Borradores de ECONOMÍA

Banning Price Discrimination under Imperfect Competition: Evidence from Colombia's Broadband

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No. 1148
2020

BANCO DE LA REPÚBLICA
COLOMBIA

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Abstract

Economic theory is inconclusive regarding the effects of banning third-degree price discrimination under imperfect competition because they depend on how the competing firms rank their market segments. When, relative to uniform pricing, all competitors want higher prices in the same market segments, a ban on price discrimination will reduce profits and benefit some consumers at the expense of others. If, instead, some firms want to charge higher prices in segments where their competitors want to charge lower prices, price discrimination increases competition driving all prices down. In this case, forcing the firms to charge uniform prices can increase their profits and reduce consumer surplus. We use data on Colombian broadband subscriptions to estimate the demand for internet services. Estimated preferences and assumptions about competition are used to simulate a scenario in which firms lose their ability to price discriminate. Our results show large effects on consumer surplus and large effects on firms' profits. Aggregate profits increase but the effects for individual firms are heterogeneous. The effects on consumer welfare vary by city. In most cities, a uniform price regime causes large welfare transfers from low-income households towards high-income households and in a few cities, prices in all segments rise. Poorer households respond to the increase in prices by subscribing to internet plans with slower download speed.

JEL codes: L10, L20, L50

Keywords: Price discrimination, regulation, market structure

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Sobre las Consecuencias de Prohibir la Discriminación de Precios bajo Competencia Imperfecta: Evidencia de los Mercados colombianos de Banda Ancha

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Resumen

La teoría económica no es muy concluyente con respecto a los efectos de pasar de un régimen de discriminación de precios de tercer grado a un régimen de precio uniforme en un ambiente de competencia imperfecta, porque dichos efectos dependen de como las firmas que compiten ranquean los segmentos de mercado. Si las firmas coinciden en el ranking que hace de los segmentos de mercado, un régimen de precio uniforme reduce los beneficios de la firm comparado con los beeneficios que haría bajo discriminación. Si en cambio, las firmas tienen diferentes rankings para los segmentos de mercado, el precio uniform puede ser más alto que los precios bajo discriminación, incrementando los beneficios de las firmas a expensas de los consumidores. En este articulo, usamos datos sobre suscripciones a servicios de internet en Colombia para estimar la demanda por dichos servicios. Además hacemos supuestos sobre la forma en que compiten las firmas lo que nos perimte simular equilibrios en los que las firmas cobran precios uniformes. Los resultados muestra grandes transferencias entre grupos de consumidores y moderados efectos sobre los beneficios de las firmas. Los beneficios agregados de las firmas aumentan ligeramente, pero los cambios en beneficios individuales son heterogéneos. Los efectos sobre el bienestar de los consumidores varían por ciudad. En la mayoría de las ciudades el precio uniforme causa transferencias desde hogares de bajos ingresos a hogares más ricos, pero en unas cuantas ciudades los precios aumentan en todos los segmentos. Los hogares más pobres responden al aumento de precios sustituyendo por planes de menos calidad.

JEL codes: L10, L20, L50

Palabras clave: Discriminación de precios, regulación, estructura de mercado

1 Introduction

Third degree price discrimination is a common practice. Well-known examples include its use by theaters, diners and car rentals: students pay lower prices than the rest of moviegoers for tickets to the same film; the elderly get a reduced price on their meals; veterans get discounts for renting a vehicle. To treat different segments as independent markets, firms must first identify them, often relying on information about consumers provided by a third party. Theaters use student identification cards issued by colleges and universities; restaurants ask senior citizens for AARP cards; and car rental companies require a Veteran Affairs ID. In this paper, we examine empirically the welfare effects of limiting the firms' access to the information that allows them to price-discriminate, effectively removing their ability to exert price discrimination.

As explained by Varian (1985), when the firm in question is a monopoly, economic theory provides clear predictions about changes in the ability to exert price discrimination, because the role information about consumers plays on a monopoly's profits is straightforward. More knowledge about consumers aids in devising more ornate tariffs. More ornate tariffs cannot harm the monopolist because it solves the same profit maximization problem minus the constraints of having equal prices across segments. In other words, a price-discriminating monopolist always retains the option of charging the same price in each segment. Whether uniform price harms consumers depends on how different the prices are under price discrimination and how many consumers pay each price although the uniform price will lie, for certain, somewhere between the discriminating prices.

But in many industries, like the ones in the examples above, a few firms practice price discrimination in an imperfect competition environment. In those cases theory does not provide precise predictions about the welfare effects of removing the firms'

ability to practice price discrimination. As shown by Corts (1998), the effects of forcing firms to charge a uniform price depend, among other things, on how the rival firms rank the market segments, that is, on whether all firms agree on which segments should pay higher prices. When firms don't have the same ranking for the segments, price discrimination can enhance competition, thus, consumers in all segments could experience an increase in prices when switching to a uniform price regime.

In this paper, we use data from Colombia's telecommunications industry to understand the effect of banning price discrimination. Telecom carriers in Colombia use third degree price discrimination to sell bundles of phone, broadband and cable TV, because the country's unique socioeconomic strata system allows them to segment their markets and charge up to six prices for the same product within a city. Using data on prices, market shares and product characteristics, we estimate a demand model for telecom bundles that coupled with an assumption of Bertrand-Nash competition, allows us to recover estimated marginal costs and to perform counterfactual analysis. In particular we are interested in using the estimated demand and marginal cost estimates to simulate an equilibrium in which firms charge uniform prices.

Colombia's telecom markets are a suitable setting to study competing firms that practice price discrimination. Colombian cities are divided in smaller areas, called strata, that contain relatively homogeneous groups of households. The strata are labeled with numbers between 1 and 6, and households within a stratum tend to be similar in size, income and education levels. Households in stratum 1, for instance, tend to be poorer, larger and less educated while households in stratum 6 are smaller, richer and more educated. Because strata are correlated with income, telecom companies treat strata as independent markets, and two households within a city could pay different prices for identical services if their dwellings are located in different strata.

As an illustration, table 1 shows a plan in our data sold under this kind of price

discrimination. During the second quarter of 2015 in Bogotá, Claro (an ISP) sold a broadband plan with a download speed of 20 Mbps. The plan was available to households in strata 3 through 6 at three different prices: strata 3 and 4 paid specific prices while strata 5 and 6 paid one price. Our goal is to simulate an equilibrium in which firms observed exerting price discrimination are forced to charge an optimal uniform price to all segments they operate in. So in the Claro example above, in the new equilibrium, it will charge the same price for the 20 Mbps broadband plan in strata 3 through 6. Moreover, any firm selling a bundle of telecommunications services in several strata will charge a unique profit-maximizing price, given that all its competitors are charging uniform prices as well.

Our results indicate that a ban on price discrimination would have large effects on consumer surplus, with households in lower strata facing an overall increase in prices, and households in higher strata paying lower prices for their telecom services. The welfare gains of consumers living in higher strata, measured as yearly compensating variation, exceed the losses of those living in lower strata by almost $80,000. Although the effects on consumer welfare in most cities mirror the total effect, in a handful of cities a uniform price regime results in an increase in prices across segments that would hurt consumers in every strata. We don't encounter effects on the extensive margin, that is, under the counterfactual price distributions the market shares for the outside option don't change much but there are sizable substitution effects. The effects on firms profits are heterogeneous, with some firms seeing their profits increase slightly under uniform price.

The rest of the article is organized as follows. In the literature section we present the relevant economic theory that explains some of the expected effects of banning price discrimination, and show how our work relates to existing empirical papers. In the next section we describe in detail Colombian strata and how firms use them to define the

Table 1: An example of Price Discrimination

	Price
Stratum 3	32.44
Stratum 4	33.88
Stratum 5	39.30
Stratum 6	39.30

Price in 2015 dollars of Claro's 20 Mbps Internet plan in Bogotá, second quarter, 2015.

market segments where price discrimination is currently applied. Then, we present the empirical demand model, the results of estimating it, and show the welfare effects on consumers and firms. Finally, we discuss the results.

2 Literature

Since we are interested in changes to social welfare if firms cannot use the strata system to charge different prices to consumers in different segments, the paper relates to a rich theory literature inquiring on the welfare effects of third-degree price discrimination (Schmalensee, 1981; Varian, 1985; Schwartz, 1990; Ikeda and Nariu, 2009; Ireland, 1992) and, in particular, to those articles whose settings are oligopolistic markets of final goods like Holmes (1989). Particularly relevant are the insights of (Corts, 1998) who shows that competing firms that engage in price discrimination can end up intensifying competition if their best response functions are sufficiently asymmetric, in which case, a ban on price discrimination could lead to an overall increase in prices. This kind of demand asymmetries can arise, for instance, when firms discriminate between their own and their rival's customers as shown by (Shaffer and Zhang, 2000). Similarly, Bang et al. (2014) show that third degree price discrimination applied to Bayesian buyers can lead to sellers offering a higher price to low valuation buyers, a phenomenon that they dub *Reverse Price Discrimination*. Armstrong and Vickers (2001) find that if markets are

sufficiently competitive, price-discriminating firms can always make more profits, with the possible exception of third-degree price discrimination. Their conclusions, however, clash with Dobson and Waterson (2005) who show that practicing price discrimination is not always best as they find conditions under which firms raise profits by charging uniform prices. Ultimately, this paper is about how profits and consumer welfare change as the information used by firms to devise more ornate tariffs stops being available. A great survey on the role of information on devising more ornate tariffs can be found in Armstrong (2006).

Being an empirical paper, our work is directly related to the literature using data to answer economic questions about price discrimination. A big part of that empirical literature is concerned with testing whether observed differences in prices are true price discrimination or if there are alternative explanations for the observed dispersion in prices Shepard 1991; Gary-Bobo and Larribeau 2004; McManus 2007; Cohen 2008; Busse and Rysman 2005. We are not concerned with testing for it, because price discrimination is a fact of our data. With that in mind, our work resembles more a group of papers that ponder on the convenience, from the social-welfare maximizing standpoint, of different levels of price discrimination.

Leslie (2004), for instance, estimates a structural model of price discrimination with data from a Broadway play. The estimates allow him to compare welfare under the observed price discrimination, which is a medley of all kinds of price discrimination, and the counterfactual uniform pricing. He finds that firms make more profits under price discrimination while consumer welfare wouldn't vary much should firms charge uniform prices.

Villas-boas (2009), on the other hand, looks at the effects of banning wholesale price discrimination on business-to-business transactions between supermarkets and wholesalers. Her estimates suggest that welfare increases if wholesalers can't exert price

discrimination. The gain in welfare originates from a gain in efficiency. Upstream price discrimination with cost differences downstream allocates production to inefficient firms, so uniform prices help guarantee that, in the margin, only the lowest-cost downstream firms are allocated additional goods.

Grennan (2013) studies price discrimination practiced by upstream firms that provide hospitals with medical devices. According to his findings, if upstream providers practice uniform pricing, hospitals' profits suffer because it softens competition in their input markets. The hospital's ability to bargain is the reason for the different results for hospitals and supermarkets.

Our work also relates broadly to a rich branch of literature dealing with price discrimination in service industries (Lambrecht et al., 2012) and particularly to papers about price discrimination in the context of telecommunications services like telephony (Miravete, 2003; Narayanan et al., 2007; Miravete and Röller, 2004) and cable TV (Crawford, 2008; Crawford and Yurukoglu, 2012). However, these papers are mostly concerned with bundling and non-linear pricing (second-degree price discrimination) whereas ours is with third-degree price discrimination. To the best of our knowledge this is the first paper that empirically looks into the effects of switching from third-degree price discrimination to uniform price in an oligopolistic environment.

3 Price discrimination, best-response asymmetry and enhanced competition

As described in detail by Corts 1998, a key determinant of the effects of banning price discrimination in a market characterized by monopolistic competition is the way firms' best-response functions relate to one another. If the best-response functions are symmetric, that is, if the firms coincide on where to increase prices, they make more

profits under price discrimination than under uniform pricing. This happens because, relative to uniform pricing, price discrimination softens competition. Individual firms want to raise prices in the markets where their rivals also want to raise prices and so they all face less-than-usual competitive pressure. In terms of consumer surplus there is a transfer from consumers in high valuation segments, who see their prices go up, to those in low valuation segments, who see their prices go down. In this scenario, a ban on price discrimination hurts the firms and the overall effect on consumers depends on the specifics of the demand functions for each market segment.

If the best-response functions are asymmetric, a firm may want to raise prices in market segments where its rivals want to lower them. This means that, relative to uniform pricing, the firm wanting to increase prices faces more competition (in the sense of lower competitor prices) in that segment than it did before. If this is the case, the competition pressure generated by the price discrimination can be such that all prices fall and the firms earn fewer profits and the firms find themselves in a Prisoner's Dilemma kind of situation. In this case, the competing firms benefit from a ban on price discrimination because it helps them avoid the bad equilibrium.

From observed prices alone, it is impossible to know whether the firms in the data have the same rankings for the market segments where they provide their services. However, there is anecdotal evidence of instances in which price discrimination has increased competition. For example, for many years, DirecTV was aimed at richer households and as a result it has traditionally been perceived as a luxury brand associated with higher strata.[1]In 2010, DirecTV started selling prepaid TV aimed at poorer households which put competitive pressure on cable operators that were already providing services to lower strata.[2] By 2014, tech journalists were writing about how competitive the

[1]"DirecTV: We used to be seen as an elitist product"(https://archive.is/RKhej).
[2]"DirecTV goes after strata 1, 2 and 3" (https://archive.is/i75zK)

telecom markets were and how cheap telecom services were as a result.[3]

4 Strata

Simply put, strata are numbers the Colombian Government assigns to houses. These numbers typically range from 1 to 6 and correlate well with household characteristics such as income, level of schooling and family size. The government introduced strata to assist in assigning subsidies for basic utilities like water, electricity and gas. Originally, the idea behind the strata was to charge a price below marginal cost to households in lower strata and a price above marginal cost to households in higher strata. The extra revenue generated by overcharging households in higher strata was meant to cover the losses generated by undercharging households in lower strata.

The first attempt at regulating the price of utilities comes with the creation of the Bureau for Utility Pricing whose aim was to make sure that households payed according to their purchase power.[4] The bureau chose the value of the dwelling where the household lived as a proxy for the household's purchase power. At first, the Bureau used the latest transaction price of the house as a measure of its value. Soon, it was evident that this method had flaws.[5] Despite its flaws, the Bureau assigned subsidies in this manner for over fifteen years. After that and until 1990, it was the providers who had to appraise every case and decide which households should receive subsidies. This new method of assigning subsidies imposed a huge burden on the providers, which already struggled to recover their costs. The 1991 constitution passed on the responsibility of defining the strata to the municipal governments and thus the strata system was born.

In the current approach municipal governments must first identify homogeneous

[3] "Have you seen the offers in telecommunications?" (https://archive.is/vP9QS)

[4] Junta Nacional de Tarifas de Servicios Públicos (Law 3069 of 1968)

[5] For instance, rich households owning large houses that had not been sold for over 30 years were being subsidized because of the low nominal price of their estates.

neighborhoods. Then, the government collects information about the characteristics of the dwellings in those areas, such as the materials used on facades, the number of rooms, number of bathrooms, and surrounding amenities. The predominant characteristics of an area determine how it ranks with respect to other areas within the city. Finally, all the houses within the same homogeneous area are assigned the same stratum. As a result of the methodology used to rank neighborhoods, the strata are highly correlated with the characteristics of the households residing in them. For instance, households living in stratum 6 areas are, on average, richer, more educated and smaller than households living in stratum 1.

Because they are highly correlated with the household's characteristics, Cable TV and Internet service providers in Colombia have in strata an ideal tool to exert price discrimination. At the very least, a stratum conveys information about the expected income of the household, which in turn implies that, everything else constant, households located in higher strata should have, on average, higher willingness to pay for a goods than households located in lower strata.

To be able to charge different prices for the same plan to households in different strata, providers have to ensure that subscribers won't pretend to reside in lower strata in order to have access to the lower prices offered there. When a household wants to subscribe to a cable TV plan, for example, the provider requires copy of any utility bill. Because strata were created to cross-subsidize public utilities like water or electricity, the bill clearly states the stratum where the utilities are, and where the TV plan will be delivered. The operator then can charge a price specific to people living in that stratum and because the stratum is tied to the address where the service is provided, households in lower strata can't buy a plan and re-sell it to households in higher strata for a profit, nor can households in higher strata pretend to be poorer to pay cheaper prices.

In recent years the strata system has been under scrutiny by multilateral organizations like Interamerican Development Bank or United Nations due to perceived unintended consequences. For instance, the strata system is suspected of fostering already existing segregation and of creating incentives that hinder social mobility.[6] For these reasons, there have been several attempts at passing laws to end the strata system. In 2014 the Bogotá city council debated about the convenience of keeping the strata and tried to find alternatives to it. More recently, in 2017, UN-Habitat and the city's electric and water utilities companies proposed a model to assign subsidies as a substitute to strata.[7] This paper provides information about potential impacts of removing strata that go beyond its direct efect on the prices of utilities and, as such, it provides crucial information to prevent future unintended consequences.

5 Data

To estimate the model, we use two datasets: administrative data collected by the Communications Regulation Commission (CRC for its acronym in Spanish) and data from a current population survey. The CRC data contain market shares and product characteristics. The current population survey is the Great Comprehensive Household Survey (GEIH for its acronym in Spanish) which is a household survey from where we get demographics describing households in each stratum. Next on, we describe them in more detail.

5.1 CRC's Form 5

The CRC is the agency charged with regulating and fostering competition in Colombia's telecommunications industry. To fulfill its mandate it constantly monitors the

[6]https://archive.is/AGROz
[7]https://archive.is/QzY68

markets and has the authority to request detailed information about the provider's technical and commercial operations. For instance, every quarter all firms providing telecommunications services fill out Form 5, reporting information about all the services provided in each stratum of all cities, hence we observe the universe of providers and the universe of services.That means there is no need to worry about having a selected sample of providers, or having to include some of the services consumers are choosing from in the outside option. CRC's Form 5 allows us to know, for every telecom service sold in Colombia, the number of households subscribed to it, as well as some of its most salient attributes. We use data from 3 basic services -Internet, cable TV and phone- that are sold bundled or as standalone products.

When a subscription includes TV, the firms report whether at least one channel is High Definition (HD), whether it has at least one premium channel, and the technology used to deliver the service.[8] They do not report, however, how many or which channels come with the TV component of the bundle. This raises concerns for the estimation, as it is likely that more expensive bundles include more or better premium channels. This concern, however, is no different then the usual concern about utility components that, although observed by the firm and the consumer, are unobserved by the econometrician, generating an endogeneity bias. We describe below how such concerns are addressed.

When the bundle includes broadband, firms report the download and upload speeds advertised, and the technology used for its delivery but they do not report whether or not the household subscribing to the service is renting a modem.[9] This should not be a

[8]Premium channels are channels like HBO, AMC, Playboy or Sundance. TV can be delivered through 3 means: IPTV, cable and satellite. The utility specification does not include the technology used to deliver the TV service for 2 reasons. First, because average households are unlikely to have strong preferences about one or the other. Second, because even if households could prefer a type of technology, usually only one is available per house and households are limited by the only technology available.

[9]The last mile connection can be done via ADSL, DSL, coaxial, fiber, wimax, etc. Same as with TV. We don't include the means used to deliver broadband in the utility. From the consumers standpoint if they subscribe to a 10 Mbps broadband plan, they should get 10 Mbps regardless of if it is delivered

big problem, given the high prevalence of modem rentals around the world. Although we do not have data about how often Colombians rent modems we know Americans do it over 90% of the times which is a reasonable lower bound. Therefore, assuming all Colombian households rent modems from their providers is a reasonable assumption.[10]

5.1.1 Summary statistics

Table 2 shows the average prices for all types of plans sold and reported in Form 5. Unsurprisingly, Internet is on average the most expensive of the standalone services while phone is the cheapest. The most abundant and expensive bundle is the one containing all the basic services, which is often dubbed Triple Play in telecommunications jargon. As the large standard deviations show, there is a lot of heterogeneity because the table summarizes plans offered in diverse cities to even more diverse types of customers. The distribution of prices is roughly characterized by the following features: there isn't much within year variation for a given plan (the the average coefficient of variation is close to zero for all types of bundles); there is some year-to-year variation mostly driven by the last quarter of a year and the first quarter of the next (average coefficient of variation is 110%); some between-cities variation (average coefficient of variation is 110%); and a lot of within-city variation (average coefficient of variation close to 200%).

via coper or optic fiber. Also, most of the times households can choose as availability of either in the area is determined on a technical level.

[10] http://archive.is/qdoVR

Table 2: Price of plans

	Obs.	Mean	SD
Internet	1,590	16.32	8.17
Phone	1,888	9.25	5.63
TV	2,748	10.89	3.67
Internet-phone	3,778	21.93	10.31
Internet-TV	1,843	21.95	7.99
Phone-TV	1,175	12.81	5.45
Internet-Phone-TV	5,299	23.47	9.76

Price in 2015 dollars of bundles offered by all providers and all cities.

Naturally, the prices of subscriptions to telecom services vary by strata. As shown in table 3, households in higher strata subscribe to more expensive plans. For instance, the average price of a standalone Internet subscription in stratum 6 is almost twice the average price of a standalone Internet plan in stratum 1. Though operators usually exert price discrimination -varying in intensity from city to city and from operator to operator- the differences in the average prices between strata displayed in the table are not caused by actual discrimination, because we are not controlling for the attributes of the plans.

To show how different the characteristics of plans purchased by richer and poorer households are, table 4 shows the average characteristics of Internet and Phone plans by strata. Internet plans sold to higher strata tend to have faster download and upload speeds. For instance, the average download speed available to households in stratum 6 (6.64 Mbps) is almost three times the speed available to households in strata 1 (2.27 Mbps). In contrast, the number of minutes included in phone plans sold in stratum 6 households seems to be slightly lower than that for plans sold in stratum 1 -albeit this difference is not statistically significant.

In table 5 the means and standard deviations account for the number of subscribers to each plan. Because a large percentage of households fall in lower strata, this table is

Table 3: Price of bundles by strata in 2015 dollars

	Stratum					
	1	2	3	4	5	6
Internet	14.31	14.17	16.35	19.12	25.00	27.76
	(6.03)	(5.75)	(7.01)	(10.14)	(11.73)	(10.95)
Phone	8.24	8.53	9.17	10.15	11.60	12.14
	(5.28)	(5.62)	(5.33)	(5.47)	(5.61)	(6.08)
Internet-phone	20.59	20.07	21.32	24.22	28.21	31.72
	(8.75)	(9.29)	(9.29)	(10.97)	(12.77)	(14.14)
TV	10.15	10.20	10.30	12.88	15.06	16.45
	(2.73)	(2.84)	(3.12)	(3.91)	(5.25)	(7.39)
Internet-TV	19.90	20.11	21.64	23.75	27.38	32.25
	(4.67)	(4.91)	(7.05)	(10.06)	(12.22)	(14.43)
Phone-TV	10.73	10.70	13.66	14.18	16.23	16.21
	(4.21)	(3.43)	(5.01)	(6.08)	(8.04)	(8.27)
Internet-Phone-TV	20.17	19.95	23.33	25.20	30.27	32.37
	(6.85)	(6.64)	(9.18)	(9.82)	(12.11)	(13.51)

Price of average bundle by strata in 2015 dollars. The numbers in parenthesis are the standard errors.

Table 4: Internet and Phone characteristics by strata (Means and S.D.)

	Download (Mbps)	Upload (Mbps)	Minutes
Stratum 1	2.27	0.70	308.31
	(2.48)	(1.10)	(1034.47)
Stratum 2	2.71	0.76	295.84
	(2.89)	(1.00)	(1051.10)
Stratum 3	3.45	0.90	288.94
	(3.99)	(1.25)	(1172.92)
Stratum 4	4.75	1.13	269.46
	(5.61)	(1.43)	(1258.47)
Stratum 5	5.76	1.24	309.77
	(7.28)	(1.45)	(1272.41)
Stratum 6	6.64	1.42	265.68
	(8.06)	(1.78)	(1144.55)

Average speeds of bundles containing broadband and phone. Download and upload speed in megabits per second. Minutes refers to number of long distance minutes included with phone subscription.

Table 5: Bundle characteristics by strata (Weighted Means and S.D.)

	Download (Mbps)	Upload (Mbps)	Minutes
Stratum 1	1.78	0.49	306.71
	(2.15)	(1.11)	(1022.52)
Stratum 2	2.33	0.68	286.34
	(2.45)	(1.08)	(1046.27)
Stratum 3	3.75	1.04	281.24
	(3.93)	(1.28)	(1171.89)
Stratum 4	5.27	1.12	264.88
	(6.27)	(1.46)	(1268.46)
Stratum 5	6.02	1.00	312.85
	(7.87)	(1.29)	(1285.72)
Stratum 6	7.60	1.01	263.71
	(10.18)	(1.62)	(1146.68)

Average speeds of bundles containing broadband and phone weighted by number of subscribers. Download and upload speed in megabits per second. *Minutes* refers to number of long distance minutes included with phone subscription.

a more accurate depiction of the actual average characteristics Colombian households subscribe to. After weighting for the number of subscriptions, the gap between characteristics of the average plan available to lower and higher strata is even larger. The average speed to which households in stratum 6 subscribe (7.60 Mbps) is more than 4 times that of the plans chosen by households in stratum 1 (1.78 Mbps). This persistent gap between the broadband adoption rates of poorer and well-off households has motivated policies aimed at fostering adoption of faster internet by poorer families.

Unsurprisingly, TV plans are better in higher strata as well. As seen on table 6, only a third of the plans offered in stratum 1 have at least one HD channel, whereas more than half the plans offered in the highest stratum have them. Only 3% of cable TV plans sold to strata 1 have premium channels but over 12% of those in the highest strata do. The incidence of Video on Demand in the highest strata almost doubles that of the lowest.

Table 6: Characteristics TV (Percent of plans with)

	HD	Premium	VoD
Stratum 1	0.33	0.03	0.06
Stratum 2	0.45	0.06	0.07
Stratum 3	0.49	0.11	0.09
Stratum 4	0.55	0.13	0.12
Stratum 5	0.56	0.12	0.11
Stratum 6	0.55	0.12	0.13

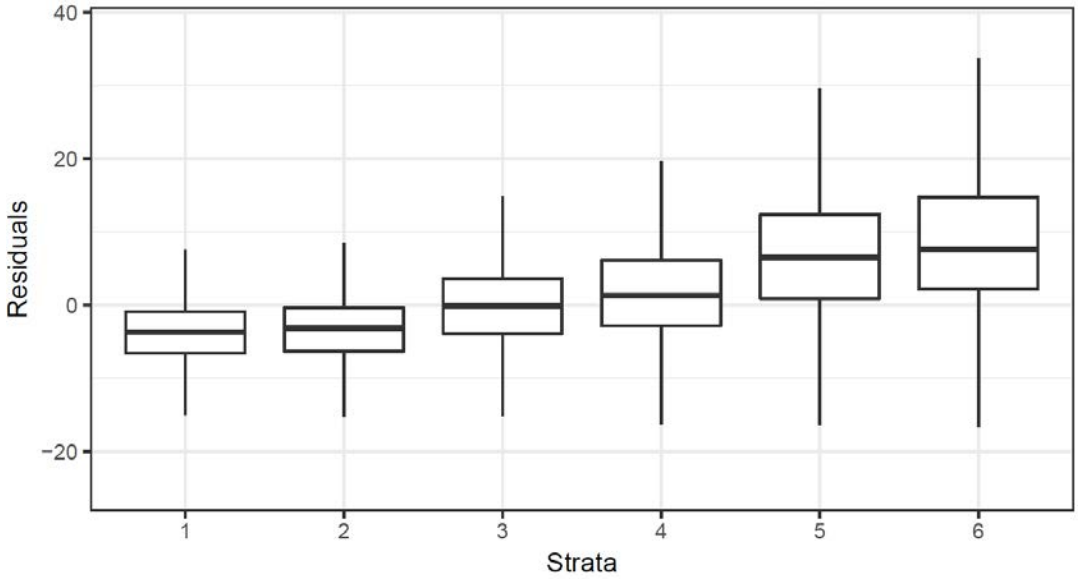
HD: proportion of TV subscriptions with at least one channel in high-definition. *Premium*: proportion of TV subscriptions with at least one premium channel. *VoD*: proportion of TV subscriptions that include access to a library of titles on demand.

We present evidence of actual price discrimination in figure 5.1 where we plot, by strata, the residuals of a simple regression of prices on bundle characteristics. The main feature of the figure is that as we move to higher strata the medians and upper whiskers of the box plots are higher, implying that the conditional distributions of residuals are shifted upwards. There is also an apparent lower bound for the residuals, that is likely caused by phone plans sold as standalone. The price discrimination can be seen by looking at the median and interquartile ranges of different strata. For instance, in stratum 3 the observed characteristics of the median bundle fully explain its price because the median residual in that stratum is exactly zero. In strata 1 and 2, on the other hand, over 75% of the observed prices are too low for the characteristics of the bundles. In contrast, when looking the residuals of strata 5 and 6, the first quartiles are located above zero, meaning that the characteristics of over 75% of bundles in those strata are insufficient to account for the observed prices.

5.2 Household Survey

The other source of information for the empirical strategy is the Gran Encuesta Integrada de Hogares (GEIH). The GEIH is a household survey similar to the CPS con-

Figure 5.1: Price residuals by strata



Each box plot depicts the distribution of residuals that result of regressing price on characteristics. The bold lines in the middle of the boxes are the median residuals for each strata. The top and bottom lines of the box are the upper and lower quartiles respectively. The upper and lower whiskers represent residuals outside the middle 50%.

ducted by the Census Bureau and the Bureau of Labor Statistics in the US. It samples households from 24 populated regions.[11] The households report, among many other things, occupational information about their working members and their living standards. From each of the 24 regions and each strata on them we draw 80 households and their characteristics. Sampling from each stratum in each city permits a finer control on households characteristics which enhances the precision of the estimates on preferences obtained below, but, getting 80 observations from the highest stratum was impossible as the survey sample doesn't include many of them. To overcome his minute obstacle6 we pool stratum 6 observations from several cities. Table 7 shows descriptive statistics for the sample of households. A noteworthy feature of the table is how correlated income (as well as schooling and family size) and strata are. This high correlation

[11]The 24 areas are 13 metropolitan statistical areas and 11 cities. Well over 80% of the country's population live in those 24 areas.

Table 7: Household characteristics by strata

	Stratum					
	1	2	3	4	5	6
Schooling	6.94	8.28	9.72	11.75	11.85	13.86
	(2.45)	(2.49)	(2.96)	(3.42)	(3.27)	(3.42)
HH age	0.68	0.61	0.62	0.59	0.56	0.65
	(0.47)	(0.49)	(0.49)	(0.49)	(0.50)	(0.48)
Family size	5.34	4.76	3.65	3.86	3.59	3.37
	(3.45)	(2.27)	(1.48)	(1.62)	(1.53)	(1.52)
Income	386.26	534.17	556.37	933.36	1,084.72	1,957.3
	(366.42)	(363.72)	(523.72)	(997.25)	(1,549.46)	(2,277.01)
Observations	1,040	1,040	1,040	1,040	1,040	1,040

Schooling: average number of years of schooling for members within the household. *HH age*: head of the household is between 25 and 45 year old. *Family size:* number of members of the household. *Income:* monthly income in 2015 dollars.

between household characteristics and strata is why telecom providers find strata so useful. It conveys information necessary to define, within a city, the market segments that determine the price discrimination.

6 Empirical demand

We estimate a random coefficients discrete choice model for demand and assume that consumers select the bundle of telecom services that yields the highest level of utility. Cities are divided into up to 6 strata indexed by $d \in \{1, 2, 3...\}$. Operating in the city are $\mathscr{F}$ firms indexed by $f \in \{1, 2, 3, ..., \mathscr{F}\}$. A firm can provide any subset of the following standalone services: phone (land-line), cable TV and Internet (broadband). These standalone services are indexed by $g \in \{1, 2, 3\}$. Furthermore, the firms can bundle any subset of the standalone services they provide. These bundles are indexed by $b \in \{1, 2, 3, ..., \mathscr{B}_f\}$, with $\mathscr{B}_f$ denoting the number of bundles sold by firm f. One recurrent bundle in the data, for instance, is the Triple Play bundle which contains Internet, phone and TV. Finally, the firms may charge different prices for the same

bundle within a city.

6.1 Utility

Most of the subscriptions observed in the data, are subscriptions to bundled services. To reflect this fact, we write the utility from subscribing to a bundle as the sum of utilities of individual services included in the bundle. Next, we start by specifying how consumers derive utility from subscribing to a standalone service and then write the utility of subscribing to groups of services as a function of the standalone utilities.

The utility a consumer i living in stratum d derives from subscribing to a single service g is given by

$$\bar{u}_{idg} = \begin{cases} p_{dg}\bar{\alpha}_{id} + \sum_k \bar{\beta}_{idgk} x_{gk} + \xi_{dg} & \text{if } g \text{ is standalone} \\ \left(p_{dg} + \nabla p_{dg}\right)\bar{\alpha}_{id} + \sum_k \bar{\beta}_{idgk} x_{gk} + \xi_{dg} & \text{if } g \text{ is bundled} \end{cases} \tag{6.1}$$

where p_{dg} is the price charged to consumers in stratum d for service g and ∇p_{dg} is any discount applied to the service when sold as part of a bundle. $x_{g1}, ..., x_{gK}$ are the service's observed non-price characteristics. The term ξ_{dg} captures the utility derived from characteristics of the service that, although observed by the consumer and the firm, are unobserved by the econometrician. Examples of ξ_{dg} specific to the telecom industry are loyalty discounts or waved installation fees. The $\bar{\alpha}_{id}$ and, $\bar{\beta}_{idgk}$ parameters represent the preferences a consumer i living in a house in stratum d has for price and characteristic k respectively. We allow these preferences to vary with the consumer's observed and unobserved characteristics:

$$\begin{aligned} \bar{\alpha}_{id} &= \alpha_d + \textstyle\sum_r \alpha^o_{dr} z_{idr} + \alpha^u_d \nu_{idp} \\ \bar{\beta}_{idgk} &= \beta_{dgk} + \textstyle\sum_r \beta^o_{dgkr} z_{idr} + \beta^u_{dgk} \nu_{idgk} \end{aligned} \tag{6.2}$$

To allow for heterogeneity of tastes, a consumer's preference for price p_{dg} (attribute x_{gk}) is modeled as a deviation from a mean preference α_d (β_{dgk}). How different the response of an individual consumer is with respect to the average consumer will depend on the consumer's observed (z_{idr}) and unobserved characteristics (ν_{idgk}).

The utility a consumer gets from subscribing to a bundle is written as the sum of the utilities of standalone goods in the bundle. If we let $b = 0$ be the outside option, then the utility of any bundle is given by

$$u_{idb} = \begin{cases} \varepsilon_{idb} & \textbf{if } b = 0 \\ \sum_{g \in b} \bar{u}_{idg} + \varepsilon_{idb} & \textbf{if } b > 0 \end{cases} \tag{6.3}$$

where the ε_{idb} are residual terms assumed to follow a type 1 extreme value distribution. Putting together equations 6.1, 6.2 and 6.3 we can write the utility a consumer derives from subscribing to a bundle as

$$u_{idb} = \delta_{db} + \sum_{g \in b,r} \alpha^o_{dr} \left(p_{dg} + \nabla p_{dg}\right) z_{idr} + \sum_{g \in b,k,r} \beta^o_{dgkr} x_{gk} z_{idr} + \sum_{g \in b} \alpha^u_d \left(p_{dg} + \nabla p_{dg}\right) \nu_{idp} + \sum_{g \in b,k} \beta^u_{dgk} x_{gk} \nu_{idgk} + \varepsilon_{idb} \tag{6.4}$$

where

$$\delta_{db} = \sum_{g \in b} \alpha_d \left(p_{dg} + \nabla p_{dg}\right) + \sum_{g \in b,k} \beta_{dgk} x_{gk} + \sum_{g \in b} \xi_{dg} \tag{6.5}$$

Households subscribe to either bundles or standalone service, so, to keep things simple we use the term *bundle* to mean subscriptions to plans including several ser-

vices (actual bundles) or singleton bundles (standalone services) when referring to a household purchase decision. Note that the utility an individual in stratum d derives from consuming bundle b consists of three parts. First, a component that is the same for all households in the stratum consuming the bundle (δ_{db}) and that only depends on the bundles characteristics, both observed and unobserved. Second, a term $(\sum_{g\in b,r} \alpha^o_{dr} (p_{dg} + \nabla p_{dg}) z_{idr} + \sum_{g\in b,k,r} \beta^o_{dgkr} x_{gk} z_{idr})$ that allows households with different observed characteristics to have different tastes for product attributes and price. And third, a term not observed by the econometrician that helps rationalize why households with the same observed characteristics would exhibit different attitudes toward the same bundle $(\sum_{g\in b} \alpha^u_d (p_{dg} + \nabla p_{dg}) \nu_{idp} + \sum_{g\in b,k} \beta^u_{dgk} x_{gk} \nu_{idgk})$. Given the distributional assumptions, the market share of households choosing bundle b is obtained by integrating out the ε_{idb} to get

$$s_{db} = \int_\nu \int_z \frac{\exp\left[\sum_{g\in b} \bar{u}_{idg}\right]}{1 + \sum_{f=1}^{\mathscr{F}} \sum_{l=1}^{\mathscr{B}_f} \exp\left[\sum_{g\in l} \bar{u}_{idg}\right]} dF_z dF_\nu \tag{6.6}$$

where F_z and F_ν are the distributions of observed and unobserved characteristics of households, $\mathscr{F}$ is the number of firms in the market and $\mathscr{B}_f$ is the number of bundles offered by firm f.

Described succinctly, the estimation algorithm finds the parameters that make the predicted shares in 6.6 close enough, under some metric, to the shares observed in the data. As usual, there are at two challenges worth mentioning. The first challenge comes from the choice of distribution for the errors. Under logit errors, the integrals in 6.6 have no analytical closed form solution so we use Montecarlo integration to simulate them. Second, the presence of unobserved attributes -ξ_{dg} in equation 6.1- known to the firm and the consumers but not observed in the data, causes endogeneity problems

that make any estimates that don't account for it suspect of biasness. In particular, one would expect higher values of ξ_{dg} to be associated with more expensive bundles, which would lead to underestimation of the coefficient on price.

6.1.1 Instruments

The second challenge is tackled using instrumental variables. Explicitly, we construct a GMM estimator, that interacts a matrix H of instruments and a structural error term $\omega(\theta*)$ written as an implicit function of the parameters. Then, the moment conditions are given by

$$E[H\omega(\theta^*)] = 0 \tag{6.7}$$

For the instruments to be valid, they must be correlated with prices. In addition, one requires the instruments to be orthogonal to the unobserved characteristics of the bundles as well. For instance, the prices of the same bundle in two different markets are correlated, because the marginal costs of providing them influence their price determination. If one is willing to assume that the demand shocks are uncorrelated across markets, then, the price of a bundle in a market is a good instrument for the price of the same bundle in a different market. This is the idea behind the so called Hausman instruments proposed first by Hausman et al. (1994) and then by Nevo (2001), among others.

Similarly, the price of a bundle is correlated with the characteristics of competing bundles. The reason for this correlation is that firms decide their pricing strategies based on their competitor's attributes. Hence, when pricing a given bundle the firm considers the characteristics of competing bundles. For the characteristics of other bundles to be valid instruments, one needs to assume that the characteristics are decided exogenously

or at least they are predetermined. This is the kind of instruments that Berry et al. (1995) advocate for.

We construct instruments to get the best of both approaches. We include in H average prices of similar bundles sold by the firm in other markets, the characteristics of competing products and the number of competitors that sell the same product in the market.

6.2 Demand Estimates

Figure 6.1 shows the estimates for the parameters on bundle characteristics, which can be interpreted as marginal utilities, that is as the utility change caused by marginal changes in the attributes of the bundle like price, download and upload speeds, access to premium channels, video on demand, and long distance minutes. Each panel depicts, by strata, the mean utility response to changes in a bundle's characteristic with its 95% confidence intervals.

The coefficients on price have the expected negative sign across all strata and are statistically significant. Moreover, the sensitivity to a price change is highest for households in stratum 1 (-0.92) and lowest for households in stratum 6 (-0.71). A negative relation between price sensitivity and strata is expected. Strata are positively correlated with income, so for households in stratum 1 expenditure on telecom services tends to represent a higher portion of their income. Because the income of a representative household raises with stratum, the sensitivity to changes in prices goes down as the strata increase.

The estimates for marginal utility of download and upload speeds are positive across all strata and vary in magnitude, as one would expect, with the marginal utility for download being larger than the marginal utility for upload. The reason behind this is that, in general, download speed has a more direct role in determining a person's

web experience: with faster download speeds Netflix and Youtube buffering times are reduced, it is quicker to check emails, play games, etc. Upload speeds, on the other hand, although crucial from a technical point of view are incidental to most users. Unlike the case of price, the estimates on tastes for upload and download speeds do not exhibit a clear correlation with strata. Moreover, the tastes for speeds are so heterogeneous, as attested by the wide confidence intervals, that the differences between strata are not statistically significant.

Households in all strata derive positive utility from having premium channels and video on demand on their TV subscriptions. Everything else constant, access to premium channels has a stronger impact on utility than access to video on demand, although the marginal valuations for these characteristics decline for higher strata. The value that households in strata 1 place on having access to premium channels is about 30% higher than households in strata 6.

Finally, the estimated marginal utility of long distance phone is presented. The magnitude of the coefficient on the preference for extra minutes of long distance calls is decreasing in strata implying that lower strata have a stronger preference for long distance minutes than do higher strata. A plausible explanation for this is that cell phones are substitutes for long distance minutes and households in higher strata tend to have better cellphone plans that include more minutes.

Table 8 presents the estimates of the consumer demand heterogeneity terms by strata. In general, there is very little heterogeneity in the price sensitivity coefficient within strata. Lower strata, specifically strata 1 and 2, are more heterogeneous in their preferences for download speed. The coefficients on *Video on Demand* and *Minutes* have, by far, the highest heterogeneity across strata.

Figure 6.1: Demand estimates

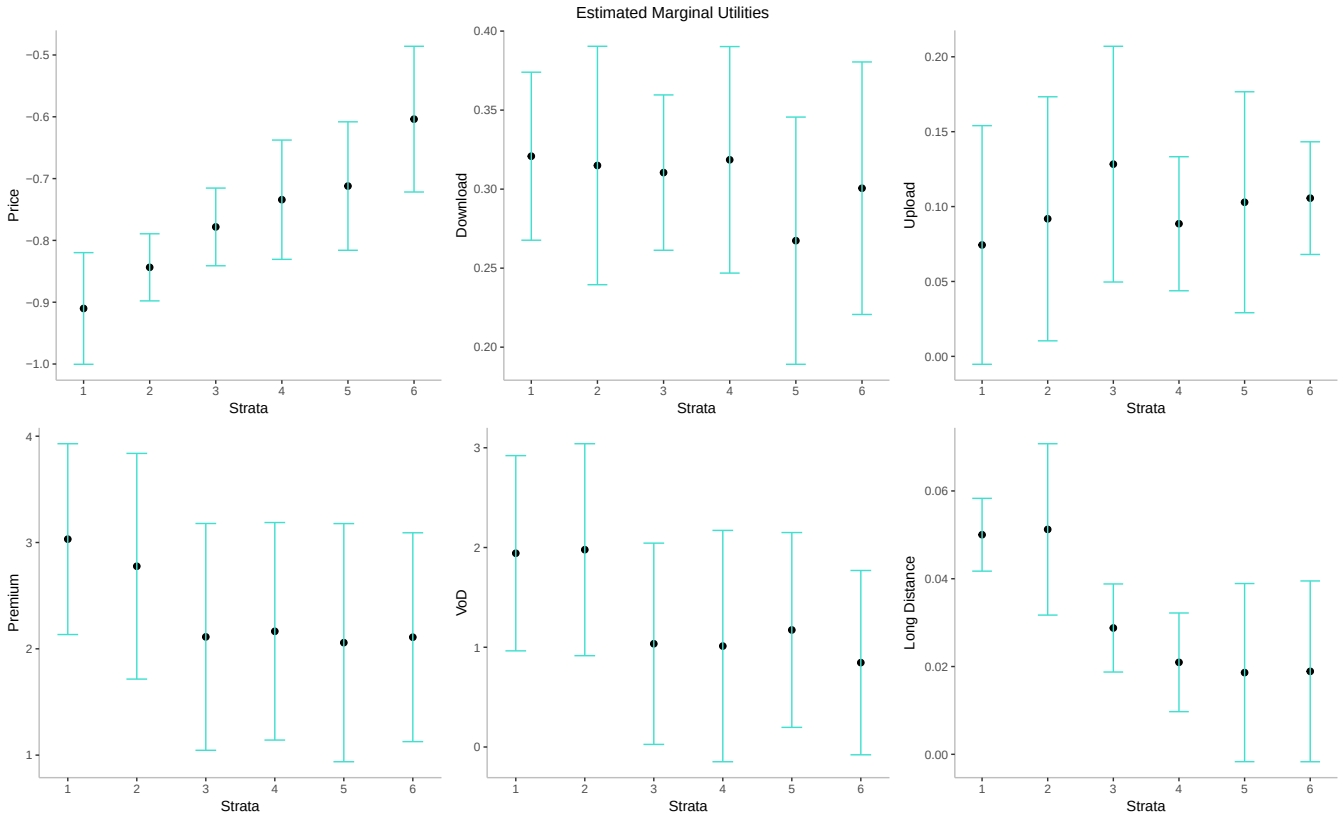


Table 8: Demand estimates: Standard deviations

	Price	Download	Upload	Premium	HD	VoD	Minutes
Stratum 1	0.03	1.23	3.27	1.72	1.65	2.8	6.59
	0.01	0.09	2.07	0.67	0.23	0.48	1.94
Stratum 2	0.03	2.24	2.49	1.9	1.57	3.4	5.48
	0.02	0.19	1.54	0.54	0.89	0.45	1.64
Stratum 3	0.05	2.26	1.11	2.17	1.49	2.83	4.89
	0.03	0.06	0.97	1.41	0.35	0.42	1.67
Stratum 4	0.04	1.48	2.78	1.97	1.77	2.87	6.78
	0.02	0.98	1.76	1.43	0.49	0.49	1.46
Stratum 5	0.08	1.79	1.97	1.78	1.60	2.77	6.41
	0.05	0.77	1.11	2.14	0.78	0.41	1.48
Stratum 6	0.11	2.27	1.14	1.22	1.43	3.01	6.31
	0.03	1.71	2.13	1.46	0.41	0.46	1.79

6.2.1 Marginal costs

We use the demand estimates and an assumption about the kind of competition that characterizes the firms' behavior to recover the marginal costs. In particular, due to the oligopoly setting, we assume that the firms play a static Bertrand-Nash game. We find that, on average, the cost of providing a bundle varies slightly by strata with the estimated marginal costs of providing services to the highest strata being slightly higher than those of providing similar services to the lowest strata. Two facts could explain systematically higher costs of delivering a service to the most affluent neighborhoods. A well known fact of wired telecommunications, is that population density is negatively correlated with last-mile costs.[12] In Colombia, higher strata are less densely populated than lower strata, so last-mile costs alone are capable of explaining why it is costlier to provide a given bundle to a household in higher strata than providing the same bundle to lower households in lower strata. In addition, homeowner associations in higher strata are particularly stern and require that hook-ups and other works related to connecting the subscriber to the node be made without affecting the facades and other aesthetic aspects of buildings.

However, these cost differences are to be interpreted cautiously, keeping in mind that they are not the cause of the different prices households pay. On the one hand, the differences are not statistically significant between consecutive strata and are only marginally different between high and low strata on average. On the other hand, virtually no plans are available to both lowest and highest strata households, usually a plan is sold to strata 1, 2 and 3, while others are sold to 5 and 6 and so on.

[12]In telecom jargon, last-mile refers to the connection between the node and the consumer.

6.2.2 Elasticities

In general, our estimates yield elasticities that imply the profit maximizing behavior of firms selling differentiated product, which is reassuring. However, our elasticities tend to be higher when compared to other elasticities obtained in similar settings. For instance, for broadband internet we find slightly larger elasticities than Galperin and Ruzzier (2013) which is expected considering that, not only our markets are more narrowly defined, but our demand is specified to the brand-bundle level.

7 Uniform pricing

In this section we investigate what would happen to economic welfare if firms cannot rely on the information conveyed by the strata. In particular, we want to measure the change in consumer surplus and firm profits when the providers switch from a regime of price discrimination to one of uniform prices. In practice, we take firms selling plans under price discrimination and force them to find an optimal uniform one price that they'll charge to all households in a city regardless of their stratum. To simulate such a world, we rely on the estimates for the demand and marginal costs obtained above to write the first order conditions (FOC) to maximize profits under a uniform pricing regime and solve for the new uniform prices.

As an illustration, consider a firm selling a single good to two strata under price discrimination. The firm chooses prices for each stratum, p_1 and p_2, to maximize

$$\pi_{PD}(p_1, p_2; \mathbf{p_{-1}}, \mathbf{p_{-2}}) = s_1(p_1; \mathbf{p_{-1}})(p_1 - mc) + s_2(p_2; \mathbf{p_{-2}})(p_2 - mc) \tag{7.1}$$

where $\mathbf{p_{-1}}$ and $\mathbf{p_{-2}}$ are vectors containing the prices of rival firms competing with the firm in question in stratum 1 and 2 respectively. The FOC for such problem are

given by

$$\frac{\partial s_1(p_1; \mathbf{p_{-1}})}{\partial p_1}(p_1 - mc) + s_1(p_1; \mathbf{p_{-2}}) = 0$$

$$\frac{\partial s_2(p_2; \mathbf{p_{-2}})}{\partial p_2}(p_2 - mc) + s_2(p_2; \mathbf{p_{-2}}) = 0$$

In the counterfactual there is an additional restriction, namely, the firm must charge the same price to consumers in both segments, $p_1 = p_2 = p$. With this restriction, the new objective function is

$$\pi(p; \mathbf{p_{-1}}, \mathbf{p_{-2}}) = s_1(p; \mathbf{p_{-1}})(p - mc) + s_2(p; \mathbf{p_{-2}})(p - mc)$$

and the new FOC for the profit-maximizing firm is

$$\sum_{l=1}^{2} s_l(p; \mathbf{p}_{-l}) + \sum_{l=1}^{2} \frac{\partial s_l(p; \mathbf{p}_{-l})}{\partial p}(p - mc) = 0 \tag{7.2}$$

The system of equations defined by first order conditions like 7.2 for all firms in a city defines the new Bertrand-Nash equilibrium under uniform pricing.

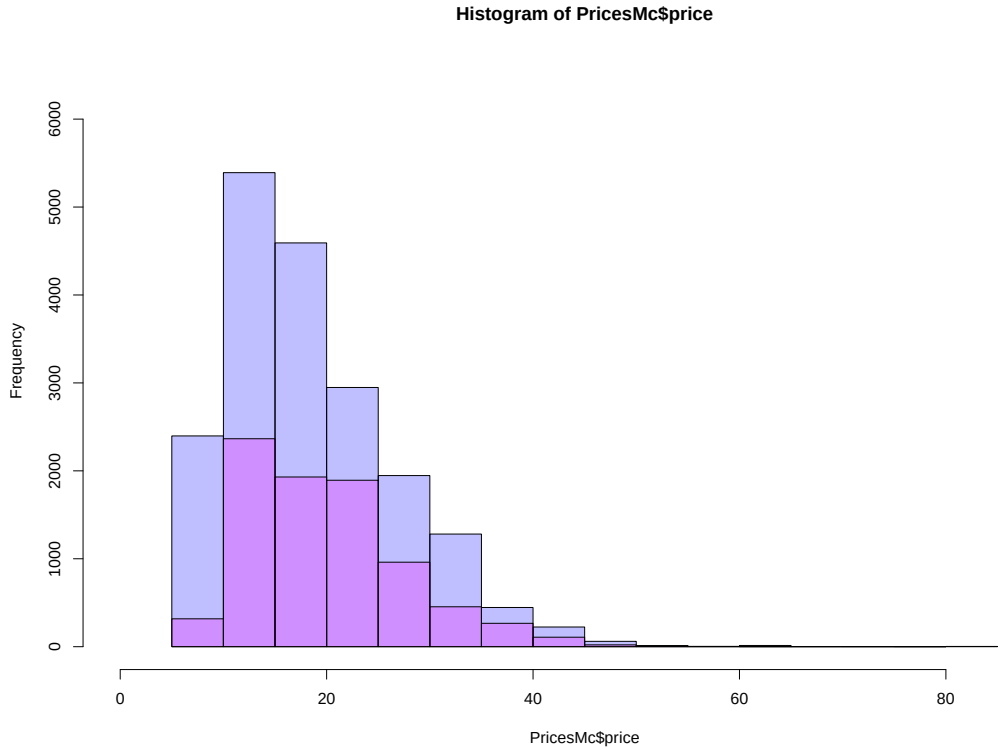
7.1 Results

The next two subsections describe the main highlights of the new equilibrium under uniform prices. First, the effects of uniform prices on consumers are discussed. Second, we calculate the change in profits for the firms.

7.1.1 Consumers

First, we start by comparing, in figure 7.1, the counterfactual (lighter) and baseline (darker) distributions of prices. In the counterfactual equilibrium mass is moved to-

Figure 7.1: Price histogram



Blue: Baseline prices. Pink: Uniform prices.

wards the center (fewer really low and fewer really high prices) which seems to confirm the conventional wisdom: uniform prices lie between the discriminating prices. However informative, the histogram hides an important force driving consumers in the new equilibrium: substitution. The substitution happens in two ways: when consumers are faced with higher prices they could stop demanding telecom services at all (substitute toward the outside option) or they could buy a plan with inferior characteristics (substitute between different services). We don't find evidence of the former, that is, the market share of the outside option in the counterfactual does not change relative to the baseline. Next we discuss the implications of the latter type of substitution.

Table 9 shows the change in consumer surplus caused by forcing firms to charge, for the same bundle, a unique price across strata within a city. The first column

shows the monthly average compensating variation for households in each city. The second column shows the total compensating variation by city. A key feature of these results is how heterogeneous the effects are. While a regime of uniform prices benefits average households in cities like Bogotá, Medellín or Cali, it harms them in Barranquilla, Pereira or Bucaramanga. Moreover, the magnitude of the average consumer surplus loss is more than twice the average gain. Because the small average gains in consumer surplus are concentrated in large, populous cities and the losses occur in smaller, less populated cities, the net effects are negative and relatively small - just under $80.000 USD consumer surplus loss per year for the 13 largest cities-.

The net effects seem small because the effects of winner and losers balance each other out within a city as do the effects of net-winning cities and net-losing cities. However, there are large aggregate consumer surplus effects, specially when considering separately who gains and who loses. For instance, a uniform price regime in Bogotá would imply a total net yearly gain of just over $240.000, but for households benefiting from the policy the total yearly gains ($425.000 USD) more than double the losses of households being hurt ($185.000 USD).

Next, we consider how the effect of banning price discrimination varies across strata. Figure 7.2 shows the variation in consumer surplus experienced by the average household in a stratum/city. The height of each dot represents the amount of dollars one should have to take away from an average household in that stratum/city to return it to the same level of utility it derived under price discrimination. As expected, households in higher strata tend to benefit from a uniform price schedule whereas households in lower strata are hurt by it because under price discrimination, the former tend to pay higher prices than the latter. For instance, for the average stratum 6 household in Manizales to enjoy the same utility it did under price discrimination we would have to remove $3.5 from their income every month. In contrast, we would have to give a little

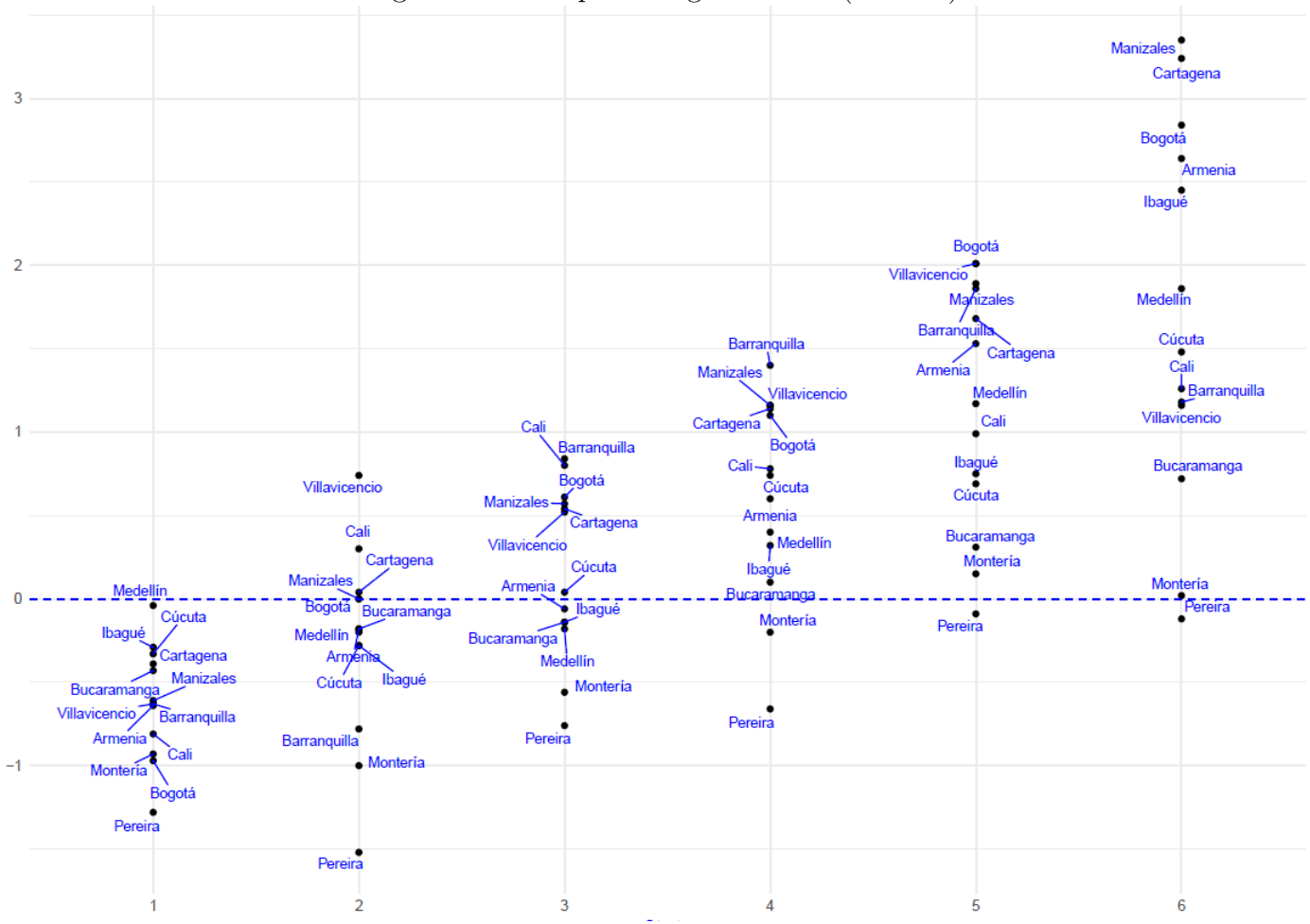
Table 9: Monthly compensating variation

	Average household	Total
Bogotá	0.01	-2,475.11
Medellín	0.02	3,657.18
Cali	0.02	2,003.26
Barranquilla	-0.03	-1,613.70
Cartagena	0.05	1,572.35
Bucaramanga	-0.03	- 1,769.77
Cúcuta	-0.02	831.22
Pereira	-0.03	-28,966.67
Manizales	-0.02	-1,426.16
Ibagué	0.03	493.89
Armenia	-0.02	-490.94
Montería	-0.02	-14,400.94
Villavicencio	0.03	1,107.91

Compensating variations in 2015 dollars.

over $0.5 to a stratum 1 household in the same city if we wanted it to enjoy the same utility as in the previous regime. Pereira and Montería are two exceptions to this rule because in those cities households in all strata are hurt by a uniform price regime.

Figure 7.2: Compensating Variation (in USD)



Because Colombia's government has made big efforts to foster broadband adoption among poorer households in recent years, we also look at the effect that a uniform pricing schedule has on the distribution of download speeds adopted. In table 10, we compare average download speeds, weighted by number of subscribers, under price discrimination and under uniform pricing. The average speed poorer households (strata 1 and 2) subscribe to, in the new equilibrium, falls slightly as a result of banning price discrimination. Even if switching to uniform prices is almost neutral in terms of net consumer surplus, policymakers should take into account that households may substitute faster plans for cheaper slower ones, thus undoing some of the achievements of previous policies.

Table 10: Bundle characteristics by strata (Weighted Means)

	Download Speed	
	Baseline	Uniform
Stratum 1	1.84	1.36
Stratum 2	2.26	2.02
Stratum 3	3.75	4.01
Stratum 4	5.23	5.58
Stratum 5	6.03	6.31
Stratum 6	7.58	7.94

Average download speeds in Mbps. *Baseline* refers to the predicted equilibrium with price discrimination. *Uniform* refers to the equilibrium in which firms charge uniform prices.

7.1.2 Firms

Aggregate revenue increases as a result of forcing the firms to charge uniform prices. Firms make almost 8 million dollars of additional aggregate revenue per year when they stop using price discrimination. In an industry with 16 billion dollars of annual

revenue, that represents a 0.05% increase.[13] However, the effects on individual firms are heterogeneous. Some firms seem to benefit from a ban on price discrimination whereas profits decrease for others. Moreover, the effects vary by city which implies that the nature of competition, i.e. whether best responses exhibit symmetry or asymmetry, is not the same in all cities.

The increase in aggregate profits begs the question, why would firms choose to practice price discrimination if they could earn more profits under uniform prices? Corts 1998 provides a possible explanation, according to which, "firms find themselves in a prisoner's dilemma: price discrimination is a dominant strategy that results in lower equilibrium profits for the firm". Another explanation, pertaining to the specifics of Colombia's telecommunications industry, has to do with the fact that most of these firms started as Local Exchange Carriers. In the past LEC were obligated to charge different prices in each strata, so the current price discrimination schemes may reflect inertia. Finally, an important source of revenue for ISP and cable operators around the world is the rental fees on modems and top boxes.[14] Perhaps, Colombian ISP and cable operators make more profits by selling subscriptions to more households under price discrimination because then they can rent modems and top boxes to those additional households and our data does not account for those revenues.

[13]To put it in context: Telmex's revenues are 3e12 COP and has a little more than 2 million subscribers which means they make 15e5 COP revenue from each subscription on average, or 125000 pesos monthly. Same numbers in dollars: 1e9 (1 billion) revenue, 2 million subscribers, 500 per subscriber year, or 42 monthly we also estimate a margin of 31.8% (Telmex claim they make 30%) with a marginal cost of 29.4 dollars and a variable profit of 12.6.

[14]Centurylink charges $10 dollars a month for renting a modem on a $68 broadband subscription, which means that 15% of the revenue comes from the modem, which in addition has zero marginal cost. A low estimate for Comcast revenues coming from renting modems and top boxes is north of $675 million per quarter (https://goo.gl/iRGfwM).

8 Conclusion

This paper explores the effects of banning price discrimination in the context of Colombia's wired telecommunications industry. Our results show large effects on consumer surplus, because in most cities a uniform price regime would result in a substantial transfers of surplus from poorer to richer households. Total consumer welfare would decrease monthly by about $80,000 if firms stopped practicing price discrimination and a collateral effect of removing the firms ability to price discriminate is that households in lower strata substitute away from faster broadband plans toward cheaper but slower ones. As a result, removing strata has the potential to undo some of the progress made by policies aimed at fostering the adoption of faster broadband.

The results also suggests that, as an aggregate, firms would benefit from charging uniform prices. Total profits of the industry would increase by about 8 million dollars per year, despite some individual firms making less profits under uniform prices. There are several explanations as to why firms are engaged in a sub-optimal equilibrium. One possible explanation is that firms rank markets differently, that is, where one firm wants to raise prices other firm wants to lower them. Under this scenario price discrimination enhances competition so banning price discrimination prevents a prisoner's dilemma and firms reach an equilibrium with higher profits. Another reason could be inertia, as most of these firms were obligated to practice price discrimination in the past. One final reason is that the data does not include an important source of revenue for telecom providers: rentals of modems and top boxes. Firms may prefer to serve more households, at an apparently sub-optimally low price, because they get revenue from renting modems and top boxes.

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A Appendix

A.1 Demand estimates

Table 11: Demand estimates (Means)

	Price	Download	Upload	Premium	HD	VoD	Minutes
Stratum 1	-0.92	0.32	0.07	3.12	1.07	2.01	0.05
	0.08	0.09	0.07	1.20	0.03	1.03	0.01
Stratum 2	-0.84	0.31	0.09	2.67	1.02	1.97	0.05
	0.05	0.07	0.07	1.17	0.05	1.07	0.02
Stratum 3	-0.78	0.31	0.12	2.09	0.55	1.04	0.03
	0.06	0.09	0.08	1.15	0.06	1.03	0.01
Stratum 4	-0.73	0.33	0.09	2.12	1.01	1.06	0.02
	0.15	0.11	0.05	1.13	0.09	1.02	0.01
Stratum 5	-0.72	0.27	0.10	2.11	1.23	1.02	0.02
	0.23	0.13	0.06	1.22	0.11	0.97	0.01
Stratum 6	-0.71	0.30	0.10	2.13	1.08	1.01	0.02
	0.52	0.22	0.04	1.46	0.34	0.84	0.02

Table 12: Compensating variations

	S1	S2	S3	S4	S5	S6
Bogotá	-0.24	0.00	0.61	0.55	0.67	0.71
Medellín	0.01	-0.10	-0.09	0.20	0.39	0.62
Cali	-0.34	0.15	0.40	0.39	0.33	0.63
Barranquilla	-0.36	-0.39	0.42	0.70	0.62	0.59
Cartagena	-0.04	0.02	0.54	0.57	0.56	0.81
Bucaramanga	-0.17	-0.09	-0.07	0.05	0.1	0.35
Cúcuta	-0.17	-0.14	0.02	0.37	0.23	0.37
Pereira	-0.69	-0.76	-0.38	-0.33	-0.03	-0.06
Manizales	-0.13	0.00	0.57	0.58	0.63	0.67
Ibagué	-0.22	-0.14	-0.14	0.16	0.25	0.49
Armenia	-0.17	-0.09	-0.03	0.30	0.51	0.66
Montería	-0.41	-0.50	-0.28	-0.10	0.05	0.01
Villavicencio	-0.15	0.37	0.52	0.58	0.67	0.58

A.2 Counterfactual prices and consumer surplus

Table 13: Counterfactual prices

	Uniform Prices			Change		
	Average	Minimum	Maximum	Average	Minimum	Maximum
Stratum 1	19.85	9.83	47.81	1.21	0.01	5.55
Stratum 2	20.14	9.74	55.93	1.73	-0.262	8.62
Stratum 3	20.06	9.06	52.69	0.87	-3.06	8.06
Stratum 4	18.953	8.83	46.29	-0.97	-3.65	0.06
Stratum 5	19.15	8.48	75.76	-1.87	-6.85	0.42
Stratum 6	21.11	7.52	70.80	-3.14	-13.93	0.67

Uniform Prices are the prices of a simulated equilibrium in which firms don't exert price discrimination across strata within a city. *Change* refers to the difference between the simulated prices under uniform rices and the simulated prices under price discrimination.


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