potential products that firm f can offer. Within this set, J_f includes all active products that are being offered in the market. By contrast, $\bar{J}_f$ is the complement of the set of active products, including all products that the firm can offer but has decided not to introduce.

Given the equilibrium products decision J_f, I can derive an upper bound on the fixed costs by comparing the expected net profits of offering J_f with the expected gross profits of removing product j from J_f. The resulting upper bound is given by

$$F_j \;\leq\; E_e\Big[\pi_f^V(J_f) \;-\; \pi_f^V(J_f \setminus \{j\})\Big] \;\equiv\; \bar{F}_j, \quad \forall j \in J_f \tag{11}$$

where $J_f \setminus \{j\}$ represents the removal of product j from the set of active products and E_e indicates that the expectation is computed over the joint distribution of the demand and marginal cost shocks. The equilibrium condition (11) states that a single-product removal should not lead to higher profits.

Similarly, if product j was not offered ($j \notin J_f$), I can derive a lower bound on the fixed cost by comparing the gross expected profits of the product offering J_f with the expected net profits of adding product j. The resulting lower bound is given by

$$F_j \;\geq\; E_e\Big[\pi_f^V(J_f \cup \{j\}) \;-\; \pi_f^V(J_f)\Big] \;\equiv\; \underline{F}_j, \quad \forall j \in \bar{J}_f \tag{12}$$

where $J_f \cup \{j\}$ represents the addition of product j to the set J_f. The equilibrium

[21] The estimation procedure closely follows the description provided by Eizenberg (2014).

[22] The exposition is done for a given municipality and period so I can suppress these indices.

condition (12) states that a single-product addition should not be profitable. Since $F_j = F_f + \nu_j$, the two equilibrium conditions separately lead to

$$E[\underline{F}_j | j \in \bar{J}_f] \ \leq \ F_f + E[\nu_j | j \in \bar{J}_f] \qquad \text{and} \qquad F_f + E[\nu_j | j \in J_f] \ \leq \ E[\bar{F}_j | j \in J_f].$$

Using these inequalities, I cannot identify the bounds on the fixed cost parameter F_j as the conditional expectation of the shock is not zero, representing a selection bias. To overcome this problem, it is necessary to obtain lower and upper bounds for every potential product $j \in \mathcal{J}_f$. In doing so, one could apply the unconditional expectation to the fixed cost shock ($E[\nu_j | j \in \mathcal{J}_f] = 0$) and obtain unbiased bounds.

Identification Following Eizenberg (2014), I obtain bounds on F_j for every potential product by imposing a bounded-support condition. For every product associated with firm f, I assume that the fixed cost has an unknown support on $[F_f^L, F_f^U]$. To identify this support, Eizenberg (2014) assumes that the support of the fixed costs is contained within the support of the expected change in variable profit resulting from single-product deviations. The latter support is denoted by $[V_f^L, V_f^U]$.[23]

Using the bounded-support condition, I can fill in the missing bounds and define bounds for all potential products as follows

$$L_j(\Theta) = \begin{cases} V_f^L(\Theta) & j \in J_f \\ \underline{F}_j(\Theta) & j \in \bar{J}_f \end{cases} \qquad U_j(\Theta) = \begin{cases} \bar{F}_j(\Theta) & j \in J_f \\ V_f^U(\Theta) & j \in \bar{J}_f \end{cases},$$

where the parameter vector Θ explicitly shows the dependence on the demand primitives. With this bounds at hand, one can define the fixed cost bounds for any potential product j and compute the unconditional expectation to obtain an identified set for the parameter F_f:

$$E[L_j(\Theta)] \ \leq \ F_f \ \leq \ E[U_j(\Theta)] \quad \forall j \in \mathcal{J}_f \tag{13}$$

Estimation To estimate the fixed cost bounds in (13), I replace the parameter vector Θ with the consistent estimator $\hat{\Theta}$. Next, I estimate four different components. First, $\underline{F}_j(\hat{\Theta})$ is estimated by simulating the expected changes in variable profits arising from single-product additions.[24] Second, for active products, I estimate the missing lower bound, $V_f^L(\hat{\Theta})$, using the minimum change in expected variable profits among inactive products. Third, $\bar{F}_j(\hat{\Theta})$ is estimated by simulating the expected changes in variable profits arising from single-product removals. Fourth, for inactive products, I estimate the missing upper bound, $V_f^U(\hat{\Theta})$,

[23] I refer the reader to Eizenberg (2014) for a discussion regarding the bounded-support assumption.

[24] The simulations involve taking expectations over the distribution of demand and marginal cost shocks. I replace the expectation operator by the sample average over 50 draws from the distribution of the shocks.

using the maximum change in expected variable profits among active products. Using the aforementioned components, I can compute $L_j(\hat{\Theta})$ and $U_j(\hat{\Theta})$ and obtain the estimated set $[\bar{\ell}_n(\hat{\Theta}), \bar{u}_n(\hat{\Theta})]$, where

$$\bar{\ell}_n(\hat{\Theta}) = \frac{1}{n^f} \sum_{j=1}^{n^f} L_j(\hat{\Theta}), \quad \bar{u}_n(\hat{\Theta}) = \frac{1}{n^f} \sum_{j=1}^{n^f} U_j(\hat{\Theta}) \tag{14}$$

and $n^f = |\mathcal{J}_f|$ is the number of potential products that firm f can offer in the market.

6 Empirical Results

This section presents the empirical results. I divide the analysis into two parts. In the first subsection, I examine how consumers make choices in the market for Internet services in Colombia, and show how different product characteristics relate to implied marginal costs. The parameters arising from these results are used to set-identify the fixed costs of offering Internet plans. In the second subsection, I present and analyze the fixed cost bounds.

6.1 Demand and supply estimates

Table 2 reports the estimation results for the demand and supply models. The first column (Logit) shows the estimates for the consumer demand model without addressing endogeneity issues. The price variable is normalized by income (divided by \$100), which is treated as a non-random variable equal to the mean income in each market. The price coefficient is negative and statistically significant. Due to the underlying endogeneity of price in the demand model, the price coefficient is rather small in magnitude, leading to inelastic median own-price elasticity and unrealistic markups. In addition, some of the coefficients are imprecisely estimated and have counter-intuitive signs (e.g., connection speed).

The second column (IV logit) shows the estimates when using instrumental variables to address price endogeneity. I use instrumental variables that are in the spirit of Berry et al. (1995). More specifically, the demand instruments are given by the number of plans and the number of broadband (high-quality) plans offered by the Internet provider. In the Appendix, I show that the main results hold when using other instrumental variables.[25].

[25] I show that the OLS bias is corrected by using the instrumental variables which do not exhibit weak instrument and overidentification problems. In particular, I provide the Kleibergen-Paap Wald F statistic and the J-statistic of the Hansen J-test. The former is employed to test the relevance of the instrumental variables. According to the critical values proposed by Stock and Yogo (2005), I reject the null hypothesis that the instruments are not relevant (weak). As for the Hansen J test, I check the validity of the overidentifying restrictions. This can be done since the GMM model is overidentified. According to the p-value, I fail to reject the joint null hypothesis that the instruments are valid.

Table 2. Demand and Supply Estimates

	Demand			Supply
	Logit	IV logit	RC logit	log(mc)
Price / Income	-0.158	-0.773	-1.899	
	(0.007)	(0.123)	(0.483)	
Speed	-0.235	0.304	0.203	0.163
	(0.027)	(0.112)	(0.121)	(0.02)
Broadband (1/0)	0.947	1.658	1.441	0.303
	(0.062)	(0.159)	(0.156)	(0.032)
Tech: Cable	1.529	1.69	1.641	0.244
	(0.445)	(0.435)	(0.454)	(0.154)
Tech: xDSL	0.923	1.085	0.982	0.333
	(0.442)	(0.433)	(0.451)	(0.135)
Seniority	0.272	0.421	0.434	0.046
	(0.039)	(0.095)	(0.084)	(0.018)
Market Coverage	-0.005	-0.022	-0.014	-0.001
	(0.002)	(0.005)	(0.005)	(0.001)
Subsidiary (1/0)	-0.372	-1.361	-0.862	0.1
	(0.307)	(0.758)	(0.651)	(0.133)
Centers Compartel	0.008	0.04	0.028	
	(0.006)	(0.014)	(0.015)	
Internet Cafes	0.008	0.005	-0.061	
	(0.031)	(0.052)	(0.050)	
Income Variable	$\bar{y}$	$\bar{y}$	y_{it}	
Median Own Elasticity	-0.94	-4.59	-3.91	
Median Outside Diversion (%)	89.57	89.57	59.03	
Median Markup (p/mc)	-0.79	1.30	1.45	
J-Statistic		0.51	0.77	

Notes: All regressions include year-quarter, firm-year and municipality-firm fixed effects. The total number of observations is 36,293. Income variables (individual and mean) are scaled by \$100. The first-stage statistic for the IV Logit is 26.07, whereas the J-statistic corresponds to the Hansen J-test with a p-value for the IV Logit of 0.47 (see Table 6). Standard errors (in parentheses) are clustered at the municipality-firm level.

The estimated price coefficient increases in magnitude with the instruments. The point estimate goes from -0.158 to -0.773, leading to a median own-price elasticity of -4.6 and markup of 1.3. Furthermore, the speed coefficient is significant and has the expected sign, indicating that consumers place a positive valuation for the main quality attribute of the Internet services.

The third column (RC logit) reports the estimates of the random coefficients demand model presented in Section 4.1. This model incorporates heterogeneity in the price sensitivity parameter by using 500 individual income draws. The results indicate that high-income consumers have a smaller reaction to price changes than low-income consumers. The price coefficient translates into a median own-price elasticity of -3.9. Figure 13 in the Appendix displays the distribution of own-price elasticities, showing that the bulk of the products have an own-price elasticity lying between -9.3 (5th percentile) and -1.9 (95th percentile).

The demand estimates have expected signs and are precisely estimated, except for the Internet Cafes parameter. Consumers place a positive valuation for connection speed. Interestingly, this preference is reinforced by the broadband label which increases the perceived quality of high-speed plans compared to narrowband (low-speed) plans. This finding suggest that the broadband label could effectively curb important informational asymmetries related to product quality.[26] Regarding last-mile technologies, the average consumer places positive valuation for services offered using cable and xDSL technologies relative to the wireless technologies. Firm seniority represents the number of periods that the Internet provider has been operating in the market. The corresponding estimate indicates that seniority is an important determinant of consumer choices, and it might take time to establish a consumer base, particularly following market entry. Finally, the estimate of market coverage is negative and significant, suggesting that consumers exhibit a preference for local providers over national counterparts.

The diversion to the outside option indicates the number of consumers that would switch to the outside option following a price increase for a particular product. The median outside diversion implies that the outside option, which is primarily dominated by the no take-up decision, is the second-best choice for 59% of the consumers. This number is not surprising given the low adoption rates of Internet services in Colombia (see Figure 1), and highlights the opportunities for Internet providers to draw consumers from the outside option. In the Appendix, Figure 14 displays the evolution of the sales-weighted outside diversion ratio. This diversion ratio has drastically decreased over the sample period, going from about 65% in 2006 to 35% in 2011.

Using the demand estimates together with the behavioral assumption on price setting decisions, I calculate that the median implied markup is equal to 1.45. This measure of market power has, however, changed over time. Figure 17 reports the changes of average markups over time. Aggregate markups have steadily increased, going from under 1.5 in 2005 to 3 in 2011. In addition, I show that the increase in average markup seems to be largely driven by one of the large incumbents whose markup shows a sharp increase after 2007.

The last column of Table 2 (log(mc)) presents the supply-side results. The constant

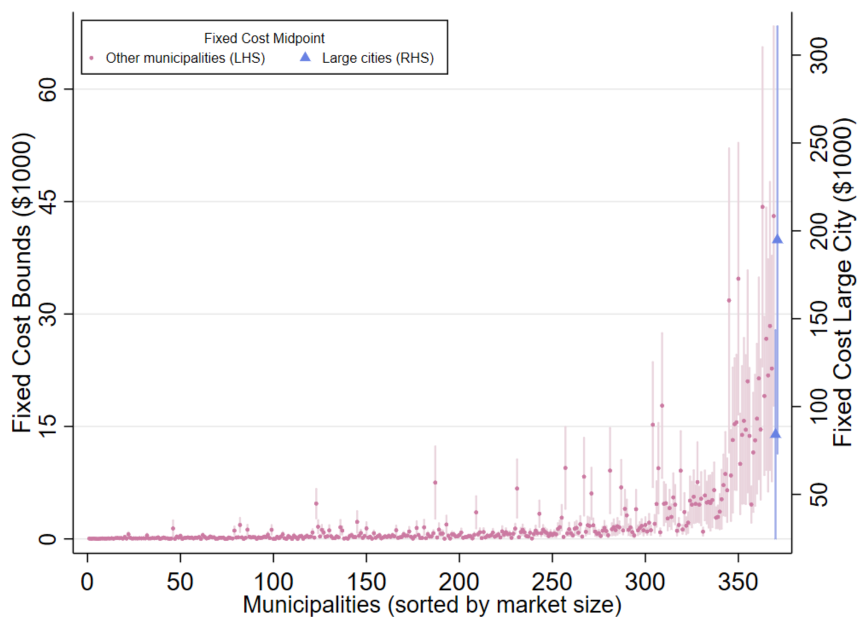
[26] Clavijo and Hidalgo (in progress) exploit the changes in the definition of broadband (high-speed) services to analyze the equilibrium effects in the Colombian market for Internet services.

marginal cost function controls for product characteristics and incorporates year-quarter, firm-year and municipality-firm fixed effects. The estimates suggest a positive relationship between marginal cost and connection speed. The magnitude of the coefficient indicates that an increase of 1 Mbps of the speed leads to an increase of 16% of the marginal costs. Similarly, offering broadband services leads to an increase in marginal cost. More specifically, the estimates show that marginal cost are 35% greater for broadband plans than for narrowband plans.[27] This result most likely reflects the cost associated with complementary services bundled with broadband plans (e.g., multiple private email accounts or residential wiring points) or with the increased upload speed offered in this type of plans.

6.2 Fixed cost bounds

Figure 3 plots the results for the fixed costs bounds across municipalities. These municipality level bounds are computed as the subscribers-weighted average bounds across firms and periods. The bounds vary widely across jurisdictions, specially for the largest municipalities.

Figure 3. Estimated fixed cost bounds



Notes: This figure displays the upper and lower bounds of product fixed cost across 371 municipalities. The dots denote the midpoints. The municipality-level fixed cost is computed as the weighted average fixed costs across firms and periods, where the weights are given by the number of Internet subscribers. The municipalities along the x-axis are sorted by market size, with the capital city having the largest market (more than 2 million potential subscribers).

[27] Exactly, the marginal cost is $\exp(0.303) - 1 = 35.4\%$ higher for high-speed plans than for the low-speed counterparts.

The results suggest a positive correlation between fixed costs and market size. This relationship might be attributed to high inventory and marketing expenditures required to operate within larger cities.

For the smallest municipalities (fewer than 20 thousand potential subscribers), the average fixed cost lie between \$420 and \$1,550. Since this group of municipalities tend to have low adoption rates, the market expansion effect is also relatively low. Accordingly, the fixed costs that rationalize the observed product decisions are low. In mid-sized municipalities (market size between 20 and 100 thousand of potential subscribers), the fixed costs fall between \$3,227 and \$14,448. As for the largest municipalities (excluding the largest cities), the average fixed costs range between \$9,000 and \$38,070. The major cities (Bogota and Medellin) exhibit the widest bounds, with an average lower bound of \$50,000 and upper bound of \$229,000.

In the Appendix, Figure 16 shows the estimated fixed cost bounds for the large Internet providers (large incumbents and entrant) and only for the municipalities with market entry. Except for ETB, the estimates show a high correlation between market size and fixed costs, and they appear to be somewhat similar across Internet providers.

To examine the factors influencing the fixed costs of offering an Internet plan, I study the relationship between the estimated bounds and market characteristics using the approach in Wang (2023). I outline the approach in the Appendix 8. The results indicate an upward trend in fixed costs over time and higher costs in wealthier markets. I also find that fixed costs tend to be higher in markets with a more developed media market. In particular, the fixed cots of offering an Internet plan are positively correlated with the number of local TV channels, radio stations and newspapers. Overall, these findings suggest that the fixed costs primarily involve marketing expenditures.[28]

7 Counterfactual Analysis

In this section, I examine the entry of Telmex in the market for Internet services in Colombia. Section 7.1 provides details of the implementation of the counterfactual analysis. Section 7.2 presents the results.

[28] This analysis is work in progress as the gathered local media data are cross-sectional and do not present variation over time. In addition, the approach yields estimates that predict fixed costs that are not consistent with the estimated bounds. To address this, I could alternatively use more sophisticated and robust methods (e.g., Bontemps et al. (2012)).

7.1 Description of the Counterfactual Analysis

This paper aims to examine how the entry of Telmex affects welfare and the adoption rate in the market for Internet services in Colombia. To achieve this, I simulate the price equilibrium under different counterfactual scenarios, each representing different entry status and portfolio of Internet plans.

To perform the counterfactual simulations, the system of first-order conditions (9) can be inverted to solve for the equilibrium price:

$$\mathbf{p} = \mathbf{c} - \left(\theta^{\mathcal{F}} \odot \Delta(\mathbf{p})\right)^{-1} s(\mathbf{p}). \tag{15}$$

This equation can be used to compute the price equilibrium under different entry and product variety scenarios. Specifically, assuming no changes in marginal costs, the counterfactuals primarily involve changes in the product ownership matrix $\theta^{\mathcal{F}}$. The different ownership matrices not only aim to represent the change in market structure due to the entry of the new competitor, but also the adjustment in product offerings by the incumbents.

Formally, I employ four different ownership matrices, each corresponding to a specific counterfactual scenario. Take the entry of Telmex in 2007:4 as an example. The scenario **I** ($\theta^{\mathcal{F},\mathrm{I}}$) represents the post-entry market in 2007:4, where Telmex competes with the incumbents who, in turn, decide to offer a post-entry menu of product offerings (new plans). The opposite counterfactual is the scenario **IV** ($\theta^{\mathcal{F},\mathrm{IV}}$). This scenario reflects the setting in which Telmex is absent and the incumbents offer the menu of product offerings that they would have offered, had Telmex not entered the market (old plans). In practice, for the pre-entry plans, I use the observed menu of Internet plans that were offered in the last period before the entry of Telmex (i.e., 2007:2).

The scenarios **II** and **III** are intermediate counterfactuals in that they represent step-wise changes. The former describes the market with Telmex and old plans ($\theta^{\mathcal{F},\mathrm{II}}$), whereas the latter represents the market structure without Telmex and new plans ($\theta^{\mathcal{F},\mathrm{III}}$). In practice, starting from the post-entry scenario **I**, I implement these counterfactual scenarios as follows:, for scenario **III**, I remove all products offered by Telmex in 2007:4 and define the new matrix $\theta^{\mathcal{F},\mathrm{III}}$. Similarly, for scenario **IV**, I remove Telmex and the menu of products offered in 2007:4 by the incumbents. Then, I insert all Internet plans that were offered by the incumbents in 2007:2. The resulting ownership matrix is defined as $\theta^{\mathcal{F},\mathrm{IV}}$. The scenario **II** follows the same logic.

I conduct these counterfactuals simulations for all entry events observed between 2007:4 and 2009:1.[29] To simulate the new price equilibrium, I use fixed point iteration on equation

[29] I restrict the counterfactual analysis to the municipalities experiencing only entry of Telmex. That is,

(15). Subsequently, I compute the adoption rate at the market level (total number of subscribers divided by the market size), producer surplus (total variable profits), and consumer surplus.

The second objective of this paper is to quantify the total effect of market entry and decompose it into the the price and the product variety effects. Using the outcomes from the counterfactual simulations, I conduct this decomposition. First, the total effect is measured by the change in outcomes between scenario **I** and **IV**. Second, the price effect gauges the effect of the entry of Telmex, holding the menu of products fixed. That is, it is the difference between scenario **II** and **IV**. Finally, the product variety effect measures the effect of changes in the menu of products, holding the entry status of Telmex fixed. This is given by the difference between scenario **I** and **II**.[30]

When computing the counterfactual predictions, I implicitly make several assumptions (Nevo, 2000). First, the marginal costs stay the same before and after either the entry of Telmex or the adjustment of the menu of product offerings. Second, the demand estimates also remain constant which implies that the gross valuation of each Internet plan (mean utility without price) and the value of the outside option also do not change. Third, the entry (or exit) of Telmex and the adjustment of the choice set do not trigger the entry (or exit) of any other competitor.

7.2 The Impact of Entry on Adoption Rate and Welfare

Table 3 summarizes the results, aggregated over municipalities experiencing market entry between 2007:4 and 2009:1.[31] In the first two columns (**I** and **II**), the entry status is held fixed, while allowing incumbents to adjust their product portfolios. The next two columns (**III** and **IV**) present the results in the absence of market entry. The fifth column (**I-IV**) shows the total effect of market entry on different outcomes, computed as the difference between the first and the fourth columns.

In the post-entry scenario, there are 1.05 million Internet subscribers, representing an adoption rate of 20.31 percent. In the absence of market entry and any product adjustment, this adoption rate falls to 13 percent, implying that market entry increases the adoption of Internet services by 7.31 percentage points. This increased rate amounts to having 0.38 million new Internet subscribers. In terms of surplus, market entry increases consumer

do not consider entry of other large incumbents. It might be the case that in some municipalities there is entry/exit of small Internet providers. I keep these markets, assuming that these changes in market structure were not triggered by the entry of Telmex and

[30]Notice that these effects alternatively can be defined using scenario **III**.

[31]In total, there are 31 different municipalities experiencing market entry at different time periods: 4 in 2004:4, 9 in 2008:2, 15 in 2008:4, and 3 in 2009:1.

surplus by \$10.3 millions. To put this finding into perspective, the surplus per individual consumer is \$9.83 (26 percent of the average price) and the total consumer gains amount to 32 percent of the total post-entry sales. Finally, market entry raises variable profits by \$5.5 millions.

The entry of Telmex prompts responses from incumbents in two ways. Market entry not only intensifies competition leading to a price reaction in the market, but also leads incumbents to adjust their product portfolio. Holding the response in product portfolio fixed, I can compute the price effect by removing Telmex from the market. In practice, the price effect can be computed by comparing columns **I** and **III**. Regarding the product variety effect, I hold the absence of entry fixed and allow incumbents to adjust the menu of Internet plans. I quantify this effect by comparing columns **III** and **IV**. The last two columns of Table 3 reports the extent to which the price and variety effects contribute to the overall effect of market entry.

Table 3. Counterfactual analysis of market entry

	Entry		No Entry		Total effect	Decomposition (%)	
	New plans (I)	Old plans (II)	New plans (III)	Old plans (IV)	(I-IV)	Variety effect	Price effect
Subscribers	1.05	0.91	0.82	0.68	0.38	39.42	60.58
Adoption rate (%)	20.31	17.43	15.88	13.00	7.31	39.42	60.58
Consumer surplus	25.44	21.35	18.73	15.11	10.32	39.57	60.43
Variable profits	18.11	15.56	15.34	12.63	5.48	46.59	53.41

Notes: This table presents the counterfactual analysis of market entry for 31 municipalities. The sample of municipalities is restricted to those experiencing only market entry of Telmex and not entry/exit of any other large Internet provider. The last two columns decompose the total effect into the product variety effect (I-II) and the price effect (II-IV). The values of the variables are in millions unless otherwise indicated. Consumer surplus and profits are expressed in US dollars.

The decomposition of the total effect of market entry on adoption and consumer surplus reveals that about 61 percent arises from the price effect, while the remaining 39 percent can be attributed to the adjustments in product variety. This finding highlights the important role of product variety on the adoption of Internet services. This is particularly significant in contexts where consumers struggle to get access to new digital services (e.g., developing countries) and entry barriers prevent the entry of new competitors (e.g., telecom industry). One potential implication is to implement policies associated with the menu of product offerings. For instance, policies mandating regular updates of the menu of product offerings, together with the respective information disclosure, could intensify competition in product variety and raise adoption rates.

To study the total welfare impact of entry, I need to take into account the cost of adjusting the product portfolios. Table 4 reports a summary of the welfare analysis, indicating that the total gross welfare amounts to $15.8 millions. To compute the net welfare, it is necessary to subtract the fixed costs incurred from changes in product variety from the gross welfare. The fourth column of Table 4 shows that these fixed costs range between $2.09 and $9.77 millions. As a result, taking the mid-fixed cost as a conservative measure, the net welfare gain resulting from market entry is estimated to be $9.88 millions.

Table 4. Welfare effect of market entry

Consumer surplus	Variable profits	Gross welfare	Fixed costs	Net Welfare
10.32	5.48	15.8	5.93 [2.09,9.77]	9.88 [6.03,13.72]

Notes: All values are in millions of US dollars. The values in squared brackets show the results obtained using the upper and lower bounds of the fixed costs.

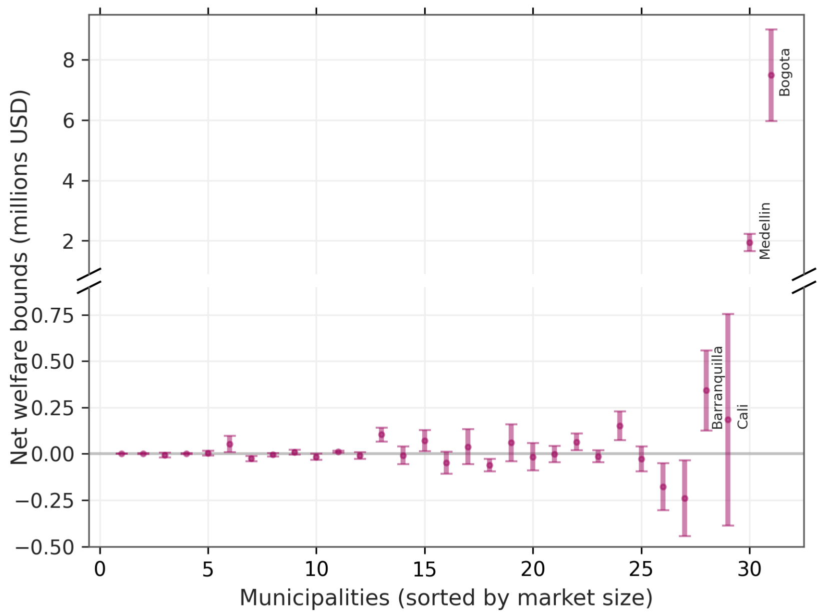
Given the heterogeneity in fixed costs (see Figure 3), the net welfare gains could potentially vary across jurisdictions. In Figure 4, I examine this by analyzing the heterogeneity in net welfare bounds across municipalities. The results suggest that the positive aggregate net welfare gains are driven by the large cities, whereas for the other municipalities the net welfare gains are rather small or even negative.

This finding, however, corresponds to just one month of Internet services. Unlike other products or one-time services, the Internet plans involve subscription and monthly fees intended to last for years. Hence, extrapolating the welfare analysis over a year (or more) would exhibit increases in gross welfare while keeping constant the fixed costs. As a result, in the long-term, I could expect the net welfare gains to be positive for all (or the vast majority) of municipalities.

8 Concluding Remarks

In this paper, I have analyzed the entry of a new Internet provider in the market for Internet services in Colombia. Using data on the universe of Internet plans, I estimate a differentiated products demand model to study how consumers make decisions in this market and to better understand the substitution patterns. The demand parameters jointly with a supply-side model allow to infer information on the cost structure of the firms (marginal and fixed costs). Using the structural model and the estimated parameters, I conduct a series of counterfactual

Figure 4. Net Welfare effect of market entry



Notes: This figure displays the upper and lower bounds of the net welfare effects of market entry across 31 municipalities. The dots denote the midpoints. The welfare effects are in millions of US dollars.

analyses to evaluate the impact of market entry on various equilibrium outcomes. In addition, I decompose the total effect of market entry into the price and product variety effects.

The findings indicate that market entry increases the adoption rate for Internet services by 7.31 percentage points and raises consumer surplus by $10.32 million. Further, when examining the decomposition of the total effect, I find that the price effect accounts for 61% of the total effect, whereas the remaining can be attributed to the adjustment of the menu of product offerings. This finding highlights the important role of product variety on the adoption of Internet services. This is particularly significant in contexts where consumers struggle to get access to new digital services (e.g., developing countries) and entry barriers prevent the entry of new competitors (e.g., telecom industry).

There are potentially several policy implications stemming from these findings, especially for less developed countries, which would be interesting to study in future work. One potential implication is to implement policies associated with the menu of product offerings. For instance, policies mandating regular updates of the menu of product offerings, together with the respective information disclosure, could intensify competition in product variety and raise adoption rates.

This paper focuses on the short-term effects of market entry (and product variety) on

Internet adoption and assumes away the long-term effects of investment (e.g. upgrades of the telecom network). When entering the Colombian the market, Telmex had to incur in sizeable investments to roll out the necessary infrastructure to provide Internet services and this, in turn, may have triggered a reaction in terms of investments by incumbents. As a result, both the investment per provider and for the total industry may have change. The natural question then to ask is whether these investments are fixed costs savings, or correspond to marginal cost savings and quality improvements. While the former increases welfare but not to the benefit of consumers, the latter has the potential to benefit consumers and boost the adoption of Internet services in the long-run. In future research, it would be interesting to long-term investment decisions to elicit a more complete analysis of the welfare effects.

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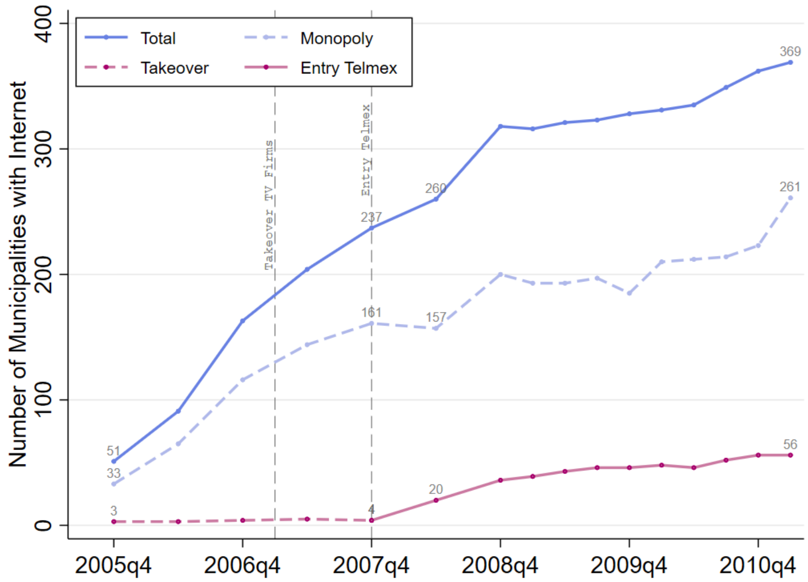
Appendix A: Descriptive Evidence

Table 5. Sample description

Period	Obs	Markets	Internet providers				Market Share
			Total	Large	Small	Per Market	Large ISPs
2005:4	355	51	18	3	15	1.6	81.8
2006:2	525	91	20	3	17	1.6	49.2
2006:4	1193	163	21	3	18	1.6	61.2
2007:2	1401	204	22	3	19	1.6	57.6
2007:4	1688	237	20	4	16	1.6	54
2008:2	2063	260	18	4	14	1.8	52.9
2008:4	2406	318	19	4	15	1.8	53.8
2009:1	2483	316	20	4	16	1.8	52.7
2009:2	2991	321	19	4	15	1.9	52.5
2009:3	3034	323	20	4	16	1.8	53
2009:4	2934	328	20	4	16	1.8	54.7
2010:1	2825	331	20	4	16	1.7	59.7
2010:2	2864	335	19	4	15	1.7	60.3
2010:3	3181	349	19	4	15	1.7	59.2
2010:4	3191	362	19	4	15	1.7	60.4
2011:1	3159	369	15	4	11	1.5	62.5

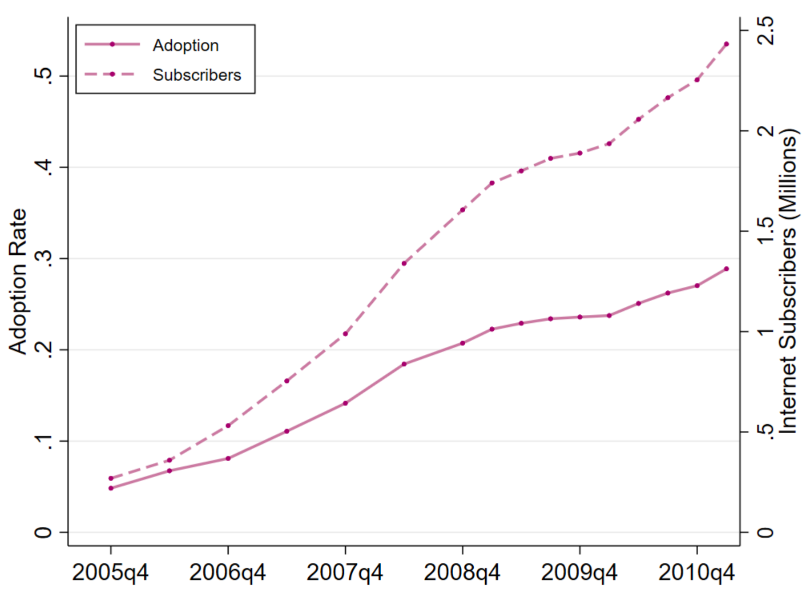
Notes: Market shares are in percentage and denote the average share of Internet subscribers across markets.

Figure 5. Number of Municipalities with Internet Services



Notes: This figure displays the number of municipalities with only one Internet provider (Monopoly) as well as the number of municipalities with market entry (Telmex). Prior to entry, the Internet provider Telmex took over several TV cable operators, some of which were active in the Internet service sector. The dashed line represents the number of municipalities where such acquisitions occurred.

Figure 6. Internet adoption and subscribers over all markets

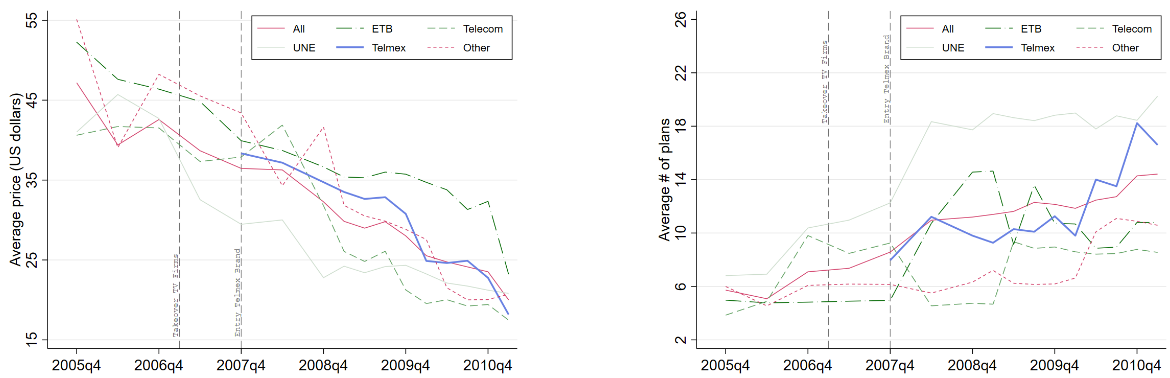


The following figures display the evolution of equilibrium outcomes by Internet provider. Panel (A) in Figure 7 provides the evolution of the monthly fee. The graph shows that average prices follow a decreasing trend and seem to be converging towards the end of the sample. On the other hand, Panel (B) in Figure 7 shows the evolution of the average number of plans offered per market during the sample period. It appears that there was not a unified response by the incumbents to the entry of Telmex. First, the number of plans provided by ETB and other carriers presents a slight fluctuation over time but in general remains stable. In contrast, the number of Internet plans served by UNE and local providers shows a marked increase in 2008Q2. After the entry of Telmex, the number of services remains stable at 10 plans on average. Second, the menu of product offerings of Colombia Telecomunicaciones fluctuates substantially over time. In particular, at the entry of Telmex, the provider shrinks drastically the menu of products for one year. Finally, Telmex started operations by offering, on average, 4 different plans per market. Its menu of plans remained relatively steady, showing a slight increase over time.

With respect to the download speed, Figure 8 depicts two different (increasing) patterns before and after 2008. On the one hand, prior to 2008, the vertical differentiation was minimal in the sense that the ISPs served plans with similar average speeds. As of 2008, local and other providers started offering services with lower quality, whereas the rest of carriers continued offering similar high-quality plans. From this graphical analysis, it is difficult to determine whether the observed differentiation after 2008 can be attributed to the entry of Telmex or to the regulation of quality standards. However, it is worth noting that the upgrading of the broadband definition in 2010 seems to trigger a similar, but more moderate, reaction in the market, suggesting that the observed effect in 2008 could be the result of both entry and regulatory effects.

Figure 7. Evolution of prices and product variety by firms

(A) Prices (B) Internet plans



Notes: These figures display the changes in average prices (Panel A) and the average number of Internet plans (panel B) by Internet provider. The dashed lines denote time periods related to market entry. The first dashed line in 2007:1 represents the acquisition of TV cable operators, whereas the second one in 2007:4 denotes the introduction of Internet services under the Telmex brand.

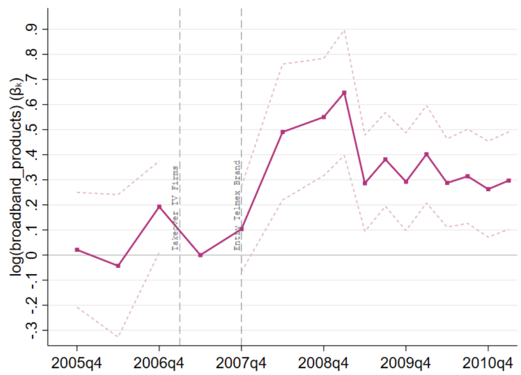
Figure 8. Evolution of connection speed by firms

Notes: This figure displays the changes connection speed (in Mbps) by Internet provider. The dashed lines denote time periods related to market entry. The first dashed line in 2007:1 represents the acquisition of TV cable operators, whereas the second one in 2007:4 denotes the introduction of Internet services under the Telmex brand.

Appendix B: Relative changes in prices, product variety and speed

Figure 9. Relative changes in product variety (large incumbents)

(A) Broadband plans



(B) Narrowband plans

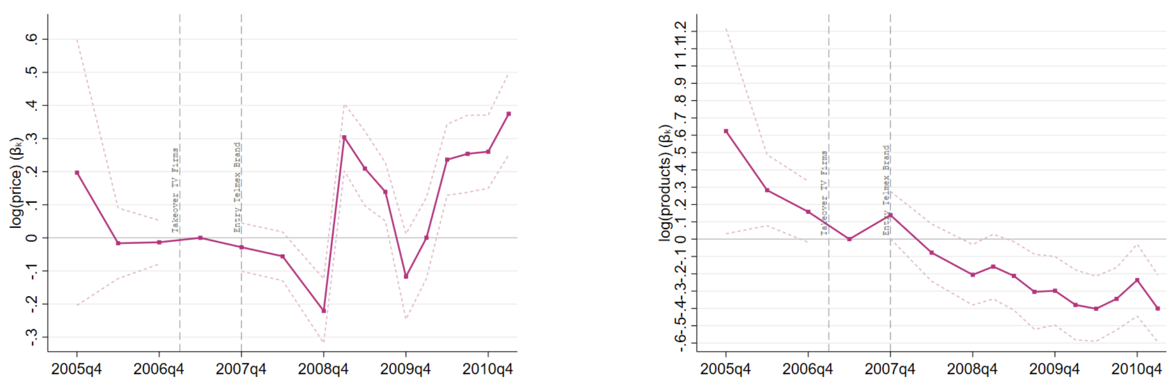
Notes: This figure displays the coefficients of the event study regressions for large incumbents, where the coefficient for the period 2007:2 is normalized to 0. The dashed (pink) lines correspond to the upper and lower bounds of the 90% confidence interval which is based on robust standard errors clustered at the municipality level. Each panel shows the results separately for the number of broadband (A) and narrowband (B) plans. See the main text for the definition of broadband labels. The sample consists of municipality-firm pairs that show up in the pre- and post-entry periods. In panels (A) and (B) the dashed vertical lines denote periods related to market entry. The first dashed line in 2007:1 represents the acquisition of TV cable operators, whereas the second one in 2007:4 denotes the introduction of Internet services under the Telmex brand.

Figure 10. Relative change in speed (large incumbents)

Notes: This figure displays the coefficients of the event study regressions for large incumbents, where the coefficient for the period 2007:2 is normalized to 0. The dashed (pink) lines correspond to the upper and lower bounds of the 90% confidence interval which is based on robust standard errors clustered at the municipality level. The outcome variable is the (log) connection speed. The sample consists of municipality-firm pairs that show up in the pre- and post-entry periods. In panels (A) and (B) the dashed vertical lines denote periods related to market entry. The first dashed line in 2007:1 represents the acquisition of TV cable operators, whereas the second one in 2007:4 denotes the introduction of Internet services under the Telmex brand.

Figure 11. Relative changes in prices and product variety (non-large incumbents)

(A) Prices (b) Internet plans



Notes: This figure displays the coefficients of the event study regressions for other (non-large) incumbents. See Figure 2 for further details of the sample and event study.

Figure 12. Relative changes in equilibrium outcomes: Balanced municipality sample 2005:4 - 2011:1

Notes: This figure displays the coefficients of the event study regressions. The analysis is done separately for large and non-large incumbents and for prices and number of Internet plans. The sample consists of municipalities that show up in every period between 2005:4 and 2011:1 (balanced panel of municipalities). See Figure 2 for further details of the event study.

Appendix C: Demand Estimates and Substitution Patterns

	(1) OLS	(2) IV1	(3) IV2	(4) IV3	(5) OLS	(6) IV1	(7) IV2	(8) IV3
Price	-0.042	-0.212	-0.166	-0.163				
	(0.001)	(0.053)	(0.041)	(0.041)				
Price / Income					-15.841	-77.288	-75.453	-74.722
					(0.490)	(12.093)	(11.741)	(11.537)
Speed	-0.183	0.563	0.332	0.313	-0.235	0.304	0.284	0.277
	(0.016)	(0.252)	(0.192)	(0.191)	(0.021)	(0.110)	(0.106)	(0.104)
Broadband (1/0)	0.992	1.946	1.725	1.712	0.947	1.658	1.673	1.656
	(0.025)	(0.316)	(0.255)	(0.255)	(0.029)	(0.157)	(0.153)	(0.150)
Tech: Cable	1.516	1.516	0.815	0.808	1.529	1.688	1.519	1.522
	(0.093)	(0.528)	(0.470)	(0.470)	(0.093)	(0.440)	(0.428)	(0.427)
Tech: xDSL	0.950	1.078	0.469	0.480	0.923	1.083	0.968	0.956
	(0.078)	(0.531)	(0.483)	(0.483)	(0.078)	(0.436)	(0.430)	(0.430)
Seniority	0.283	0.492	0.417	0.419	0.272	0.421	0.409	0.401
	(0.023)	(0.099)	(0.078)	(0.078)	(0.024)	(0.095)	(0.092)	(0.089)
Market Coverage	-0.005	-0.017	-0.009	-0.008	-0.005	-0.022	-0.021	-0.021
	(0.001)	(0.008)	(0.006)	(0.006)	(0.001)	(0.005)	(0.005)	(0.005)
Subsidiary (1/0)	-0.233	-0.464	0.005	0.033	-0.372	-1.361	-1.562	-1.495
	(0.169)	(0.733)	(0.579)	(0.578)	(0.174)	(0.753)	(0.722)	(0.706)
Centers Compartel	0.001	0.014	0.016	0.014	0.008	0.040	0.041	0.040
	(0.004)	(0.013)	(0.010)	(0.010)	(0.004)	(0.014)	(0.014)	(0.014)
Internet Cafes	0.028	0.037	0.023	0.026	0.008	0.005	0.007	-0.000
	(0.014)	(0.049)	(0.040)	(0.040)	(0.015)	(0.050)	(0.049)	(0.047)
Elasticity	-1.2	-6	-4.7	-4.6	-0.9	-4.6	-4.5	-4.4
Weak IV		14.97	19.35	14.52		34.80	26.07	20.17
J-test (p-value)		0.00	0.00	0.00		0.47	0.20	0.27

Notes: The sample consists of 36293 observations. All specifications include municipality-firm, firm-year and year-quarter fixed effects. The parameters in columns (2)-(4) and (6)-(8) are estimated using two-step feasible GMM. The instrumental variables consist of sums of characteristics of own and rival products: IV1 uses the constant term (own) and connection speed (rival); IV2 adds the broadband attribute (own); and IV3 adds a quadratic term for the connection speed. The weak IV and J-test correspond to the Kleibergen-Paap F-statistic and the Hansen J-test (p-value). Median elasticities are computed using the estimated parameters. Standard errors reported in parentheses and clustered at the firm-municipality level.

Table 6. Estimation of Internet Services Demand - Logit Model

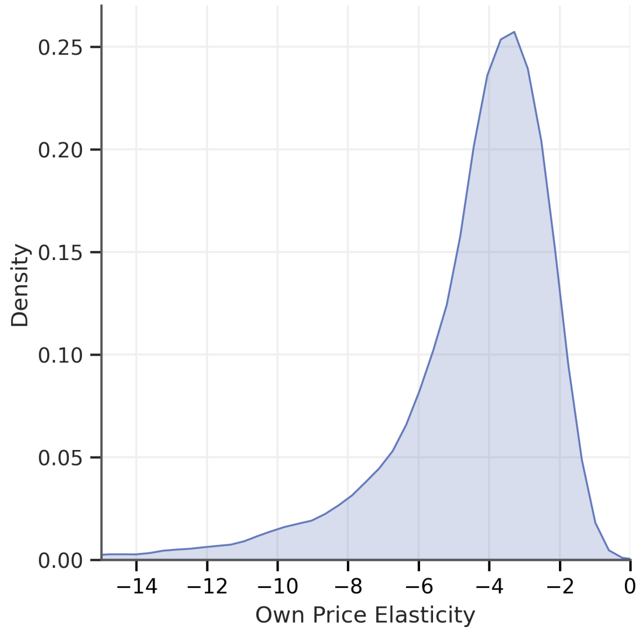


Figure 13. Distribution of own-price elasticity

Notes: This figure displays the distribution of product-level own price elasticity.

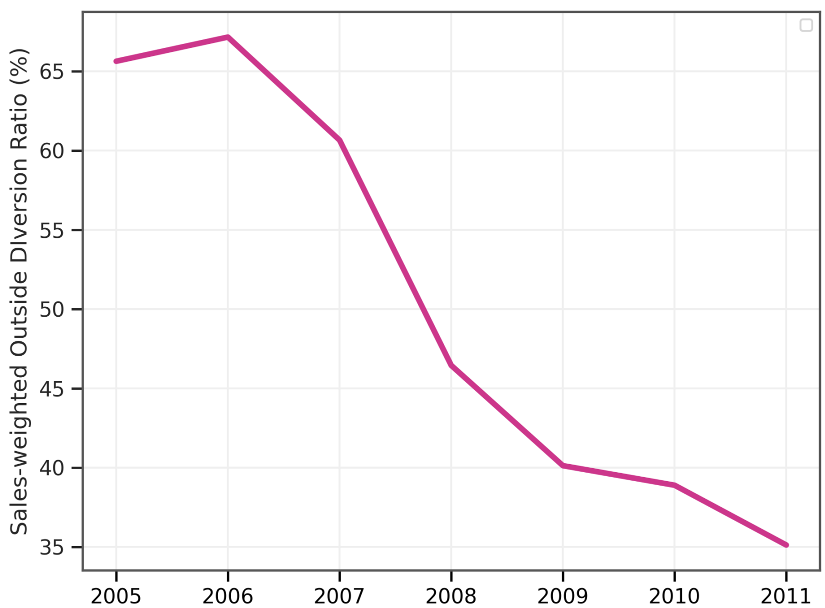


Figure 14. Changes in the outside diversion ratio

Notes: This figure shows the evolution of the sales-weighted outside diversion ratio. The diversion to the outside good represents the proportion of Internet subscribers willing to switch to the outside option due to a price increase of a product.

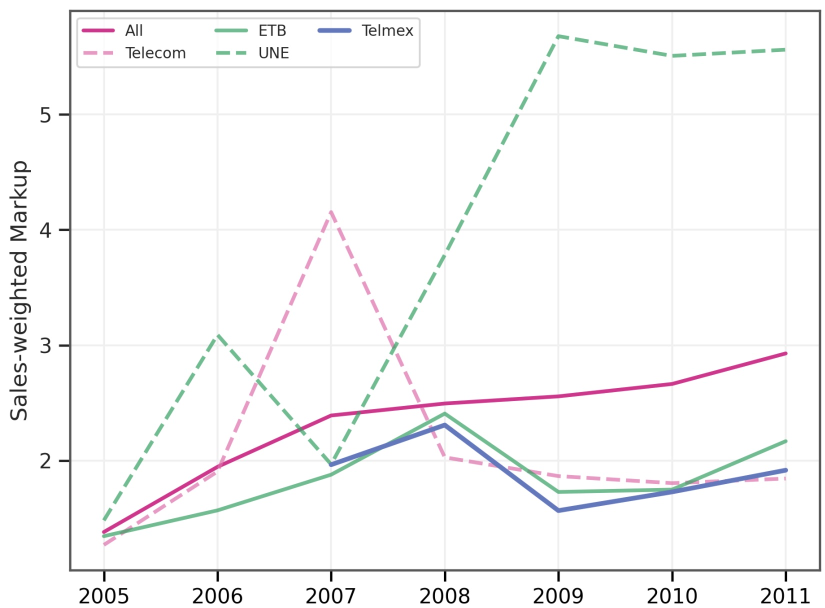


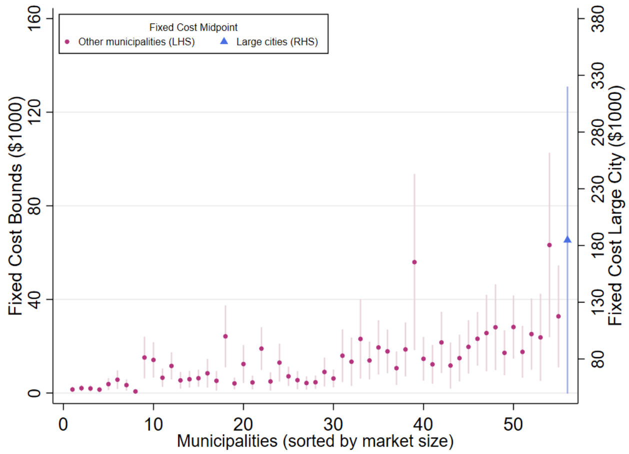
Figure 15. Changes in market power

Notes: This figures displays the evolution of sales-weighted average markups. Markups are defined as the ratio of price to marginal cost.

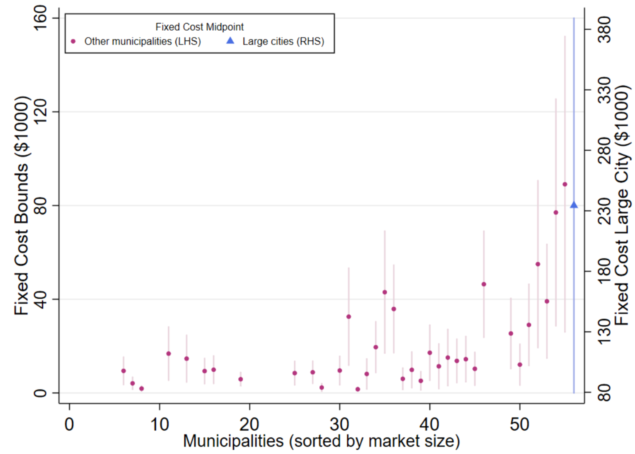
Appendix D: Fixed Cost Bounds

Figure 16. Estimated fixed cost bounds for municipalities with market entry

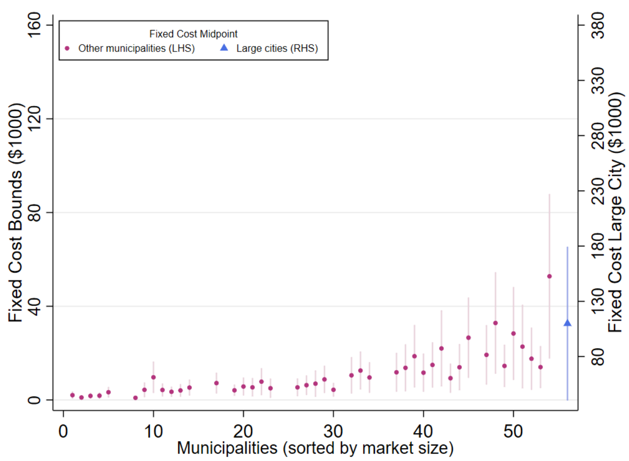
(a) Telmex



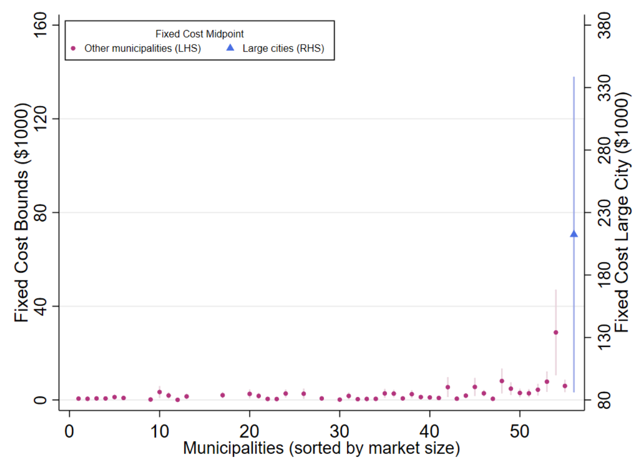
(b) UNE



(c) Colombia Telecom



(d) ETB



Notes: This figures displays the upper and lower bounds of product fixed costs for the sample of 56 municipalities experiencing market entry. The fixed cost bounds are shown separately for each of the large Internet providers.

To examine the factors influencing the fixed costs of offering an Internet plan, I study the relationship between the estimated bounds and control variables. In particular, I follow Wang (2023) and parametrize the estimated fixed costs as follows:

$$\log(F_{fmt}) \;=\; \lambda^F X^F_{fmt} \;+\; \eta_{fmt}.$$

In this equation, I model the per-period fixed cost of firm f in municipality m as a function of firm and market characteristics, as well as firm fixed effects (all contained in vector X^F_{fmt}). Following Wang (2023), I use this model jointly with the estimated fixed cost bounds to define a simulated inequality objective function:

$$\mathcal{Q}(^F) \;=\; \frac{1}{s}\sum_{s,f,m,t}\Big[\max\big\{F(\lambda^F, X^F_{fmt}|\eta^s_{fmt}) - \bar{u}_{fmt}, 0\big\}^2 \;+\; \max\big\{\bar{\ell}_{fmt} - F(\lambda^F, X^F_{fmt}|\eta^s_{fmt}), 0\big\}\Big],$$

where the upper ($\bar{u}_{fmt}$) and the lower ($\bar{\ell}_{fmt}$) bounds are pre-estimated using the necessary conditions outlined in Section 4.2.1. The aim is to minimize this function while penalizing the parameters that fall outside the estimated bounds. In practice, I draw shocks η^s_{fmt} from an i.i.d $N(0, \sigma_\eta)$ distribution, where s denotes the number of draws and σ_η is a parameter to be estimated. I construct the objective function using these draws and solve the optimization problem by finding (λ^F, σ_η). The standard errors are computed using bootstrap.

With respect to the variables that may be related to the fixed costs of offering an Internet plan, I have gathered data on local media variables, such as the number of local TV channels, local radio stations and local newspapers.[32] Table 7 presents the estimates.

Fixed costs seem to increase on average over time and are higher in wealthier markets. The estimates associated with market coverage and average speed are positive but not precisely estimated. Concerning the local media variables, the fixed costs tend to be higher in markets with a more developed media market. In particular, the fixed cots of offering an Internet plan are positively correlated with the number of local TV channels, radio stations and newspapers. This results suggest that Internet providers incurs in higher expenses in markets with a more robust media presence. This is due to either higher ads slots prices or the need to purchase more advertising slots in large markets in order to reach more consumers. The direction of these estimates are reasonable as fixed costs are expected to reflect primarily marketing expenditures.

[32]This is information only exhibits variation across municipalities and not over time.

Table 7. Preliminary analysis: Determinants of Fixed Cots

	Fixed Cost	
	Coeff.	SE
Trend	0.104***	0.006
Income	0.213***	0.013
Market Coverage	0.003	0.006
Mean Speed	0.008	0.006
# TV channels	0.111***	0.025
# Radio stations	0.025***	0.004
# Newspaper	0.084***	0.02
σ_η	0.003*	0.002

Notes: Based on a sample of 6999 observations. The regression controls for firm fixed effects, market characteristics (income, capital, geographic features) and firm national coverage. Standard errors are bootstrapped and are presented in parenthesis.

Appendix E: Counterfactual Analysis

	Entry		No Entry		Total effect	Decomposition (%)	
Period	New plans (I)	Old plans (II)	New plans (III)	Old plans (IV)	(I-IV)	Variety effect	Price effect
2007:4	20.55	17.07	14.88	11.39	9.16	37.99	62.01
2008:2	15.74	14.10	13.66	12.02	3.73	43.97	55.76
2008:4	22.38	20.22	19.63	17.48	4.90	44.08	55.92
2009:1	13.38	12.61	12.61	11.84	1.54	50	50

Notes: The values of the adoption rate by time periods are in percentages.

Table 8. Effect on adoption rate by periods

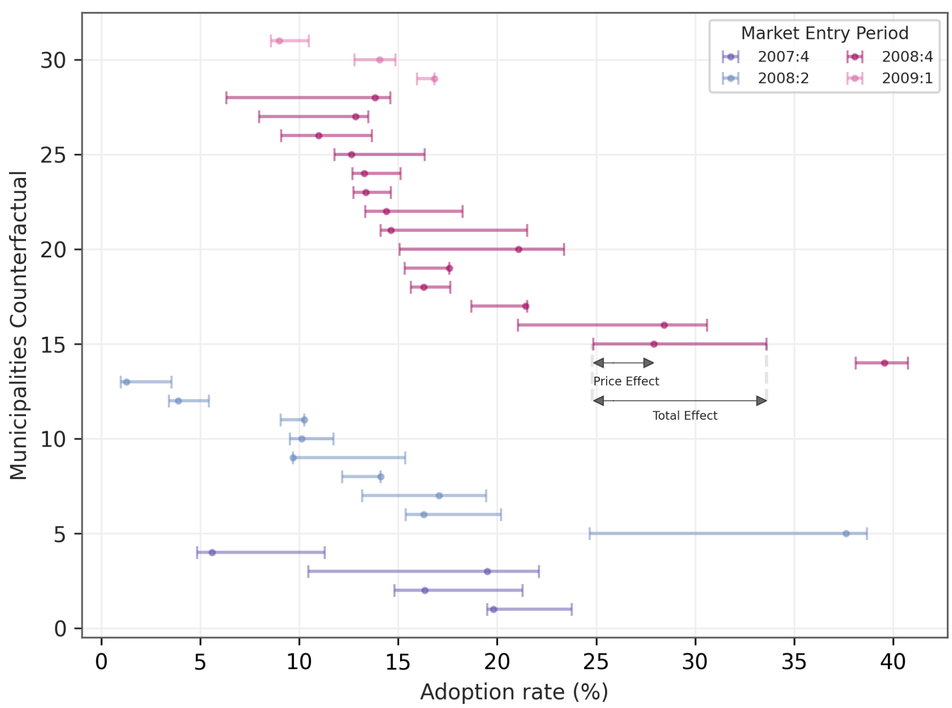


Figure 17. Effect on adoption rate by municipalities

Notes: To what extent does the entry of Telmex affect prices and the menu of products offered in the markets? This subsection provides preliminary evidence to address this question. First, consider a simple reduced- ....