Information Economics and Policy 64 (2023) 101048

Contents lists available at ScienceDirect

Information Economics and Policy

journal homepage: www.elsevier.com/locate/iep

Determinants of fixed and mobile broadband demand in Mexico using discrete choice exercises and logit and conditional logit models

Agustin J. Ros

Adjunct Professor, International Business School, Brandeis University, 415 South St., Waltham, MA 02453, United States and Senior Managing Director at Ankura Consulting

ARTICLE INFO

JEL classification number:
C25
C50
D12
L96

Keywords:
Broadband demand
Discrete choice exercises
Logit and conditional logit
Willingness-to-pay

ABSTRACT

We utilize stated preference data from discrete choice exercises administered to 15,000 households and individuals in Mexico and estimate logit and conditional logit models to identify determinants of fixed and mobile broadband demand. We find that the service attribute most consistently important for broadband demand, apart from price, was service reliability and find that urban customers are willing to pay more for reliable fixed broadband service, but rural customers are willing to pay more for reliable mobile broadband service. We find evidence that rural customers are more price sensitive compared to urban customers for mobile broadband but not for fixed broadband. We find evidence that fixed and mobile broadband services are complements and that speaking an indigenous language results in a higher likelihood of subscription for both fixed and mobile broadband as does greater daily internet usage. We do not find evidence that equipment subsidies are associated with greater likelihood of subscription.

1. Introduction

Access to the internet and the deployment of broadband has significant impact on economic and productivity growth (Li, 2019; Czernich et al., 2011; Greenstein and McDevitt 2011). According to the International Telecommunications Union (ITU 2020) the penetration rate for fixed broadband (subscribers per 100 inhabitants) in Mexico in 2019 was 15.03 and 12.11 in 2015, a compound annual growth rate ("CAGR") of 5.6%.[1] Mexico is on the low end of fixed broadband penetration, however, when compared to peer countries in Latin America.[2] With respect to mobile broadband, the penetration rate in Mexico was 73.06 in 2019 and 52.45 in 2015, a CAGR of 8.6%. Mexico is also on the low end of mobile broadband penetration when compared to peer countries in Latin America.[3]

In this paper, we use stated preference data from discrete choice exercises administered to 15,000 households and individuals in Mexico to identify and quantify the main determinants of fixed and mobile broadband demand.[4] Based upon the respondents' selections, as well as their socioeconomic and demographic characteristics, we estimate logit and conditional logit econometric models to obtain utility parameters and willingness to pay for different service attributes, such as price, service reliability, download speed, data allotment, pre-pay *vs.* post-paid options and to assess different types of subsidies.

Understanding and quantifying the value to consumers of different broadband services is important for providers, consumers, and policy makers. To date, there have been few broadband demand studies using stated preference data and even fewer regarding broadband demand in developing economies. Our study contributes to the limited literature available utilizing stated preference data from discrete choice exercises to estimate broadband demand models in a middle-income, developing economy. Like policy discussions in the United States surrounding universal service support and subsidies to low-income consumers, it is

E-mail address: aros@brandeis.edu.

[1] ITU 2020 database.

[2] Fixed broadband penetration in 2019 was 19.64 in Argentina, 15.43 in Brazil, 18.09 in Chile, 13.81 in Colombia and 29.25 in Uruguay (ITU 2020 database).

[3] Mobile broadband penetration in 2019 was 93.13 in Brazil, 97.66 in Chile, 58.67 in Colombia and 97.61 in Uruguay (ITU 2020 database). In Argentina, mobile broadband penetration was 80.65 in 2017, the latest year data are available.

[4] The Secretariat of Telecommunications and Transport ("the SCT" based upon Spanish acronym) contracted the author to develop a discrete choice exercise for different telecommunication user groups in Mexico in 2015 including fixed and mobile broadband. The SCT contracted with an outside firm, Ipsos Public Affairs ("Ipsos"), to administer the survey and to conduct the discrete choice exercise. We provide a description of the survey instrument and the discrete choice exercise and attributes in the Appendix.

https://doi.org/10.1016/j.infoecopol.2023.101048
Received 13 January 2021; Received in revised form 25 March 2023; Accepted 2 August 2023
Available online 9 August 2023

important for policymakers in Mexico to understand the economic factors and policies that make adoption in Mexico and in developing economies more likely and to avoid subsidizing activities that are unlikely to materially improve adoption and to focus on policies likely to increase broadband adoption.

We begin our paper with a review of the literature on determinants of broadband demand in developed and in developing economies in Section 2. In Section 3, we provide a brief discussion on discrete choice exercises and their use in econometric demand modelling. In Section 4, we discuss our survey instrument and discrete choice exercises. In Section 5, we provide the results for fixed broadband demand for subscribers and non-subscribers. In Section 6, we provide results for subscribers and non-subscribers of mobile broadband. We conclude in Section 7 where we summarize our main conclusions and discuss policy implications based upon our findings on the most important broadband attributes and the value consumers place on different types of subsidies.

2. Literature review

Few studies have used *stated preference* data from discrete choice exercises to estimate fixed and mobile broadband demand. Liu et al. (2018) measure households' willingness-to-pay for changes in key home broadband Internet connection features using data from two nationally administered, discrete choice surveys. They estimate utility parameters using the conditional logistic regression model. They find that households are willing to pay about $2.34 per Mbps ($14 total) monthly to increase bandwidth from 4 Mbps to 10 Mbps, $1.57 per Mbps ($24) to increase from 10 to 25 Mbps, and only $0.02 per Mbps ($19) for an increase from 100 Mbps to 1000 Mbps. They also find that households are willing to pay about $8.66 per month to reduce latency from levels obtained with satellite Internet service to levels more common to wired service. Rosston et al. (2010) use data from a nationwide survey in the U. S. and results from a choice experiment to examine household demand for broadband services. They estimate utility parameters using the probit model. The authors find that reliability and speed are important service characteristics, with a household willing to pay $20 per month for more reliable service and $45 per month for improvement in speed from slow to fast. Ida and Horiguchi (2008) examine the demand for fixed broadband services in Japan and find that willingness to pay for fixed broadband services over fibre-to-the-home ("FTTH") is almost identical between provincial (rural) and urban areas. They also find that for provincial (rural) areas, territorial digital broadcasting over FTTH accounts for a large part of willingness to pay, while in urban areas tele-working and tele-education are important.

There are more studies that use *revealed choice data* and discrete choice modelling to estimate broadband demand. Mendez et al. (2021) examine the impacts of the Lifeline subsidy on high-speed Internet prices, demand and welfare using revealed choice data from the National Telecommunication and Information Association and the Census Bureau. Their logit models show that low-income households would require large price reductions to subscribe to basic broadband. Carare et al. (2015) model potential broadband choices of non-adopters using data from a large-scale survey of non-adopting households and logit models to provide estimates of their willingness to pay for broadband. They conclude that, on average, to achieve a 10% increase in subscribership, a price reduction of about 15% is needed. Nevo et al. (2016) estimate demand for residential broadband using high-frequency data from subscribers facing a three-part tariff and provide evidence that subscribers respond to this variation, and they use their dynamic decisions to estimate a flexible distribution of willingness to pay for different plan characteristics. Glass and Stefanova (2010) examine the factors that encourage broadband adoption in rural areas in the U.S. and find that demand for broadband has become more inelastic over time, marginal increases in speed alone have lost their appeal to customers and the inclusion of video in a broadband package improves broadband take rates and willingness to pay.

Other studies use discrete choice modelling from market data to estimate broadband demand in developing and middle-income economies. Švigelj and Hrovatin (2019) use survey data from Slovenia and estimate conditional logit models to examine the factors that broadband users consider when choosing their fixed broadband access and find that age, education, gender, presence of student/pupil in the household, living in the city and subscription to TV service are important determinants of fixed broadband demand. Also, and like our findings in this paper, speed was an important determinant of fixed broadband demand. Leandro and Gomes (2019) use discrete choice models to estimate demand for fixed broadband in Brazil based upon data from 1830 municipalities and find a high price elasticity of demand ranging from −4.5 to −5.3 and find that speed has an important positive impact on likelihood of purchase. Madden et al. (2015) use survey data from Thailand to estimate multinomial logit models for bundled fixed and wireless mobile broadband services. They find that the cross-price effects are positive, suggesting that fixed and mobile broadband are substitutes, a finding that is contrary to our finding in this paper.

Finally, Tajiri (2009) examines broadband demand in 93 developing countries and in 19 developed countries and finds that from a policy perspective, on the demand side subsidies to broadband subscription might be effective in developing economies as are measures related to users' capability, such as financial support for human resource development.

3. Methodology

3.1. Discrete choice exercises

Discrete choice exercises are a common technique used in the social sciences.[5] Discrete choice exercises can use stated preference or revealed preference data as the basis of the analysis (Louviere et al., 2010). Revealed preference data uses actual consumer decisions in the market and discrete choice modelling to test hypotheses and estimate utility parameters. Stated preference data generates data from consumer surveys and from discrete choice exercises to test hypotheses and to estimate utility parameters. While there is a healthy dose of scepticism in the use of stated preference, the technique has developed a strong theoretical foundation and is used frequently by researchers in a host of fields and topics.[6]

A discrete choice exercise has two components. The first requires asking respondents to select from amongst several competing products, with each product having a different set of attributes—*i.e.*, obtaining their stated preferences—while the second component involves statistical/econometric modelling. In a discrete choice exercise, the respondent selects the most preferred option from numerous combinations (scenarios) of different attributes. As the number of scenarios increases and by varying the attribute of each option across the scenarios, the researcher can identify the attributes that are most important to the

[5] See Train (2003) for a comprehensive discussion on discrete choice analysis methodology and econometric estimation techniques.

[6] Louviere et al. (2010). The use of stated preference data is particularly superior to revealed preference data in a few situations, such as estimating the demand for new products and services where market data is lacking, situations where the explanatory variables have little variation or are highly collinear, and where policy variables and choices are hard to observe and model. In addition, the potential biases that can occur with the use of stated choice data emanating from consumer difficulty in accurately expressing and describing their preferences, can be mitigated using discrete choice exercises, which asks consumers to select from various choices, see Carare et al. (2015). Discrete choice exercises require an individual to conduct several rounds of choices among alternatives in a short period of time which makes it difficult to maintain bias throughout each choice and makes it more likely, when combined with the econometric modelling, to reveal an individual's true trade-offs among alternatives.

respondent in selecting a product or service. A typical discrete choice exercise will present the consumer with between 10 and 20 scenarios, in such a way that each scenario contains different attributes and different combinations of attributes, which allows the researcher to check and quantify the trade-offs that the respondent makes in the different selections.

Our study was funded by the Mexican SCT, which had an underlying objective of performing a survey to gauge consumer behaviour in broadband markets and the incremental costs of conducting a discrete choice exercise was relatively low. In addition, the SCT was interested in several potential new policy issues—such as whether providing free internet equipment or free training would materially impact broadband penetration—for which market-based data was not available and the use of revealed preference data would have been of little help.

3.2. Econometric models

We use logit and conditional logit models to estimate broadband demand.[7] We use the logit model to estimate broadband demand for non-subscribers and conditional logit for subscribers.[8] For the non-subscriber group, our goal is to identify those economic and public policy factors that will make subscription more or less likely. We present the respondents with a binary choice of whether they would purchase or not purchase the broadband product, given its attributes and the use of the logit model is well suited for that purpose. We do not ask respondents to select one broadband option from competing options because these are respondents that are non-subscribers and currently do not obtain any utility from the service.[9] With respect to the subscriber group, we estimate conditional (fixed-effect) logistic regression models.[10] For this group, these respondents already are subscribers and are obtaining utility from broadband service and our goal is to have respondents reveal their trade-offs when selecting broadband services to estimate willingness to pay for different service attributes. We use conditional (fixed-effects) logit models for this group because we better exploit the data by asking respondents to select their *most* preferred option from three competing options and to select their *least* preferred option.[11]

There are more sophisticated models that could be utilized—such as nested logit, random coefficients, and multinomial probit—that are used to address the strong assumption, in some instances, of the logit model which is the Independence of Irrelevant Alternatives (IIA) assumption. In our paper, the IIA is less likely to be a significant issue as we are estimating Subscriber and Non-Subscribes separately through different models. Assuming equal variance of the unobserved effects for Subscribers and Non-Subscribers is not unreasonable and the classic IIA problem identified in the literature—for example the choice between automobile commuting for work and the blue bus/red bus choice—is less likely to apply in this case.[12]

4. Survey

The discrete choice exercises were developed by the author with assistance and supervision of Dr. Kenneth Train and are presented in the Appendix. We selected the attributes for the discrete choice exercises for the Non-Subscriber group and the Subscriber Group based upon research that identified the most relevant attributes driving fixed and mobile broadband subscription, which included price, capacity, speed, reliability, and pre-paid *vs*. post-paid.[13] We developed a representative market package of these attributes based upon current market conditions in Mexico and the representative package formed the basis of the range of values presented to the respondent for each attribute as described in the Appendix. In addition, the SCT was interested in including policy attributes that measured the impact that equipment and training subsidies would have on broadband demand.

While we could have selected additional attributes, having too many attributes can dilute the discrete choice exercise, cause confusion on the part of the respondent who may struggle to internalize the various trade-offs amongst attributes and options and increase the number of full factorials required to ensure an efficient discrete choice exercise.[14] In general, there is an inherent trade-off and diminishing marginal benefit with additional attributes so it is important to select the most important economic factors driving consumer behaviour and, in this case, policy interest on the part of the government agency sponsoring the survey.

Each respondent (both for the Subscriber Group and the Non-Subscriber Group) was presented with five discrete choice exercise. For the Subscriber Group, the respondent was asked to select among three options, and to state which is the "most preferred" option, and which is the "least preferred" option. The selection of the most preferred option provides information on the utility of that option compared to the other two options while the selection of the least preferred option provides information on the disutility of that option compared to the other two options. In turn, each of the five discrete choice exercise generates five observations. The selection of the most preferred option provides three observations—a "one" for the selected option and two "zeros" for the two options that were not selected. We have two more data points because the least preferred option is assigned a "zero" while the option that was neither most preferred nor least preferred was assigned a "one" when compared to the least preferred option. These five observations form a "group", and we utilize the conditional logit model to estimate the parameters on this data set as discussed in the previous section.

For the Non-Subscriber Group, the respondent was asked to select whether they would subscribe to the service based on the characteristics.

[7] The use of logit and conditional logistical regression is common in the applied work on broadband demand identified in the literature review of the paper—*e.g.*, see, Liu, Prince and Wallsten (2018); Carare, McGovern, Noriega and Schwartz (2015); Švigelj and Hrovatin (2019).

[8] See Train 2003. We base a good part of the content of this section of our paper upon Chapters 2 and 3 of Train 2003.

[9] The binary choice includes the outside good or not, but no competing broadband options. This is not unreasonable as we do observe through the survey given in conjunction with the discrete choice exercise, characteristics of the non-subscribers, including whether they have a computer, non-broadband telecommunications services (such as fixed-line or mobile service) and whether they subscribe to the other broadband service. Models 3 and 4 of our Non-subscriber demand models contained below, contain this information so that we are able to estimate likelihood of subscription, contingent upon these competing options.

[10] See Greene (2018, chapter 18) for a discussion on conditional logit models.

[11] Each scenario that the respondent views and select from allows us to better understand the trade-offs that the individual makes and increases our overall sample size. A conditional (fixed-effects) logistic regression model is well suited for this purpose and permits us to control for individual heterogeneity that is important in utility maximization.

[12] See Train 2003 chapter 3 for a discussion on the blue-bus/red-bus conundrum. The use of more sophisticated models would add a significant level of complexity to the analysis. While the generalized extreme value models—such as Nested Logit, mixed logit, and multinomial probit—can address the IIA weakness of logit models the selection criteria to adopt one of these models is not well established and raise robustness issues among competing models. Moreover, as discussed in Louviere et al. (2010) the use of more sophisticated models at times can impact an ideal design choice exercise and attribute level, as in the case of the nested logit model, and determining the optimal "tree and branch" design that is mapped to the choice exercises. The purpose of the study was to model Subscribers and Non-Subscribers differently to address specific policy questions of the regulator and as such did not lend itself to be developed with more sophisticated model in mind.

[13] The pre-paid vs. post-paid attribute was selected given the importance that pre-paid has for telecommunications demand in Mexico and in other developing economies.

[14] See Louviere et al. (2010), Chapter 5.

If the respondents stated yes, they were assigned a "one" and if they responded no, they were assigned a "zero". In this way, we have only one observation for each of the five discrete choice exercises, unlike for the Subscriber Group. We then utilized a logit model to estimate the parameters on this data set.

The SCT contracted with Ipos to undertake a survey and to administer the discrete choice exercises.[15] Ipos administered the survey and the discrete choice exercises to 15,000 women and men in Mexican households across all the socio-economic and geographic (Mexican states) strata.[16] The survey and discrete choice exercises were administered face-to-face, unlike many of the surveys we found in the literature that were administered through web-based surveys and in some cases based upon "cold-calling" of the individual. Ipsos administered the survey and discrete choice exercise over a one-month period in 2015. Ipsos calculated a sample margin of error of 0.79% at a 95 percent confidence interval, pertaining to the individual questions in the survey consisting of individual's responses to topics including whether the individual and the household are subscribers of broadband services, types of broadband services, market share of companies providing broadband services, typical uses of broadband services, monthly cost of the broadband service, and socio-economic status.

The sample selection for the urban areas consisted of use of disaggregated Mexican census data that identifies Mexican states, counties, census blocks, street blocks and households within the street blocks. Ipsos utilized a randomized selection criteria identifying four households at the individual street block level. Once Ipso identified the household, Ipso asked the responding individual basic questions to identify whether the individual was knowledgeable about the general telecommunications and broadband services consumed by the individual and the household. Ipsos followed a similar process for the rural areas but with different census block information applicable to the rural areas of Mexico. The urban areas constituted approximately 78% of the sample, with the rural area accounting for the remaining 22% of the entire sample.

5. Fixed broadband demand

5.1. Fixed broadband non-subscribers

The discrete choice exercise for non-subscribers of fixed broadband has six attributes: (1) *broadband price*, we expect price to be negatively related to the probability of selection (value of the attributes are in Mexican pesos); (2) *speed*, we constructed a variable "1/seconds" indicating the speed of downloading in seconds and we expect the coefficient to be positive ;[17] (3) *form of payment*, we assign a "1″ to "post-paid" and "0″ to "pre-paid"; (4) *equipment acquisition option*, we use three dummy variables: "equipment_free" we assign a "1″ if company provides free equipment and "0″ if equipment is not free and we expect a positive coefficient; "equipment_dis." we assign a "1″ if the equipment is discounted and a "0″ for no discounted equipment and we expect a positive coefficient; "no_equipment" we assign a "1″ if the supplier does not offer equipment and a "0″ if not the case, and we expect a negative coefficient; (5) *training sessions*, "Training" we assign a value of "0″ if the supplier offers training sessions or tutorials to learn to use the internet and a value of "1″ if not, and (6) *reliability*, we constructed a variable "reliability" in the following manner: always able to connect (we assigned a value of "4″), cannot connect one time per week (value of "3″), cannot connect 2 times per week (value of "2″) and cannot connect 3 times per week (value of "1″). We expect the sign to be positive.

We also control for several socioeconomic variables such as gender, age, years of schooling, income, and geographic variables such as the region of the country where the respondent resides as well as whether the town where they live is urban or rural. There are nine regions of the country according to their socioeconomic characteristics. The Mexican states that each region includes are :[18]Region 1: Baja California, Baja California Sur, Sinaloa, Sonora, Region 2: Coahuila de Zaragoza, Chihuahua, Durango, Region 3: Nuevo León, Tamaulipas, Region 4: Aguascalientes, San Luis Potosí, Zacatecas, Region 5: Colima, Guanajuato, Jalisco, Michoacán de Ocampo, Nayarit, Region 6: Distrito Federal, Hidalgo, México, Morelos, Puebla, Querétaro, Tlaxcala, Region 7: Tabasco, Veracruz de Ignacio de la Llave, Región 8: Chiapas, Guerrero, Oaxaca, Región 9: Campeche, Quintana Roo, Yucatán.

Table 1 below shows results for four model specifications. The first is the "base case" where we only include the attributes of the fixed broadband discrete choice exercise ("model 1″). The second is the base case with an interaction effect between price and "urban area" ("model 2″), to evaluate if there are significant differences between consumers in urban and rural areas. The third is the base case with additional demographic, socioeconomic factors, and regions ("model 3″) and the fourth is the same specification in "model 3″ with an interaction effect of price and "urban areas" ("model 4″).

The attributes price and reliability are statistically significant in all four models and have the expected signs. An increase in price lowers the probability that the respondent purchases the service. An increase in reliability increases the probability that the respondent will acquire the service. Receiving free equipment is statistically significant (at a 5% level) and has the correct sign in model 1 and model 2 but is not significant in models 3 or 4 where we control for the socio-economic and demographic factors. We found no evidence that consumers prefer either pre-paid or post-paid forms of payment and no evidence that providing training sessions increases the probability of purchasing the service. We calculate the marginal effects of the service attributes.[19] An increase in reliability results in a 3.2% higher probability of purchase. A price increase of 100 pesos above the average price lowers the probability of purchase by approximately 7.7%, based on model 3, which restricts the price coefficient to be the same between urban and rural areas.

Models 3 and 4 include various socioeconomic and geographic variables as well as whether the respondent subscribes to mobile broadband and hours spent on the Internet per day, as well as whether the respondent has a desktop or a laptop. First, having mobile broadband service (variable Broadband _mobile) increases the probability of buying fixed broadband services, holding all other factors constant. Respondents who have mobile broadband service had a 9.3% higher probability of buying fixed broadband services, providing evidence of

[15] Ipsos is a global market research firm operating in Mexico and specialized in administering survey and discrete choice exercises to individuals, families, businesses and government organizations in Mexico. We worked closely with Ipsos to develop the survey instrument on behalf of the Secretariat of Communications and Transport and Ipsos administered the survey and discrete choice exercise and provided us with the raw data for us to conduct our econometric analysis.

[16] Prior to administering the survey and discrete choice exercises, Ipso conducted a pilot study on approximately 300 respondents which permitted us to econometrically estimate discrete choice models and investigate whether the pilot results conformed with prior expectation and underlying economic theory. The pilot results did not raise concerns that required any signification modifications to the attributes or the discrete choice exercise.

[17] More specifically, the three different values of the variable are "1/3 seconds (.333)", "1/15 seconds (.0667)" and "1/30 seconds (.0333)".

[18] In our econometric models, the region that is excluded is region "6" (which includes the Mexico City and the Federal District), so the results of the coefficients of the other regions must be compared with the states that make up this region (Federal District, Hidalgo, State of Mexico, Morelos, Puebla, Querétaro, Tlaxcala).

[19] Due to the non-linear nature of the logit model, the marginal effects are not constant and must be calculated at specific values of the independent variables. We use the Stata function mfx, which computes the marginal effects at average values of the independent variables.

Table 1
Logit models for fixed broadband non-subscribers.

	Model 1	Model 2	Model 3	Model 4
Price	−0.00458***	−0.005***	−0.0047***	−0.00485***
	(0.00008)	(0.0001)	(0.0001)	(0.0002)
Equipment_free	.0947*	.0923*	.074	.0739
	(0.0435)	(0.0435)	(0.0480)	(0.0480)
Equipment discount	.0347	.0336	.0395	.0393
	(0.0438)	(0.0439)	(0.0481)	(0.0481)
No equipment	−0.0102	−0.0126	−0.0312	−0.0316
	(0.0442)	(0.0442)	(0.0487)	(0.0487)
Speed	.221	.223	.241	.241
	(0.1151)	(0.1152)	(0.1268)	(0.1268)
Training	−0.0294	−0.0305	−0.0192	−0.0195
	(0.0310)	(0.0310)	(0.0341)	(0.0341)
Post-paid	−0.00236	−0.00363	−0.0297	−0.0297
	(0.0310)	(0.0310)	(0.0341)	(0.0341)
Reliability	.168***	.167***	.196***	.196***
	(0.0140)	(0.0139)	(0.0154)	(0.0154)
Price*urban		.0006***		00,022
		(0.0001)		(0.00020)
Female			.0102	.00995
			(0.0343)	(0.0343)
Urban			.00494	−0.064
			(0.0396)	(0.0737)
Indigenous			.429***	.429***
			(0.0571)	(0.0571)
Internet hours			.07***	.0698***
			(0.0121)	(0.0121)
HH_size			−0.0461***	−0.046***
			(0.0133)	(0.0133)
Income			.0533***	.0532***
			(0.0048)	(0.0048)
Income^2			−0.00056***	−0.00056***
			(0.00007)	(0.00007)
Education			.123***	.123***
			(0.0248)	(0.0248)
Education^2			−0.0055***	−0.00553***
			(0.0013)	(0.0013)
Region_1			.0169	.0167
			(0.0648)	(0.0649)
Region_2			−0.274***	−0.273***
			(0.0699)	(0.0698)
Region_3			.132*	.131*
			(0.0660)	(0.0660)
Region_4			−0.13	−0.13
			(0.0826)	(0.0827)
Region_5			−0.181***	−0.181***
			(0.0533)	(0.0533)
Region_7			−0.59***	−0.591***
			(0.0810)	(0.0811)
Region_8			−0.654***	−0.654***
			(0.0657)	(0.0658)
Region_9			−0.253**	−0.254**
			(0.0799)	(0.0799)
Age			−0.00558	−0.00564
			(0.0072)	(0.0072)
Age^2			−9.9e-05	−9.8e-05
			(0.00009)	(0.00009)
Broadband mobile			.498***	.498***
			(0.0834)	(0.0834)
Desktop			.314***	.314***
			(0.0682)	(0.0682)
Laptop			−0.175**	−0.174**
			(0.0628)	(0.0628)
_cons	.0564	.0663	−0.553**	−0.506*
	(0.0599)	(0.06)	(0.2009)	(0.2052)
N	26,385	26,385	22,010	22,010
Logliklihood	−12,722	−12,700	−10,494	−10,493

Standard errors in parenthesis, *$p<0.05$; **$p<0.01$; ***$p<0.001$.

the complementarity nature between fixed and mobile broadband services. This last result also provides some evidence that providing subsidies for mobile broadband equipment would make it more likely that a non-subscriber of fixed broadband will acquire the service. Second, an additional hour of broadband use in people's daily lives (variable Internet_hours) results in a 1.1% greater probability of acquiring the service.[20] Finally, and not surprisingly, having a desktop computer increases the probability of subscription, while having a laptop lowers the probability.

Table 2
Conditional logit models for fixed broadband subscribers by urban and rural.

	Base	Urban	Rural
Price	−0.00219***	−0.00215***	−0.00243***
	(0.00004)	(0.00004)	(0.0001)
Speed	.181**	.156*	.334
	(0.0694)	(0.0751)	(0.1824)
Post-paid	.0067	.00156	.0395
	(0.0189)	(0.0205)	(0.0493)
Reliability	.174***	.177***	.158***
	(0.0087)	(0.0094)	(0.0234)
N	53,640	45,820	7820
Logliklihood	−17,541	−15,018	−2519
Chi-sq.	3362	2804	567
r2_p	.0875	.0854	.101

Standard errors in parenthesis, *$p<0.05$; **$p<0.01$; ***$p<0.001$.

Regarding socioeconomic and demographic factors, speaking an indigenous language at home increases the probability of acquiring fixed broadband services, with a marginal effect of 7.7%. We found no difference in the probability of buying the service by gender and we found a negative but small effect of the variable "household size". Regarding this last point, the marginal effect of an increase in the number of members of the household is approximately −0.8%. The effect of age on the probability of acquiring this service is not statistically significant. The effect of income on the probability of acquiring the service is positive and non-linear, with the effect on probability increasing at a decreasing rate. The income effect increases up to a level of approximately 49,000 pesos, and from that point begins to decrease. Education is also positive and with a non-linear effect on probability, increasing until the 11th grade and then beginning to decrease.

With respect to the nine different regions in Mexico, we found significant evidence that compared to Region 6, where Mexico City is located, the probability of purchasing the service is significantly lower in the other regions. For example, holding all other factors constant, the probability of purchasing service in Region 9 is 3.9% lower than in Mexico City. Regarding urban respondents, "model 3″ and "model 4″ provide evidence that there is no statistical difference between urban and rural respondents in terms of the probability of purchasing the service, holding all other factors constant. The urban variable in both models and the price interaction variable (price* urban) in "model 4″ are not statistically significant.

Finally, the models allow us to estimate the respondents' willingness to pay for the different attributes analysed. Using model 4, we find that respondents are willing to pay approximately 40.4 pesos per month for reliability improvements—with no statistical difference between respondents in urban or rural locations. None of the other attributes are

[20] There may be unobserved factors that are correlated with the consumers choice of Internet service and their choice of the number of hours they devote to that service in a given time period thus raising concerns with respect to potential endogeneity with the variable Internet_hours. Unobserved factors correlated with consumer choice of Internet service and number of hours can be derived from a labor-supply model—labor-leisure tradeoffs—and the intrinsic factors that help determine those tradeoffs. For example, having an intrinsic factor that results in more leisure activity can also influence hours available to devote to the Internet as well as the value obtained from different Internet service choices, which would result in an upward bias in our Internet_hours variable. At the same time, however, some customer's broadband usage generates pecuniary income, which complicates the labor-leisure tradeoff and the impact of unobserved factors and resulting bias. It seems reasonable to accept that the parameter estimates of Internet_hours are somewhat biased, but without a reasonable basis to estimate the direction or magnitude of the bias.

Table 3
Conditional logit models for fixed broadband subscribers by region.

	Region 1	Region 2	Region 3	Region 4	Region 5
Price	−0.00174***	−0.00194***	−0.00208***	−0.00213***	−0.00226***
	(0.0001)	(0.0002)	(0.0002)	(0.0002)	(0.0001)
Speed	−0.0934	−0.198	.122	.335	.122
	(0.2075)	(0.2620)	(0.2911)	(0.2798)	(0.1708)
Post-paid	.0815	.0153	.0151	.00996	−0.0374
	(0.0566)	(0.0705)	(0.0781)	(0.0779)	(0.045)
Reliability	.135***	.22***	.0871*	.172***	.165***
	(0.0256)	(0.0340)	(0.0352)	(0.0359)	(0.0213)
N	5750	3655	3160	3185	9155
Logliklihood	−1927	−1211	−1043	−1045	−2977
Chi-sq.	267	197	179	192	608
r2_p	.0648	.0754	.0791	.0842	.0926

	Region 6	Region 7	Region 8	Region 9
Price	−0.00223***	−0.00349***	−0.00198***	−0.00168***
	(0.00007)	(0.0002)	(0.0002)	(0.0002)
Speed	.371**	.0252	.296	−0.0879
	(0.1145)	(0.2559)	(0.3034)	(0.3651)
Post-paid	.00902	.123	−0.125	−0.121
	(0.0314)	(0.0719)	(0.0840)	(0.0990)
Reliability	.203***	.300***	.037	.0598
	(0.0144)	(0.0333)	(0.0385)	(0.0442)
N	19,855	4280	2740	1860
Logliklihood	−6477	−1248	−911	−632
Chi-sq.	1275	571	142	68.7
r2_p	.0896	.186	.0725	.0516

Region 1	Baja Cal., Baja Cal. Sur, Sinaloa, Sonora
Region 2	Coahuila, Chihuahua, Durango
Region 3	Nuevo Leon, Tamaulipas
Region 4	Aguascalientes, Zacatecas, San Luis Potosí
Region 5	Colima, Guanajuato, Jalisco, Michoacán
Region 6	Distrito Federal, Hidalgo, México, Morelos Puebla, Querétaro, Tlaxcala
Region 7	Tabasco, Veracruz
Region 8	Chiapas, Guerrero, Oaxaca
Region 9	Campeche, Quintana Roo, Yucatan

Standard errors in parenthesis, *p<0.05; **p<0.01; ***p<0.001.

Table 4
Conditional logit models for fixed broadband subscribers by income.

	Income-low	Income-medium	Income-high	Income-very_high
Price	−0.00249***	−0.00245***	−0.00211***	−0.00125***
	(0.0001)	(0.00007)	(0.0001)	(0.0001)
Speed	−0.196	.132	.267**	.435
	(0.2253)	(0.1142)	(0.1028)	(0.2518)
Post-paid	.0121	−0.0139	.0295	−0.0516
	(0.0618)	(0.0312)	(0.0280)	(0.0675)
Reliability	.0936**	.166***	.179***	.274***
	(0.0291)	(0.0144)	(0.0128)	(0.0315)
N	5115	19,995	24,445	4085
Logliklihood	−1639	−6412	−8034	−1395
Chi-sq.	388	1507	1451	137
r2_p	.106	.105	.0828	.0469

Standard errors in parenthesis, *p<0.05; **p<0.01; ***p<0.001.

statistically significant.

5.2. Fixed broadband subscribers

The discrete choice exercise for subscribers of fixed broadband has four attributes: price, speed, form of payment and reliability and the levels are the same as for the non-subscribers except for price, which has some higher values. Unlike the non-subscriber sample, we did not include the subsidy attributes for equipment and training as these respondents already have fixed broadband services.

For the fixed broadband user data, we use conditional logit models for estimating the parameters. Table 2 provides the results for the complete sample of respondents ("base" model) and then segments them by urban respondents ("urban" model) and rural respondents ("rural" model). The three models are consistent in the sense that the service attributes that are the most important for subscribers of fixed broadband services are price and reliability. Speed is an important service attribute for urban consumers but not for rural consumers. According to our model, including a post-paid or pre-paid option has no impact on the probability of selecting the type of fixed broadband service.

For the base model, consumers' willingness to pay for improved reliability is approximately $79.5 (pesos) per month, while the willingness to pay for higher speed is $82.7 (pesos) per month.[21] The differences in willingness to pay between urban and rural consumers are important. For urban consumers, the willingness to pay for greater service reliability is $82.3 (pesos) per month, while the willingness to pay for rural clients is $65.0 (pesos) per month for better reliability. Thus, urban consumers of fixed broadband are willing to pay approximately 24% more for a more reliable service than rural consumers. We also found that an increase in speed is not important for rural consumers, but it is for urban consumers who are willing to pay $72.6 (pesos) per

[21] These convert to approximately $5 per month using exchange rate current at the time of the study. By contrast, Rosston, Savage and Waldman (2010) estimate household willing to pay $20 per month for more reliable service and $45 per month for improvement in speed from slow to fast.

Table 5
Conditional logit models for fixed broadband subscribers by indigenous language.

	Indigenous	Non-Indigenous
Price	−0.00134***	−0.00224***
	(0.00016)	(0.00004)
Speed	.166	.182*
	(0.2952)	(0.0715)
Post-paid	−0.0465	.0112
	(0.0775)	(0.0195)
Reliability	.0655	.181***
	(0.0359)	(0.0090)
N	2890	50,750
Logliklihood	−999	−16,525
Chi-sq.	73.8	3322
r2_p	.0356	.0913

Standard errors in parenthesis, *$p<0.05$; **$p<0.01$; ***$p<0.001$.

while for households that do not speak an indigenous language, in addition to price, reliability and speed were also important.

Finally, in Table 6 below, the results are broken down by educational level. The categories are "no high school diploma" ("No_HS" model), full high school ("HS" model), technical schooling ("Technical" model), undergraduate degree ("College" model) and postgraduate degree ("Post-College"). The service attributes that are statistically significant for all educational levels are price and reliability. For respondents who did not complete high school, the willingness to pay for greater reliability is $56 (pesos) per month. For people with complete high school, the willingness to pay is $81 (pesos) per month. For people with a technical diploma, the willingness to pay is $148 (pesos) per month. Likewise, for people with a degree, the willingness to pay for greater reliability is $131 (pesos) per month, and for people with a postgraduate degree, the willingness to pay is $722 (pesos) per month.[22] The willingness to pay increases as the educational level increases. Speed is an important service attribute for people with a technical diploma (willingness to pay 294 pesos per month) and for people with a bachelor's degree (willingness to pay 330 pesos per month).

Table 6
Conditional logit models for fixed broadband subscribers by education.

	No H.S.	H.S.,	Technical	College	Post-College
Price	−0.00253***	−0.00211***	−0.0022***	−0.00151***	−0.00054
	(0.00007)	(0.00007)	(0.00015)	(0.0001)	(0.0005)
Speed	.094	.101	.646**	.498*	.200
	(0.1116)	(0.11084)	(0.2499)	(0.2006)	(0.8863)
Post-paid	.00318	.0337	.00925	−0.0254	−0.216
	(0.0302)	(0.0305)	(0.0692)	(0.0530)	(0.2535)
Reliability	.142***	.171***	.325***	.198***	.39**
	(0.0138)	(0.0141)	(0.0324)	(0.0245)	(0.12105)
N	21,450	20,680	4080	6425	290
Logliklihood	−6850	−6788	−1323	−2187	−97.9
Chi-sq.	1673	1246	279	231	12
r2_p	.109	.0841	.0954	.0501	.0576

Standard errors in parenthesis, *$p<0.05$; **$p<0.01$; ***$p<0.001$.

month more.

In Table 3 below, we provide a more detailed breakdown of the results by geographic area of Mexico based on the nine regions of the country. Price and reliability were statistically significant in most of these regions, except for regions 8 and 9. The willingness to pay for an increase in reliability varies considerably in different parts of Mexico. For example, $77.6 (pesos) per month in Region 1, $91 (pesos) per month in Region 6, and $86 (pesos) per month in Region 7—note how Region 6, where Mexico City is located, contains the highest willingness to pay for reliability of this sample of regions.

We estimate models by income category (see Table 4 below). There are seven widely used income categories in Mexico: AB (highest income category), C +, C, C-, D +, D and E (lowest income category). For our analysis, we group these six income categories into four: (1) Low income (Income_low): categories D y E.; (2) Medium income (Income_medium): categories C- y *D*+; (3) High income (Income_high): categories C y C+.; (4) Very high income (Income_vhigh): categories AB.

Price and reliability were statistically significant in all four categories, and an increase in speed causes a statistically significant increase in the probability of purchase in the "Income_high" model. The willingness to pay for greater reliability for the low-income group is $37.6 (pesos) per month, approximately $68 (pesos) per month for the medium income level, $85 (pesos) per month for the high-income group, and $219 (pesos) per month for the very high-income group. Regarding speed, the willingness to pay for a higher speed for the high-income level was $127 (pesos) per month, while for the other income levels it was not statistically significant.

Below we break down the results considering if the respondent speaks an indigenous language in the home (see Table 5 below). For the indigenous respondents, only price was an important service attribute

6. Mobile broadband demand

6.1. Mobile broadband non-subscribers

The discrete choice exercise for non-subscribers of mobile broadband has the same six attributes that we used for non-subscriber of fixed broadband plus an additional attribute for monthly data allotment in the plan: capacity (data).[23] We expect the sign for capacity (data) to be positive, as the capacity allotted in the plan increases so should the probability of selection. We control for the same socioeconomic and geographic variables that we used in our fixed broadband demand analysis in the previous section. We have estimated four model specifications. The first is the "base case" with only attributes of the mobile broadband discrete choice exercise ("model 1″). The second is the base case with an interaction effect between price and urban respondent ("model 2″), to evaluate if there are significant differences between consumers in urban and rural areas. The third model is the base case with additional demographic and socioeconomic factors ("model 3″) and the last model is model 3 with the interaction effect of price and urban respondent ("model 4″). The results of our logit models for mobile broadband non-subscribers are below in Table 7.

Price, capacity (data), no equipment, speed and reliability are the

[22] This last result should be viewed in the context that the simple size for this group was relatively small, with only 290 observations.

[23] We also have slightly different speed attributes. The three different values of the variable are "1/3 s (.333)", "1/30 s (.0333)" y "1/60 s (.0166)".

Table 7
Logit models for mobile broadband non-subscribers.

	Model 1	Model 2	Model 3	Model 4
Price	−0.00368***	−0.00425***	−0.00386***	−0.00455***
	(0.000058)	(0.000086)	(0.000068)	(0.00014)
Capacity (data)	.00681***	.00677***	.00602**	.00602**
	(0.0019)	(0.00193)	(0.00228)	(0.00229)
Post paid	−0.00169	−0.00222	−0.0243	−0.0231
	(0.0261)	(0.0261)	(0.0309)	(0.0309)
Equipment free	−0.0158	−0.0154	−0.0326	−0.0321
	(0.0367)	(0.0368)	(0.0436)	(0.0436)
Equipment discount	.0139	.0142	.00557	.00501
	(0.0366)	(0.0367)	(0.0433)	(0.0433)
No equipment	−0.0895*	−0.091*	−0.151***	−0.151***
	(0.0368)	(0.0369)	(0.0436)	(0.0436)
Speed	.227*	.227*	.374***	.377***
	(0.0892)	(0.0893)	(0.1058)	(0.1059)
Training	−0.0335	−0.034	−0.042	−0.0413
	(0.0261)	(0.0261)	(0.0309)	(0.0309)
Reliability	.156***	.157***	.183***	.183***
	(0.0117)	(0.0117)	(0.01389)	(0.0139)
Price*urban		.00076***		.00091***
		(0.000078)		(0.00016)
Female			−0.0644*	−0.0649*
			(0.0310)	(0.0310)
Urban			−0.0167	−0.313***
			(0.0376)	(0.06408)
Indigenous			.318***	.318***
			(0.0559)	(0.05625)
Internet hours			.0605***	.0597***
			(0.0095)	(0.00949)
HH size			1.1e-07	.00034
			(0.0120)	(0.0121)
Income			.0388***	.0388***
			(0.00398)	(0.00397)
Income^2			−0.00031***	−0.00032***
			(0.000045)	(0.000045)
Education			.133***	.135***
			(0.02366)	(0.02372)
Education^2			−0.00726***	−0.00734***
			(0.00119)	(0.001196)
Region_1			−0.0214	−0.0192
			(0.0570)	(0.0571)
Region_2			−0.273***	−0.272***
			(0.06205)	(0.061996)
Region_3			−0.0284	−0.0265
			(0.0623)	(0.06203)
Region_4			.0535	.0661
			(0.0700)	(0.0704)
Region_5			−0.328***	−0.328***
			(0.0488)	(0.0488)
Region_7			−0.48***	−0.485***
			(0.0643)	(0.0646)
Region_8			−0.601***	−0.601***
			(0.0627)	(0.062896)
Region_9			−0.172*	−0.168*
			(0.07815)	(0.07821)
Age			.0101	.0098
			(0.0072)	(0.0072)
Age^2			−0.00023*	−0.00023*
			(0.00009)	(0.00009)
Broadband fixed			.117**	.118**
			(0.0382)	(0.03817)
Tablet			.0464	.045
			(0.0381)	(0.0381)
Smartphone			.283***	.286***
			(0.03406)	(0.0341)
_cons	.0042	.0107	−1.04***	−0.834***
	(0.0513)	(0.0514)	(0.19389)	(0.19747)
N	34,655	34,655	25,075	25,075
Logliklihood	−17,649	−17,600	−12,594	−12,577

Standard errors in parenthesis, *$p<0.05$; **$p<0.01$; ***$p<0.001$.

Table 8
Conditional logit models for mobile broadband subscribers by urban and rural.

	Base	Urban	Rural
Price	−0.00157***	−0.00164***	−0.00128***
	(0.000063)	(0.00007)	(0.00014)
Speed	.103	.0649	.287
	(0.1341)	(0.1486)	(0.3132)
Capacity (data)	.00763**	.00882**	.00295
	(0.00293)	(0.0033)	(0.0066)
Post-paid	−0.0239	−0.051	.091
	(0.0394)	(0.0441)	(0.0885)
Reliability	.117***	.117***	.117**
	(0.01806)	(0.0199)	(0.0432)
N	12,290	9945	2345
Logliklihood	−4032	−3239	−788
Chi-sq.	745	650	104
r^2_p	0846	.0911	.0617

Standard errors in parenthesis, *$p<0.05$; **$p<0.01$; ***$p<0.001$.

attributes that are statistically significant in all four models and have the expected signs. An increase in the price and having to bring one's own mobile equipment ("No equipment") lowers the probability that the respondent would buy the service. Increases in capacity, speed and reliability increase the probability that the respondent would purchase the service. Using model 4, we calculate the marginal effects of the service attributes. The marginal effects imply that: higher speed results in a 6.8% increase in the probability of purchase, greater reliability results in a 3.3% increase in the probability of purchase and an additional 10 GBs of capacity results in an increase of approximately 1.1% in the probability of purchase. When the provider does not provide the equipment, it results in a 2.7% reduction in the probability of purchase. An increase of 10 pesos per month (respondents in rural areas) results in a reduction in the probability of purchase of 0.8%.

We did not find evidence that consumers prefer pre-paid or post-paid options or that providing subsidies for mobile broadband equipment makes it more likely that non-subscribers of mobile broadband will acquire the service as the variables "Equipment_free" and "Equipment_dis." were not statistically significant. We did not find evidence that providing training sessions to non-mobile broadband subscribers would make it more likely that they would acquire the service.

Models 3 and 4 include various socioeconomic and geographic variables as well as whether the respondent has fixed broadband and hours spent on the Internet per day, as well as whether the respondent has a desktop computer or a laptop. First, having fixed broadband service (variable "Broadband_fixed") increases the probability of subscribing to mobile broadband services, holding all other factors constant, once again confirming the complementary nature of fixed and mobile broadband that we found in the previous section on fixed broadband demand. Respondents who have fixed broadband service had a 2.2% higher probability of purchasing mobile broadband services. Second, the number of hours the person spends on the Internet in their day-to-day lives (variable "Internet_hours") is statistically significant and results in a 1.1% higher probability of buying mobile broadband. Finally, and not surprisingly, having a smartphone is statistically significant and results in a nearly 5.1% increase in the probability of purchasing mobile broadband services, but having a tablet does not have a significant impact on the probability of purchase.

We again find strong evidence that speaking an indigenous language at home results in an increase in the probability of subscription, with the marginal effect being 6.1%. Women are less likely to acquire the service, with the marginal effects indicating a value of 1.2% lower in relation to men. We did not find a significant effect of the size of the home. The effect of age on the probability of purchase is not statistically significant either. The effect of income on the probability of purchasing the service

Table 9
Conditional logit models for mobile broadband subscribers by region.

	Region 1	Region 2	Region 3	Region 4	Region 5
Price	−0.00122***	−0.00212***	−0.00064**	−0.0022**	−0.00149***
	(0.0002)	(0.00026)	(0.00024)	(0.00069)	(0.00016)
Speed	−0.184	.693	−0.42	1.43	.217
	(0.4748)	(0.5083)	(0.6441)	(1.4873)	(0.3515)
Capacity (data)	.00478	.0224	−0.0172	.0559	.0182*
	(0.0103)	(0.0115)	(0.0126)	(0.0310)	(0.0076)
Post-paid	.0198	.101	.00689	.247	.0248
	(0.1352)	(0.1507)	(0.1823)	(0.4086)	(0.1015)
Reliability	.0683	.0595	.116	.071	.145**
	(0.0613)	(0.0725)	(0.0843)	(0.1911)	(0.0456)
N	1025	905	535	135	1805
Logliklihood	−348	−280	−186	−40.2	−594
Chi-sq.	39.4	89	11.6	16.4	106
r2_p	.0537	.137	.0303	.17	.0819

	Region 6	Region 7	Region 8	Region 9
Price	−0.00177***	−0.0022***	−0.00269***	−0.00074***
	(0.00009)	(0.0003)	(0.00047)	(0.0002)
Speed	.147	.0477	.0862	−0.556
	(0.1919)	(0.6913)	(0.7958)	(0.4851)
Capacity (data)	.00395	.0213	.0139	.00074
	(0.0043)	(0.0134)	(0.0176)	(0.0105)
Post-paid	−0.0513	−0.161	−0.124	.0397
	(0.0573)	(0.1881)	(0.2432)	(0.1418)
Reliability	.154***	.344***	.159	−0.0822
	(0.02645)	(0.0942)	(0.1062)	(0.0627)
N	6030	555	415	885
Logliklihood	−1937	−169	−125	−308
Chi-sq.	448	59.4	47.3	17.4
r2_p	.104	.149	.159	.0274

Region 1	Baja Cal., Baja Cal. Sur, Sinaloa, Sonora
Region 2	Coahuila, Chihuahua, Durango
Region 3	Nuevo Leon, Tamaulipas
Region 4	Aguascalientes, Zacatecas, San Luis Potosí
Region 5	Colima, Guanajuato, Jalisco, Michoacán
Region 6	Distrito Federal, Hidalgo, México, Morelos Puebla, Querétaro, Tlaxcala
Region 7	Tabasco, Veracruz
Region 8	Chiapas, Guerrero, Oaxaca
Region 9	Campeche, Quintana Roo, Yucatan

Standard errors in parenthesis, *$p<0.05$; **$p<0.01$; ***$p<0.001$.

Table 10
Conditional logit models for mobile broadband subscribers by income.

	Income_low	Income_medium	Income_high	Income_vhigh
Price	−0.00179***	−0.00161***	−0.00152***	−0.00129***
	(0.00018)	(0.00011)	(0.00009)	(0.00022)
Speed	.176	.0441	.0532	.253
	(0.3746)	(0.2205)	(0.2086)	(0.4688)
Capacity (data)	.00722	.0105*	.00474	.0139
	(0.0079)	(0.00498)	(0.0044)	(0.0107)
Post-paid	.0368	−0.0457	−0.0376	.0512
	(0.1080)	(0.0669)	(0.05996)	(0.1372)
Reliability	−5.0e-05	.13***	.142***	.138*
	(0.0487)	(0.0308)	(0.0275)	(0.0631)
N	1715	4345	5295	935
Logliklihood	−550	−1421	−1740	−313
Chi-sq.	128	272	316	43.4
r2_p	.104	.0873	.0832	.0648

Standard errors in parenthesis, *$p<0.05$; **$p<0.01$; ***$p<0.001$.

Table 11
Conditional logit models for mobile broadband subscribers by indigenous language.

	Indigenous	Non-Indigenous
Price	−0.00055**	−0.00169***
	(0.00018)	(0.000067)
Speed	.36	.0837
	(0.4366)	(0.1414)
Capacity (data)	−0.00193	.00896**
	(0.0101)	(0.0031)
Post-paid	−0.0245	−0.022
	(0.1285)	(0.0415)
Reliability	.0515	.126***
	(0.0559)	(0.0191)
N	1115	11,175
Logliklihood	−394	−3620
Chi-sq.	10.7	769
r2_p	.0134	.096

Standard errors in parenthesis, *p<0.05; **p<0.01; ***p<0.001.

vary according to the location of the respondent, whether in an urban or rural location, and we find that rural respondents have a higher price coefficient (in absolute terms) than urban consumers, which means that they are more "sensitive" to price than urban consumers.[26]

Finally, the models allow us to estimate respondents' willingness to pay for the different attributes of the services and we find that urban consumers' willingness to pay is higher.[27] Using model 4, we find that respondents in rural areas are willing to pay approximately $40 (pesos) per month for reliability improvements, $83 (pesos) per month for higher speed, and $1.3 (pesos) per month for each GB of additional capacity. In urban areas respondents are willing to pay approximately $50 (pesos) per month more for improvements in reliability (a difference of approximately 20% compared to rural consumers), $104 (pesos) per month more for increases in speed (a difference of approximately 25% compared to rural consumers), and $1.65 (pesos) per month more for each additional GB of capacity (a difference of approximately 25% compared to rural consumers).

Table 12
Conditional logit models for mobile broadband subscribers by education.

	No HS	HS	Technical	College	Post-College
Price	−0.0015***	−0.00169***	−0.00137***	−0.00149***	−0.00357*
	(0.000098)	(0.0001)	(0.00026)	(0.00017)	(0.0014)
Speed	.158	−0.00419	.467	.11	1.39
	(0.2087)	(0.2180)	(0.608)	(0.3587)	(2.788)
Capacity (data)	.0017	.0149**	.0169	.00191	.00595
	(0.0046)	(0.0047)	(0.0148)	(0.0077)	(0.0453)
Post-paid	.00306	−0.0806	−0.0675	.00056	.583
	(0.0613)	(0.06397)	(0.1869)	(0.10596)	(0.8507)
Reliability	.0759**	.107***	.115	.262***	.536
	(0.028)	(0.029)	(0.0926)	(0.0491)	(0.3361)
N	5000	4805	555	1700	65
Logliklihood	−1656	−1558	−183	−553	−17.2
Chi-sq.	272	329	32	111	12.1
r2_p	.076	.0954	.0805	.0915	.26

Standard errors in parenthesis, *p<0.05; **p<0.01; ***p<0.001.

is positive and non-linear, increasing but at a decreasing rate. The income effect increases to a level of approximately 60,625 pesos and from there it begins to decrease.[24] The probability of purchase increases to grade 9.2, and from there it begins to decrease.

As noted above, in terms of geography, we divided the country into nine regions.[25] We find strong evidence that compared to the central region of Mexico (region 6 where Mexico City is located) the probability of purchasing the service is significantly lower in regions 1 to 5, and 7 to 9 (the only exception being region 4, which is not statistically significant at the 5% level). For example, holding all other factors constant, the probability of buying the service in region 1 is 3.5% lower and in region 2 it is 4.6% lower. With respect to respondents in urban-rural areas, model 3 provides evidence that there is no statistical difference between urban and rural respondents in terms of the probability of purchasing the service, holding all other factors constant. The urban variable is negative, but it is not statistically significant at the 5% level. In model 4, we interact the urban variable with price to allow the price coefficient to

6.2. Mobile broadband subscribers

The discrete choice exercise for subscribers of mobile broadband has five attributes: price, speed, capacity (data), form of payment and reliability and the attribute levels are the same as for the non-subscribers except for price, which has some higher values. We did not include the subsidy attributes for equipment and training as this sample of respondents already have mobile broadband services and our objective was not to determine what types of features would make it more likely for a non-user to become a user.

For the mobile broadband user data, we use conditional logit models for estimating the parameters. Table 8 below presents the results when we specify a model that contains the five attributes in a base case and then separated by urban and rural areas.

All three models are consistent in that there are two service attributes that are most important to subscribers of mobile broadband services: price and reliability. Likewise, capacity is an important service attribute for urban respondents but not for rural respondents. According to our model, higher speeds have no impact on the probability of selecting the mobile broadband service. Similarly, post-paid or pre-paid has no impact on the probability of selecting the mobile broadband service.

For the "base model", the willingness of consumers to pay for greater service reliability is $75 (pesos) per month, while the willingness to pay

[24] We measure income in thousands of pesos. The effect of income is f (x) = 0.0388 * income - 0.00032 * income ^ 2, differentiating f (x) with respect to income, equating the equation to zero and solving for "y" results in approximately 60,625 pesos.

[25] Region 1: Baja California, Baja California Sur, Sinaloa, Sonora Region 2: Coahuila de Zaragoza, Chihuahua, Durango Region 3: Nuevo León, Tamaulipas Region 4: Aguascalientes, San Luis Potosí, Zacatecas Region 5: Colima, Guanajuato, Jalisco, Michoacán de Ocampo, Nayarit Region 6: Distrito Federal, Hidalgo, México, Morelos, Puebla, Querétaro, Tlaxcala Region 7: Tabasco, Veracruz de Ignacio de la Llave Region 8: Chiapas, Guerrero, Oaxaca Region 9: Campeche, Quintana Roo, Yucatán.

[26] The urban price coefficient is "−0.00455 + 0.00091", while the rural price coefficient is −0.00455.

[27] We calculate willingness to pay by dividing the coefficient of the service attribute by the coefficient of the price on a monthly basis.

for additional GBs of capacity is $4.9 (pesos) per month (approximately 50 pesos per month for an additional 10 GB of capacity). Differences in willingness to pay between urban and rural consumers are important. For urban consumers, the willingness to pay for improvements in service reliability is $71 (pesos) per month, while for rural consumers the willingness to pay for improvements in service reliability is $91 (pesos) per month. In other words, rural mobile broadband consumers are willing to pay approximately 25% more for a more reliable service than are urban consumers.

In Table 9 below, we provide a breakdown of the results by the nine geographic areas of Mexico. The only attribute of the service that is statistically significant for all nine regions is price. Reliability is important in only regions 5, 6, and 7 while capacity is an important service attribute only in region 5. As an example, the willingness to pay for an increase in reliability in the Region 5 of the country is $97 (pesos) per month while in Region 6 it is approximately $87 (pesos) per month.

We estimate models by income category (see Table 10 below). We use the same four categories as above in our fixed broadband demand models. The only attribute of the service that is statistically significant for all income levels is price. Reliability is an important service attribute in three of the four income categories. Only the lowest income category does not consider reliability as an important attribute. Capacity is an important service attribute only in medium income levels (at 5% statistical significance) where these respondents are willing to pay $6.5 (pesos) per month for additional GBs of capacity. The willingness to pay for greater reliability for the medium income level is approximately $81 (pesos) per month, for the "high" income level it is approximately $93 (pesos) per month and for the very high-income level is approximately $107 (pesos) per month.

We have also estimated models by whether the respondent's household speaks an indigenous language in their home (Table 11 below). Less than 10% of respondents spoke an indigenous language and for these respondents only price was an important service attribute.

Finally, in Table 12 below we present the results broken down by the same level of education as in our fixed broadband demand models. The only attribute of the service that is statistically significant at all educational levels is price. Reliability is an important service attribute for respondents who do not have a high school degree (willingness to pay $51 (pesos) per month), those who have a high school degree (willingness to pay $63 (pesos) per month), and those who have a bachelor's degree ($175 (pesos) per month), but it is not for those with a technical or graduate degree. Having a bachelor's degree greatly increases willingness to pay for a reliable service. Capacity is an important service attribute only for respondents with a high school degree (willingness to pay $8.8 (pesos) per month per GB).

7. Conclusions and policy recommendations

We utilized stated preference data from a discrete choice exercise administered to 15,000 households and individuals in Mexico to identify the main determinants of demand for fixed and mobile broadband services for both subscribers of the services as well as non-subscribers. With respect to non-subscribers of fixed broadband, we found that the only two significant attributes are price and service reliability. We did not find evidence that subsidies in the form of free or discounted equipment or free training or tutorials, affect the probability of subscription nor that the form of payment—pre-paid *vs.* post-paid—impacts the probability of subscription. Regarding the non-subscribers of mobile broadband, we found that more of the service attributes were significant as we found that price, capacity (data allotment), download speed, service reliability and the consumer having to bring own equipment had a significant impact on the probability of subscription, with the signs as expected. We also found that rural customers are more price sensitive.

Our economic findings on non-subscribers' demand for fixed and mobile broadband services can assist policymakers with respect to what policies are more or less likely to increase adoption and the cost-effectiveness of such policies. Removing barriers to competition that leads to increased competition for broadband services will constrain prices and have the most impact on broadband uptake. Our evidence suggests that subsidies in the form of free or reduced equipment and free training sessions or tutorials are unlikely to be effective at significantly increasing adoption and are unlikely to pass a cost-benefit analysis. Subsidies that lower the price in rural areas of the country, however, are more likely to be effective at increasing penetration in the rural areas given our findings on the increased price sensitivity of rural customers.

Our findings with respect to the subscribers of fixed and mobile broadband services are varied but agree with the major findings on non-subscribers of fixed and broadband services that the two most important attributes for subscribers of fixed and mobile services are price and service reliability. Thus, our policy recommendations with respect to non-subscribers to remove barriers to competition will have spillover effects with respect to the subscriber group in the form of increased usage, additional subscriptions, and overall increases in consumer surplus.

Future research and analysis can include use of the estimated models in this paper to forecast mobile and fixed broadband services in Mexico. The parameters in the estimated models can be used in conjunction with forecasts of Mexican economic activity, inflation, changes in the prices of fixed and mobile broadband services as well as other key factors from our model. The parameter estimates for non-Subscribers can be used to forecast the changing penetration rate of fixed and mobile broadband subscribers in Mexico based upon different scenarios of the changing broadband attributes discussed in this paper.

Author statement

I certify that there are no other persons who satisfy the criteria for authorship but are not listed.

Data availability

Data will be made available on request.

Acknowledgments

This paper is based upon a consultancy project for the Mexican Secretariat of Telecommunications and Transport ("SCT") and I thank the SCT for providing the funding and the SCT team for the technical and logistical support throughout. I thank Dr. Kenneth Train for providing invaluable assistance with developing the survey instrument and the discrete choice exercises and attributes. I thank Douglas Umaña for invaluable assistance with the data analysis and modelling. All errors are my responsibility.

Appendix A

Discreet choice instruments and attributes

Fixed broadband (non-subscribers)

Imagine that you have opportunities to purchase fixed broadband access services. It is worth noting that fixed broadband access includes Wi-Fi. Each of these opportunities has different characteristics in terms of:

Price (MXN Pesos)

- ○ 725
- ○ 600
- ○ 475
- ○ 350
- ○ 225
- ○ 100

Speed

- ○ The broadband page takes 3 s to download.
- ○ The broadband page takes 15 s to download.
- ○ The broadband page takes 30 s to download.

Form of payment

- ○ Pre-paid
- ○ Post-paid

Wireless broadband equipment (phone) acquisition options

- ○ The provider offers free equipment.
- ○ The provider offers equipment at a discount.
- ○ The provider offers equipment at market prices.
- ○ The provider does not offer equipment.

Training sessions on Wireless broadband

- ○ The provider offers training sessions or tutorials to learn to use Wireless broadband.
- ○ The provider does not offer training sessions or tutorials to learn to use Wireless broadband.

Reliability

- ○ It is always possible to connect.
- ○ Cannot connect 1 time per week.
- ○ Cannot connect 2 times per week.
- ○ Cannot connect 3 times per week.

Example – DCE fixed broadband (non-user)

Price	225 pesos
Speed	The broadband page takes 3 s to download
Form of payment	Pre-paid
Equipment acquisition option	Supplier offers equipment at a discount from market prices
Reliability	Cannot connect to the Wireless broadband 1 times per week.
Training sessions	Supplier does not offer training sessions or tutorials on how to navigate the broadband

Thinking about the product that was just shown, would you acquire fixed broadband access services at the indicated price?

Yes
No

Fixed broadband (subscribers)

Imagine that you have three options for purchasing fixed broadband access services. It is worth noting that fixed broadband access includes Wi-Fi. Each of these options has different characteristics in terms of:

Price (MXN Pesos)

- ○ 900
- ○ 750
- ○ 600
- ○ 450
- ○ 300
- ○ 150

Speed

- ○ The broadband page takes 3 s to download.
- ○ The broadband page takes 15 s to download.
- ○ The broadband page takes 30 s to download.

Form of payment

- ○ Pre-paid
- ○ Post-paid

Wireless broadband equipment (phone) acquisition options

- ○ The provider offers free equipment.
- ○ The provider offers equipment at a discount.
- ○ The provider offers equipment at market prices.
- ○ The provider does not offer equipment.

Training sessions on Wireless broadband

- ○ The provider offers training sessions or tutorials to learn to use Wireless broadband.
- ○ The provider does not offer training sessions or tutorials to learn to use Wireless broadband.

Reliability

- ○ It is always possible to connect.
- ○ Cannot connect 1 time per week.
- ○ Cannot connect 2 times per week.
- ○ Cannot connect 3 times per week.

Thinking about the options you see below, which of the following would you select as the **most** preferred if you wanted to purchase new mobile broadband access services? And which of the following options would you select as the **least** preferred if you wanted to purchase new mobile broadband access services?

Example – DCE fixed broadband (subscribers)

	Option A	Option B	Option C
Price	450 pesos	300 pesos	900 pesos
Speed (Download)	3 s	30 s	3 s
Form of payment	Pre-paid	Post-paid	Pre-paid
Reliability	Always can connect	Cannot connect 2 times per week	Cannot connect 1 time per week

Wireless broadband non-subscribers

Imagine that you have opportunities to purchase mobile broadband access services. Each of these opportunities has different characteristics in terms of:

Price (MXN Pesos)

○ 900
○ 700
○ 500
○ 300
○ 200
○ 100

Speed

○ The broadband page takes 3 s to download.
○ The broadband page takes 30 s to download.
○ The broadband page takes 1 min to download.

Capacity (Data)

○ 1 GB.
○ 3 GB.
○ 5 GB
○ 10 GB
○ 15 GB
○ 20 GB

Form of payment

○ Pre-paid
○ Post-paid

Wireless broadband equipment (phone) acquisition options

○ The provider offers free equipment.
○ The provider offers equipment at a discount.
○ The provider offers equipment at market prices.
○ The provider does not offer equipment.

Training sessions on Wireless broadband

○ The provider offers training sessions or tutorials to learn to use Wireless broadband.
○ The provider does not offer training sessions or tutorials to learn to use Wireless broadband.

Reliability

○ It is always possible to connect.
○ Cannot connect 1 time per week.
○ Cannot connect 2 times per week.
○ Cannot connect 3 times per week.

Example – DCE mobile broadband (non-user)

Price	200 pesos
Speed	The broadband page takes 1 min to download
Capacity (Data)	5 GB.
Form of payment	Pre-paid
Equipment acquisition option	Supplier offers equipment at market prices
Reliability	Cannot connect to the Wireless broadband 2 times per week.

(*continued on next page*)

(*continued*)

Training sessions	Supplier does not offer training sessions

Thinking about the product that was just shown, would you acquire mobile broadband access services at the indicated price?

Yes
No

Wireless broadband subscribers

Imagine that you have three options for purchasing mobile broadband access services. Each of these options has different characteristics in terms of:

Price (MXN Pesos)

- ○ 1200
- ○ 900
- ○ 600
- ○ 450
- ○ 300
- ○ 150

Speed

- ○ The broadband page takes 3 s to download.
- ○ The broadband page takes 30 s to download.
- ○ The broadband page takes 1 min to download.

Data Capacity Allotment:

- ○ 1 GB.
- ○ 3 GB.
- ○ 5 GB
- ○ 10 GB
- ○ 15 GB
- ○ 20 GB

Form of payment

- ○ Pre-paid
- ○ Post-paid

Wireless broadband equipment (phone) acquisition options

- ○ The provider offers free equipment.
- ○ The provider offers equipment at a discount.
- ○ The provider offers equipment at market prices.
- ○ The provider does not offer equipment.

Training sessions on Wireless broadband

- ○ The provider offers training sessions or tutorials to learn to use Wireless broadband.
- ○ The provider does not offer training sessions or tutorials to learn to use Wireless broadband.

Reliability

- ○ It is always possible to connect.
- ○ Cannot connect 1 time per week.
- ○ Cannot connect 2 times per week.
- ○ Cannot connect 3 times per week.

Thinking about the options you see below, which of the following would you select as the **most** preferred if you wanted to purchase new mobile broadband access services? And which of the following options would you select as the **least** preferred if you wanted to purchase new mobile broadband access services?

Example – DCE mobile broadband (subscribers)

	Option A	Option B	Option C
Price	300 pesos	300 pesos	900 pesos
Speed (Download)	3 s	30 s	1 min
Capacity (Data)	1 GB.	3 GB.	15 GB.
Form of payment	Pre-paid	Post-paid	Pre-paid
Reliability	Cannot connect 3 times per week	Cannot connect 2 times per week	Cannot connect 1 time per week

References

Carare, O., McGovern, C., Noriega, R., Schwartz, J., 2015. The willingness to pay for broadband of non-adopters in the U.S.: estimates from a multi-state survey. Inf. Econ. Policy (30), 19–35.

Czernich, N., Falck, O., Kretschmer, T., Woessmann, L., 2011. Broadband infrastructure and economic growth. Econ. J. 121 (552), 505–532.

Glass, V., Stefanova, S.K., 2010. An empirical study of broadband diffusion in rural America. J. Reg. Econ. 38, 70–85.

Greene, W.H., 2018. Econometric Analysis, 8th ed. Pearson, New York.

Greenstein, S., McDevitt, R., 2011. The broadband bonus: estimating broadband Internet's economic value. Telecommun. Policy 35 (7), 617–632.

Ida, T., Horiguchi, Y., 2008. Consumer benefits of public services over FTTH in Japan: comparative analysis of provincial and urban areas by discrete choice experiment. Inf. Soc. 24, 1–17.

International Telecommunications Union, 2020 World Telecommunication/ICT Indicators Database 2020 (24th ed.).

Leandro, T., Gomes, V., 2019. Estimando a demanda por banda larga no brasil: uma analisis por meio de modelos de escolha discreta. Rev. Econ. Contemp. 23, 2.

Li, Y., 2019. Influence of the internet on economic growth of the belt and road region. Glob. J. Emerg. Mark. 11 (3), 248–259.

Liu, Yu-Hsin., Prince, J., Wallsten, S., 2018. Distinguishing bandwidth and latency in household's willingness-to-pay for broadband internet speed. Inf. Econ. Policy 45, 1–15.

Louviere, J.J., Hensher, D.A., Swait, J.D., 2010. Stated Choice Methods: Analysis and Applications. Cambridge University Press.

Madden, G., Suphachalasai, S., Makjamroen, T., 2015. Residential demand estimation for bundled fixed-line and wireless mobile broadband services. Appl. Econ. 47, 5045–5056.

Mendez, S., Molnar, G., Savage, S., 2021. The impacts of the lifeline subsidy on high-speed internet. J. Law Econ. 64, 4.

Nevo, A., Turner, J., Williams, J., 2016. Usage-based pricing and demand for residential broadband. Econometrica 84 (2), 411–443.

Rosston, G., Savage, S.J., Waldman, D.M., 2010. Household demand for broadband internet service. B. E. J. Econ. Anal. Policy 10, 1.

Švigelj, M., Hrovatin, N., 2019. Analysis of household broadband technology preferences in Slovenia. Eur. Bus. Rev. 9, 407–422.

Tajiri, N., 2009. A cross-country analysis of factors contributing to broadband diffusion. Stud. Reg. Sci. 39 (3), 615–628.

Train, K.E., 2003. Discrete Choice Methods with Simulation. Cambridge University Press.