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# Digital divide and the determinants of the demand for broadband Internet access in Latin America

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## PRESENTATION STRUCTURE

Literature review

How to measure the demand for internet access

Internet access in Latin America

Research question

Model

Estimation strategy

Data overview

Findings

# Literature review

## Related literature

### Internet Access Determinants

- Cava – Ferreruela and Alabau – Muñoz (2006) propose a fully specified model of demand and supply to determine how different factors affect the demand for broadband access in OECD countries. It also uses household subscription as a proxy for quantity demanded.
- Galperin and Ruzzier (2013) propose a demand estimation of household access to fixed broadband in LATAM by instrumenting the price variable and removing the endogeneity of the income variable by lagging the series by one-time period.
- Mariscal and Rivera (2006), and Balboni et al. (2011) use microdata from different LATAM countries to determine how different factors affected broadband access demand.

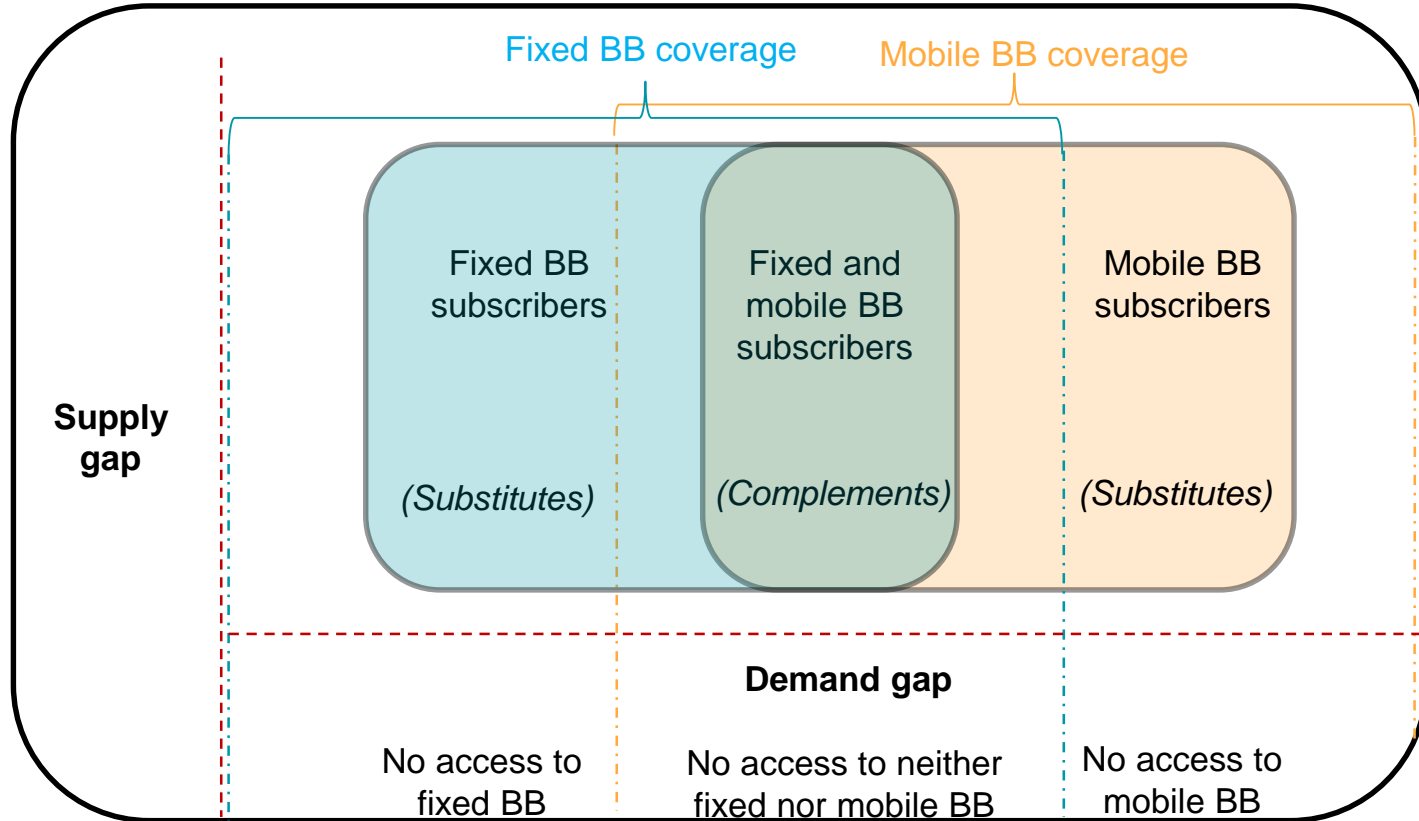
## Main contributions

This work addresses some elements of the previous literature and provides the following contributions:

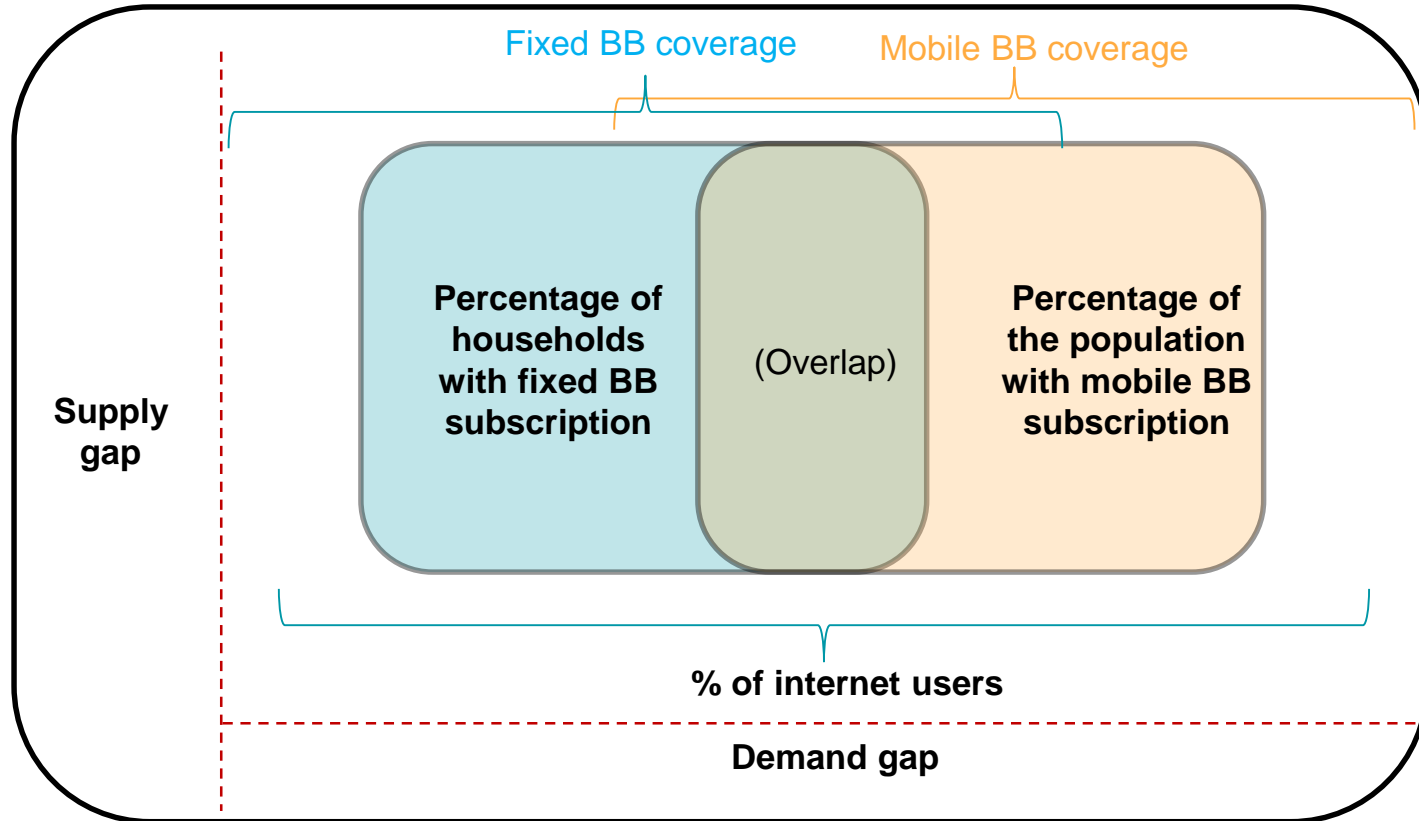
- Eliminate income endogeneity by instrumenting this variable in the estimation process.
- We use different measures of broadband access demand by including mobile broadband penetration in our analysis.
- This work also purposes a logit discrete choice model to represent the demand for internet access.

# How to measure the demand for internet access

## Fixed and mobile BB substitution and complementary



## Measurements of internet access demand

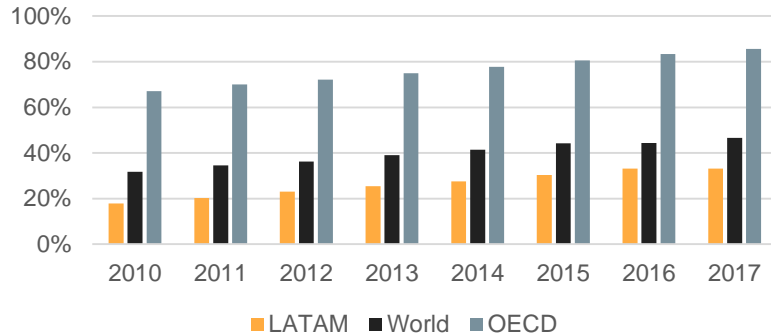




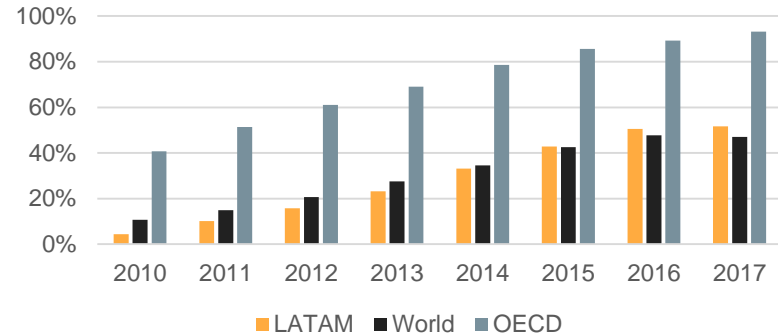
# Internet access in Latin America

# Using our three main metrics

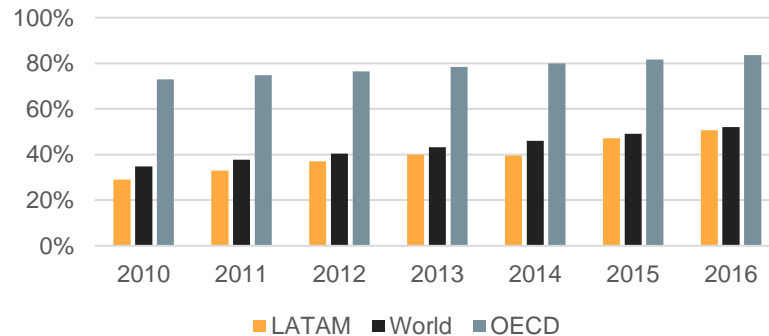
## % HH with fixed BB subs.



## % Pop. with mobile BB subs.

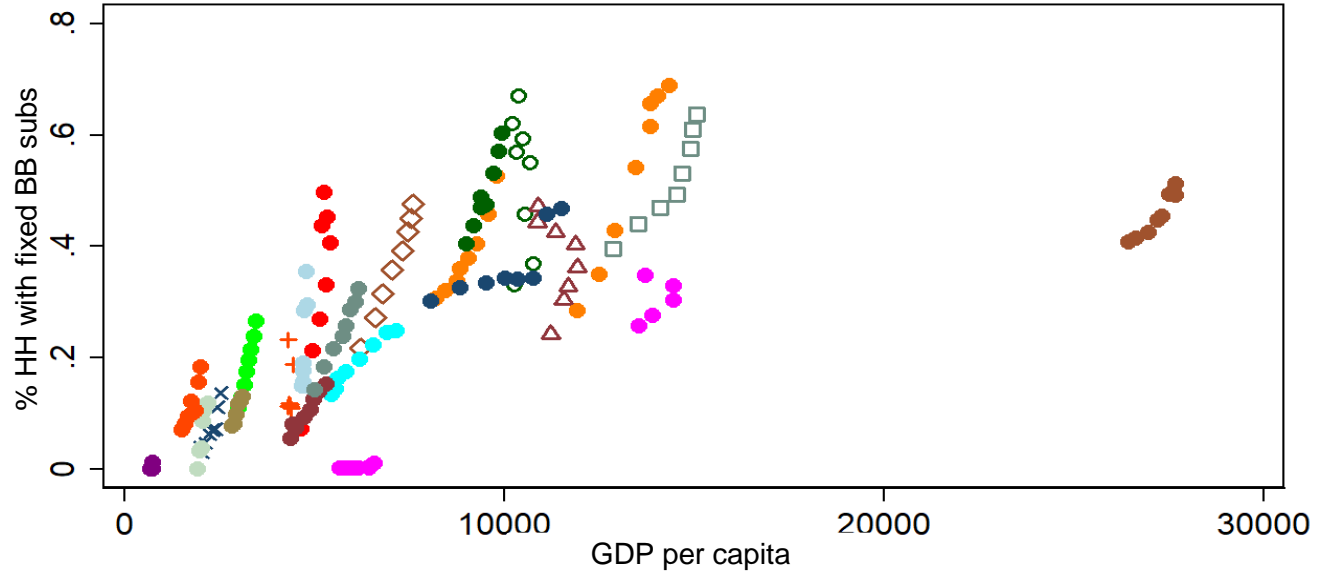


## % Internet Users



# What factors determine the demand for access to broadband internet in Latin America?

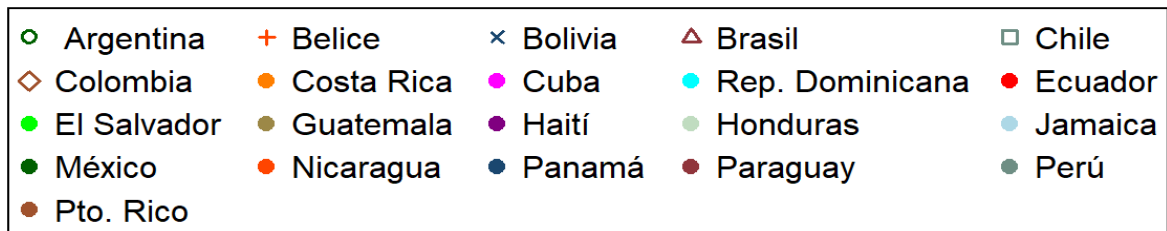
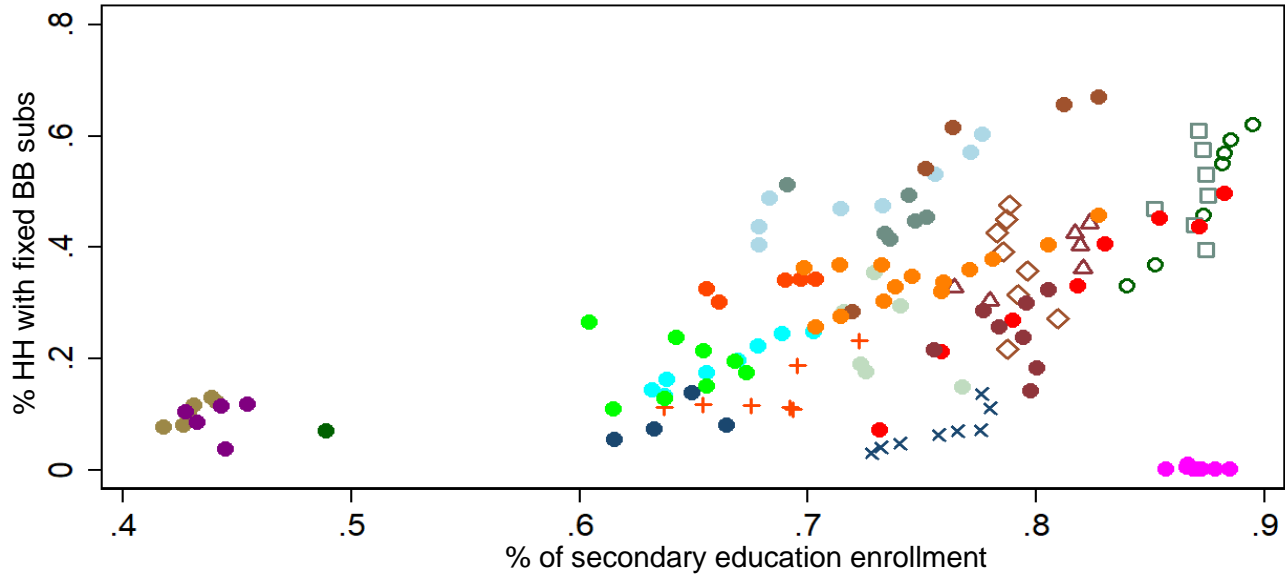
# Income?



○ Argentina	+ Belice	× Bolivia	△ Brasil	□ Chile
◇ Colombia	● Costa Rica	● Cuba	● Rep. Dominicana	● Ecuador
● El Salvador	● Guatemala	● Haití	● Honduras	● Jamaica
● México	● Nicaragua	● Panamá	● Paraguay	● Perú
● Pto. Rico				

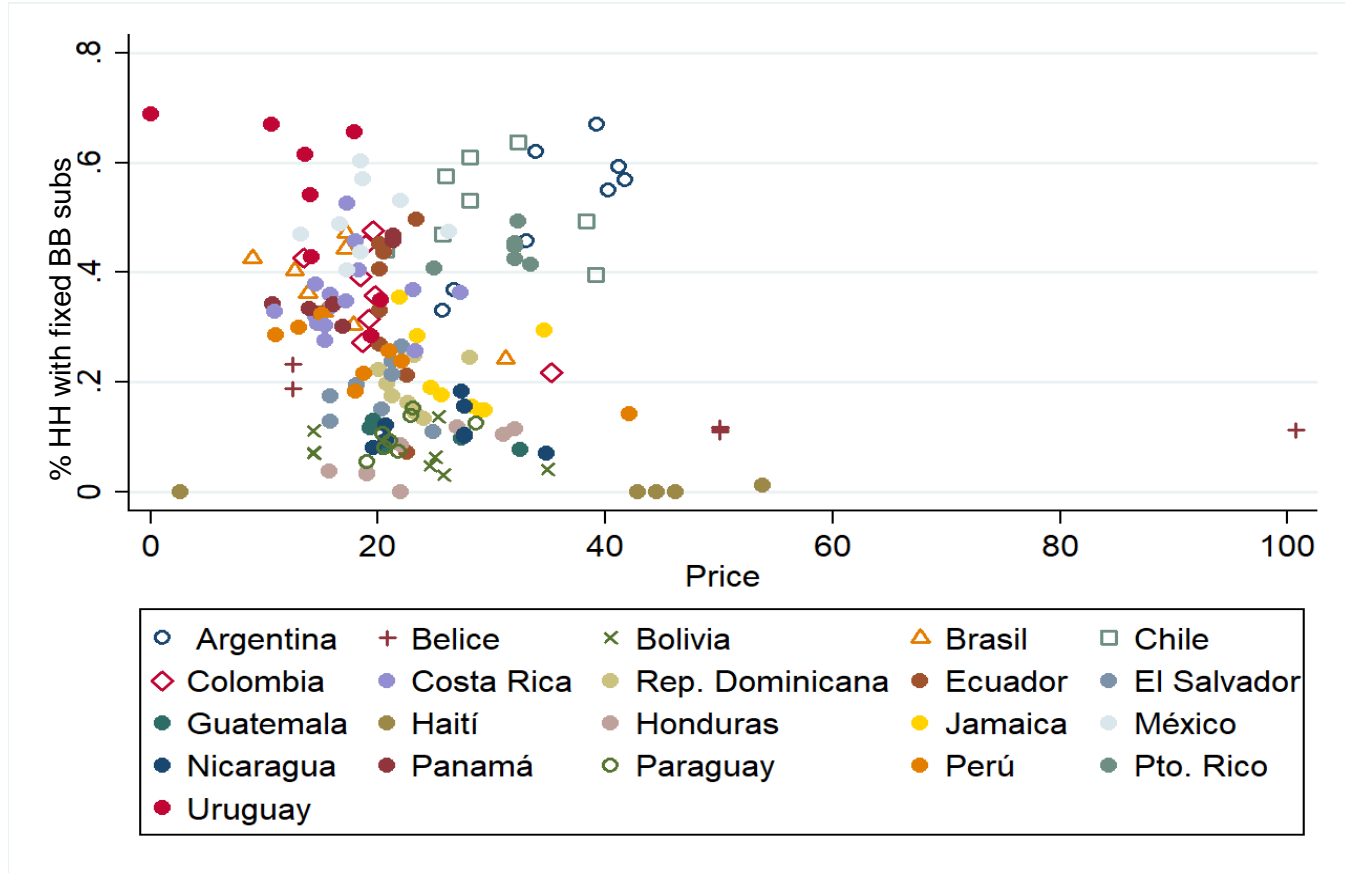
Source: ITU, World Bank.

## Education?



Source: ITU, World Bank.

# Price?



Source: ITU.

# Demand Model

## Two different approaches

### Reduced form model

- Remain agnostic about the functional form of the consumer's utility.
- Do not place assumptions on how to compute aggregated demand.

### Structural model

- Starts by assuming a specific form of the consumer's utility function.
- Construct inverse demand from the specification of the utility function.
- Provide a specific functional form for the demand function.



## Two different approaches

Reduce form model ( Two specifications)

$$Y = B' + \Gamma'W + \psi'R + E$$

$$Y = \exp(B'X + \Gamma'W + \psi'R + E)$$

Where matrix  $X$  represents product characteristics like price; matrix  $W$  represents demographic and geographic variables like education level, income level, age and percentage of rural population; matrix  $R$  represents market structure variables like regulatory framework, indirect taxes load and the existence of broadband access policies.

## Two different approaches

### Structural model ( Discrete choice demand system)

$$U_{ij} = V_{ij} + \epsilon_{ij}$$

- Individuals utility depend in observed  $V_{ij}$ , and an unobserved  $\epsilon_{ij}$  factors.
- The Unobserved factor is modeled as an i.i.d. random variable that follows a type I extreme value probability function.
- The model assesses the probability that an individual chooses to access the internet via a subscription over not access to this service.

$$U_{ij} > U_{ik} \forall k \neq j$$

$$P_{ij} = Pr(\epsilon_{ik} - \epsilon_{ij} \leq V_{ij} - V_{ik}, \forall k \neq j)$$

## Two different approaches

### Structural model ( Discrete choice demand system)

- By integrating over all consumers the model computes the probability of accessing the internet via a subscription.

$$P_j = \int I(\epsilon_k - \epsilon_j \leq V_j - V_k, \forall k \neq j) f(\epsilon) d$$

$$P_j = \frac{e^{V_j}}{\sum_k e^{V_k}}$$

## Two different approaches

### Structural model ( Discrete choice demand system)

- By dividing the probability of accessing to the internet by the probability of not accessing the internet, the model provides the odds of accessing the internet against not accessing.

$$\frac{P_j}{P_0} = \frac{\frac{e^{V_j}}{\sum_i e^{V_k}}}{\frac{e^{V_0}}{\sum_k e^{V_k}}}$$

$$\frac{P_1}{P_0} = \frac{e^{V_1}}{e^{V_0}}$$

## Two different approaches

### Structural model ( Discrete choice demand system)

- Taking logs in both sides, and by normalizing the utility of not accessing the internet to 0 the model gives the following result:

$$\log\left(\frac{P_1}{P_0}\right) = V_1$$

- By representing the observable part of the utility with the explanatory variables presented before we get:

$$\log\left(\frac{P_1}{P_0}\right) = B'X + \Gamma'W + \psi'R + \Sigma$$

# Estimation strategy

## Difficulties

**Endogeneity:** Prices and income variable endogenous with respect to the quantity of internet access demanded.

**Solution:** 2SLS estimation using instrumental variables.

## Instruments

- Exchange rate from local currency to USD.
- Proportion of the population with some secondary education.
- Proportion of the population with LTE coverage.
- Total corporate taxes collected by the government as a percentage of GDP.
- Natural logarithm of the Industry's HHI index.
- Industrial aggregated value as GDP percentage. (one period lag)
- Unemployment level
- Time trend squared

## Validity of the instruments

**Exogeneity Test:** Uses the Cragg-Donald Wald F statistic.

**Relevance Test:** Uses the Kleibergen-Paap Wald LM statistic.

**Overidentification Test:** Hansen J statistic.

Model	Exogeneity	Relevance		Overidentification	
	P-value	Statistic	Critical value at 5%	Statistic	Critical value at 5%
1	0.0000	23.34	17.7	13.709	0.0176
2	0.0017	22.658	17.7	24.092	0.0005
3	0.0000	22.658	17.7	22.229	0.0011



# Data

**Data:** 23 Latina American countries.

**Sources:** ITU WTI database 2018, ITU Regulatory Tracker, World Bank

<b>Dependent Variables</b>						
<b>Variable</b>	<b>Obs.</b>	<b>Media</b>	<b>Des. Est.</b>	<b>Min.</b>	<b>Max.</b>	<b>Fuente</b>
% of households with fixed BB subscription.	179	27.10%	18.30%	0.00%	68.80%	ITU
% of the population with mobile BB subscription.	174	30.60%	27.80%	0.00%	116.60%	ITU
% of internet users.	168	40.90%	17.10%	8.40%	83.60%	ITU
<b>Explanatory Variables</b>						
<b>Variable</b>	<b>Obs.</b>	<b>Media</b>	<b>Des. Est.</b>	<b>Min.</b>	<b>Max.</b>	<b>Fuente</b>
GDP per capita	181	7569	5765.7	662.2	27689.3	World Bank
Monthly fixed broad band subscription price	174	36.32	133.4	0	1760.4	ITU
Regulatory Tracker score	176	70.53	18.82	20	94.5	ITU
% of rural population	184	29%	15%	5%	55%	ITU
Fix broadband average speed (Mbit/s)	175	1.72	3.11	0.25	30	ITU
Dummy existence of BB access national plan	184	0.61	0.49	0	1	ITU
% of secondary education enrollment.	146	72.70%	11.90%	41.80%	89.50%	World Bank
% of population with age between 20 and 45 year.	184	40.30%	1.70%	35.90%	43.40%	World Bank
Dummy developed country	184	0.17	0.38	0	1	World Bank
<b>Instrumental Variables</b>						
<b>Variable</b>	<b>Obs.</b>	<b>Media</b>	<b>Des. Est.</b>	<b>Min.</b>	<b>Max.</b>	<b>Fuente</b>
Exchange rate form local currency to USD.	178	0.289	0.375	0	1.08	ITU
Unemployment	184	7%	4%	2%	16%	World Bank
Industry HHI index	144	4534	1782	2436	10000	ITU
Proporción de la población con educación secundaria	173	54.10%	14.60%	21.00%	87%	World Bank
Proportion of the population with LTE coverage	169	20.2%	28.9%	0.0%	96.0%	ITU
Lagged Industry Added Values as GDP %	182	29%	9%	14%	57%	World Bank
Total corporate taxes collected as percentage of GDP	152	3.20%	1.50%	0.10%	7.10%	World Bank

# Results

# Marginal effects

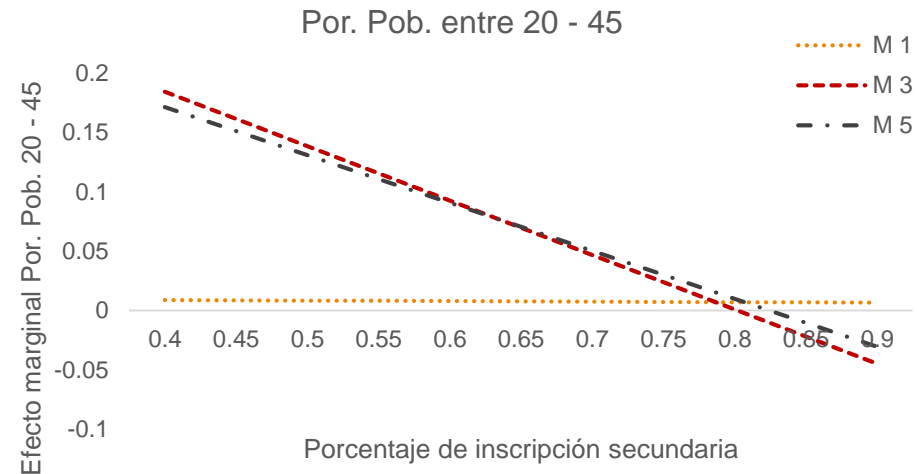
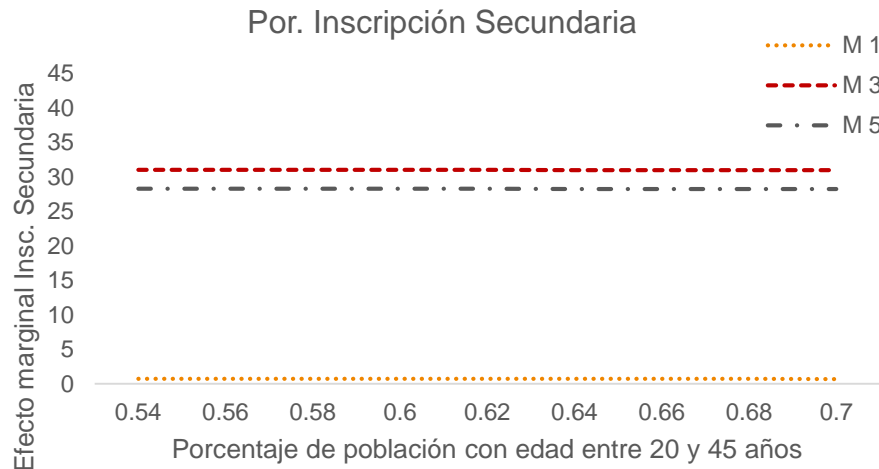
Dependent Variable	Reduce form model		Structural Model
	1	2	3
	% HH FBB	Ln(% HH FBB)	Ln(% HH FBB) - Ln(1-% HH FBB)
GDP per capita	1.07E-05*** (4.47E-06)	1.07E-05*** (4.04E-06)	1.07E-05*** (3.78E-06)
Monthly fixed broad band subscription price	-0.0019*** (2.38E-04)	-0.0052*** (4.74E-04)	-0.0040*** (3.87E-04)
Regulatory Tracker score	0.0014*** (4.97E-04)	0.0014*** (6.14E-04)	0.0014*** (5.55E-04)
% of rural population	0.1230 (0.0883)	0.2994** (0.1260)	0.2347** (0.1178)
Dummy existence of BB access national plan	-0.0173 (0.0166)	-0.0328 (0.0302)	-0.0257 (0.0270)
% of secondary education enrollment.	0.7251 (1.9400)	6.7212** (2.9468)	5.2698** (2.6194)
% of population with age between 14 and 65 year.	0.0104 (0.0245)	0.0785** (0.0377)	0.0616** (0.0335)
Interaction between education and age.	-0.0044 (0.0307)	-0.0954** (0.0462)	-0.0748** (0.0411)
Fixed broadband speed (Mbit/s)	-0.0044 (0.0307)	-0.0954** (0.0462)	-0.0748** (0.0411)
Developed countries dummy	0.1695*** (0.0175)	0.2105*** (0.0150)	0.1651*** (0.0158)
Time trend	0.0172*** (0.0029)	0.0169*** (0.0035)	0.0133*** (0.0033)
Constant	-1.8198*** (1.4810)	-7.7366*** (2.3055)	-6.0659*** (2.0348)
Observations	110	110	110
Adjusted R squared.	0.891	0.914	0.916
Standar errors in parenthesis		*** p<0.01, ** p<0.05, * p<0.1	

## Findings

- An increase in GDP per capita of USD 1,000 generates an increase of about 1.7% in the percentage of households that have a fixed broadband Internet subscription.
- A decrease of USD 10 in the price of subscription to the fixed broadband internet service, generates an increase in the percentage of households that access to this service of between 1.9% and 2.39% in models (1), and between 4.0 and 5.2% for models (2) to (3).
- Our results suggests that an improvement of a point in the Regulatory Tracker score increase the percentage of households that have a mobile broadband internet subscription in 0.14%.
- Any specification suggests that the implementation of a national plan to promote BB access or the speed of the internet have a significant impact in the demand of internet access.

## Findings

- Due to the interaction term in our specification, the magnitude and direction of the marginal effect of the population age varies depending on where it is measured.





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