Cycling to commute in the Global South: Not idiosyncrasy, but infrastructure [a]

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Abstract

The explanatory power of models can be enhanced if individual heterogeneity is addressed by the incorporation of infrastructure and idiosyncratic traits. We explore the characteristics of bike users in medium sized cities in a Latin American context. Using a Latent Class Model, our sample is divided into two classes: those exposed to better city infrastructure and those exposed to worse infrastructure. Unlike previous studies, idiosyncratic variables were not significant in this study.

Those exposed to worse infrastructure are less likely to bike if they are older or if they are women. In strike contrast, commuters facing better infrastructure are likely to bike as they age and being a woman increases the likelihood to bike. This study concentrates in the main weekday trip. The results hold across three cities: Mérida, León and Guadalajara. These medium sized cities are of particular importance, as they have the fastest growing rates, while they still have the scale to work out policies that lead to more efficient and inclusive commutes.

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1 Introduction

The promotion of biking as a way to commute is one of the best strategies to reduce congestion. Medium sized cities have the advantage of having the possibility to steer in the direction of non-motorized transportation. Unlike mega-cities that have already invested heavily in car infrastructure (Garduno Arredondo, 2013), or small cities without the institutional or financial capacity, medium sized cities can make important changes in their transportation policies that would have an impact on more than half of the urban population in the world (United Nations, 2014).

The accelerated growth of cities implies that in 2050, urban areas will host 68 % of the World's population. In Latin America and the Caribbean, 81% of the population is already urban. Small and medium cities are characterized by accelerated economic and population growth that leads to an increase in the demand for, among other things, road infrastructure, either to connect the core with the suburbs or to improve the travel time within the city (United Nations, 2014; Fahmi et al., 2014; Cohen, 2006).

Urbanization generates agglomeration economies that encourage productivity and economic growth (Bhagat, 2017; Glaeser and Gottlieb, 2009). However, urbanization also generates some disadvantages or externalities. For example: greater pollution, more traffic congestion, less space for green areas and even greater possibilities for disease transmition (Glaeser, 2014). Overall, experts claim that well managed urbanization with good information, is one of the best tools to minimize environmental degradation and maximize the benefits from agglomeration (Nations, 2018; Glaeser and Kahn, 2004).

The problem is different in rich countries than in poorer ones. Poorer cities have weaker institutions (Glaeser, 2014). In cities located at the Global South, evidence shows that a rise in income level implies the acquisition of more cars. [1] (Dargay and Gately, 1999; Han and Hayashi, 2008; Mraihi et al., 2015; Vermeiren et al., 2015; Pojani and Stead, 2015). In a recent study, researchers found that in unequal countries, such as in Latin America, the regimes promote private goods over public goods. As they conclude: "such regimes promote car dependency, transport disadvantage, and/or informal transport over strong public transport networks" Valenzuela-Levi (2018). In richer countries like the United States or Australia, the use of private car is one of the cheapest ways to commute (Hitge and Vanderschuren, 2015; Li et al., 2015).

Still, both rich and poor cities, face large costs from the use of private cars. The infrastructure that is required to use cars reaches more than $300 billion per year in the United States of America (Table 3-29 at (of Transportation Statistics, 2016)). The externalities from the use of car are costly. Some costs as due to people dying in traffic accidents (in Mexico City, 1630 people die annually due to run overs (Rodríguez-Hernández et al., 2011)). Other costs come from local air pollutants that affect human health and global air pollution that contributes to climate change. Parry et al. (2007) identify oil dependency, vulnerability to oil price volatility, and the military and geo-political costs for countries like the United States that need to allocate part of the defense budget to Middle East operations. Another cost comes from the inequality between those who use car and those who don't (Parry et al., 2007; Hill et al., 2009; Dietz et al., 2018).

Cervero (2013) studies the urban mobility challenges of the developing world and concludes that the most important strategy for cities in the Global South should focus on walking and cycling environs that are "particularly vital to the welfare and prosperity of urbanites in the world's poorest countries".

[1] Global South is a geographic term that indicates developing countries located south of Europe, US, Japan. It includes rapidly industrializing countries as India or China

According to several studies, cycling has many advantages such as being low-cost, low- pollution, health improving means of transportation(Handy et al., 2014; de Sousa et al., 2014; Schepers et al., 2015). Therefore, many cities all over the world are trying to promote cycling (Handy et al., 2014). On this regard, the literature has devoted several papers to understand what are the determinants of bicycle use (Pucher and Buehler, 2008; Pucher et al., 2010). Understanding the factors that influence the decision to commute by bike is key to the success of policies that seek to promote non-motorized transportation (de Sousa et al., 2014).

2 Literature Review

Several studies have analyzed the determinants of bike use in cities, most of them in the United States and Europe. Many of the articles devoted to understand the use of bike have analyzed the relationship between the built environment and the use of bike. Fewer articles have studied the influence of idiosyncratic variables in bike commute, but this number is growing rapidly.

There is an overwhelming number of studies in the literature that confirm that travel choice is influenced by the physical form of the urban area. Ewing and Cervero (2001) is a meta-analysis of more than fifty empirical studies, all of which consider the physical environment. A more recent compendium was released in 2010: (Ewing and Cervero, 2010).

Most of the papers agree that higher density and closeness to the core has an influence in the use of non-motorized and public transportation (Guerra, 2014; Van Wee and Handy, 2016). On the contrary, longer distances preclude the use of bike for commuting purposes(Cervero and Duncan, 2003; Cui et al., 2014). Næss (2012) analyzes a Nordic context and finds that distance to the city's main concentration of facilities, influences transportation mode: the farther, the less likely it is to use bike or public transportation.

The existence of bike lanes promotes the use of bikes (Buehler and Dill, 2016; Pucher and Buehler, 2008; Pucher et al., 2010; Heinen et al., 2010). Land mixed use and density have a positive impact on the use of bike (Pucher et al., 2011; Ewing and Cervero, 2010; Cui et al., 2014). More precisely, (Chen et al., 2008) finds that the density in the work place exerts more influence, than the density of the house neighborhood. Also, Pucher and Buehler (2008) shows that low speed traffic is also a determinant of bike use.

With similar results, in South America, Cervero et al. (2009) study the influence of road facility designs, urban densities, land use mixes and proximity to transit on walking and cycling in Bogotá. Oliva et al. (2018) consider the effect of built infrastructure in Santiago de Chile. They also divide their universe into classes according to access to different type of infrastructure (density and closeness to downtown). Interestingly, the only case where land use mix is associated with a lower use of bike is in Curitiba, Brazil (Hino et al., 2014).

Ewing and Cervero (2010) note that most studies make no effort to isolate the effects of different design features of the built environment. They explain that trying to differentiate between the different elements derives in problems of multicollinearity as most of the features of built environment are codependent.

Experts agree, that the conversion towards non-motorized transportation and public transportation and away from the car is a task with psychological, physiological, ecological and economic dimensions (Lieberoth et al., 2018; Steg, 2005). In later years we find some articles that focus in social influences to determine travel behavior (Kim et al., 2018; Walker et al., 2011; Ho and Mulley, 2015; Prillwitz and Barr, 2011).According to Heinen et al. (2010) individual factors that influence the decision to commute by bicycle can be divided into socioeconomic and psychological.

Compared with the studies focused on the influence of infrastructure, the number of studies that capture the influence from psychological factors is much lower (Zhang and Timmermans, 2010). For example Roorda et al. (2009) studies the influence of family conflict and Kim 2018 records the influence of other family members. Yet some studies have focused on the influence of attitudes or idiosyncratic variables (Hunecke et al., 2007; Heinen et al., 2011b). de Souza et al. (2014) study perceptions on the biking level. Perceived lack of safety has a strong influence on the decision to commute on bike or not.

Bohte et al. (2009) provide a definition for attitudes: “a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor". They conclude that attitudes have a significant effect on the decision to use bike to commute.

The other set of variables that has a strong influence on commute choice are socioeconomic variables. There is consensus on the fact that men are more likely to commute in bike than women (Heinen et al., 2011a, 2010; Lersch and Kleiner, 2018; Gimenez-Nadal and Molina, 2016), especially when the rates of bike use are low (Pucher et al., 2011). For Aldred et al. (2016); Garrard et al. (2012a) women are regarded as the "indicator species" to measure if a given city is bikeable. In several studies, age seems to have a negative influence on the likelihood of bike commute, especially in bike sharing programs (Fishman et al., 2013; Tech, 2012; Pucher et al., 2011; Moudon et al., 2005). However, in some cases, age is not significant (Wardman et al., 2007; Plaut, 2005). Fernández-Heredia et al. (2016) find that whites have a greater proportion of bike use in United States of America and Fishman (2016) finds the same result for bike share systems. Income is the other socioeconomic variable that seems to have an effect on bike use: Cui et al. (2014) find that income is negatively correlated with bicycle ridership, but Fernández-Heredia et al. (2016) find that income has a positive effect on bike use. Car ownership is correlated with less likelihood to bike and bike ownership has a positive influence in bike commuting (Oliva et al., 2018; Pucher et al., 2011; Fernández-Heredia et al., 2016).

Given the evidence that shows the importance of physical infrastructure and idiosyncratic variables, we analyze the sample by introducing classes or groups defined by attitudes and physical infrastructure. As the model shows, the statistical influence of physical infrastructure is stronger than the influence of the city. In other words, having access to the infrastructure of the core of any city is more important than being in Mérida, Guadalajara or León.

3 Context: Mérida, León y Guadalajara

The three cities that we analyze have been concerned about traffic congestion, pollution and the inequality derived from the proliferation of private cars (Gámez-Pérez et al., 2017; Hidalgo and Huizenga, 2013; Bertulis, 2008;

López Santillán, 2011). In an effort to promote lower car use, local governments have promoted the use of bike and public transportation.

According to Larsen (2013), Mexico is the eleventh place in number of public bike systems. Also, according to the Institute for Transportation and Policy Development, the three cities of this study are among the most bikeable cities in the Country (for Transportation and Policy, 2011). If we consider all bike lanes, shared and segregated, León has 72 Km., Guadalajara has 65 Km. and Mérida has 64 Km. Guadalajara has a public bike sharing system since 2014 (MiBici), Mérida has Bicimérida since 2011 and León is starting their bike sharing system in 2019 (Gámez-Pérez et al., 2017). In Table 1, we show frequencies of trips in private car, in transit and with non-motorized means of transportation. Guadalajara and León, have around 11% of the surveyed trips either walking or in bike. Merida has 4.5%. These percentages consider the two most important trips on weekdays. However, as biking blogs all admit: biking in Mexico is not for the faint of heart.

Table 1: Trips by Mode

	GUADALAJARA		LEON		MERIDA	
	FREQ	PERCENT	FREQ	PERCENT	FREQ	PERCENT
Private Car	159	19.9	270	22.5	144	17.9
Public Transportation	546	68.3	798	66.5	611	76.0
Bike or Walk	89	11.1	128	10.7	36	4.5
Other	6	0.8	4	0.3	13	1.6
Total	800	100	1200	100	804	100

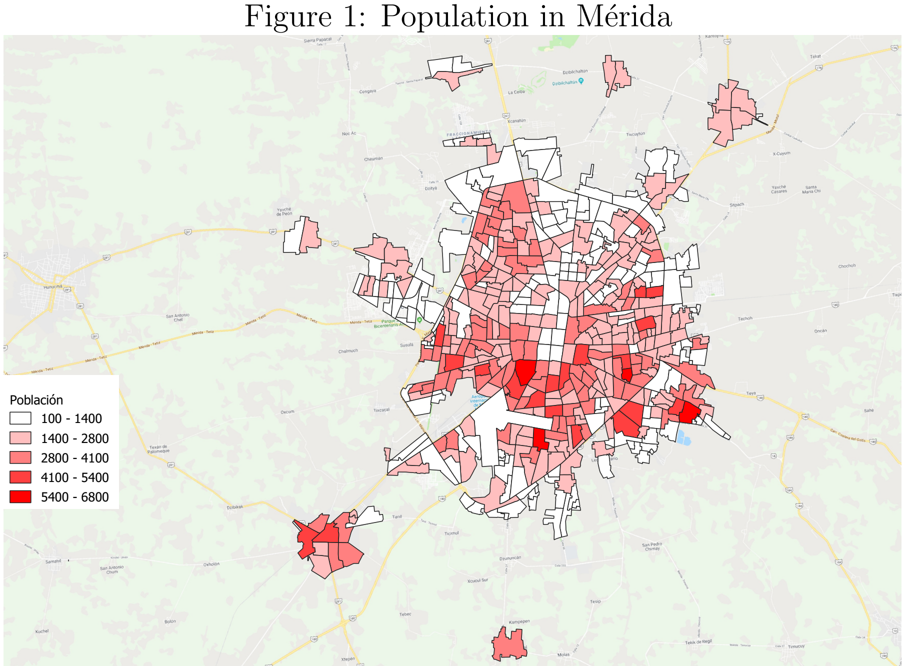
MÉRIDA

Mérida is the capital of Yucatán; it is the most important city in the Southeastern Yucatan Peninsula. Almost half of the Yucatan population lives in the metropolitan region of Mérida. In comparison with the rest of the State, people in Mérida have a higher percentage with access to social security, medical services, less percentage is illiterate, the education level is higher and the indigenous population is bilingual (Conan, 2011). Mérida is characterized by its strong Mayan influence. Unlike any other city in Mexico, in Mérida, the indigenous culture is embraced with dignity. Thus, the dressing code, the language, the food and cultural practices respond to Mayan traditions that have been alive since around 250 DC (Sharer and Traxler, 2006).

According to ONU-Habitat Mérida has one of the highest living standards in the Country (ONU Habitat, 2018). However, some experts identify strong inequalities between the core and the peripheral neighborhoods (López Santillán, 2018). The periphery has captured poor migrants from the inside of the Peninsula who come looking for opportunities. The settlements face lack of public infrastructure, uncertainty in land property rights and scarce public transportation (López Santillán, 2018, 2011).

The weather in Merida oscillates between 18 and 36 celsius degrees. The geography of the city is mostly flat. Population density is appreciated in Figure 1, as the darker districts represent more dense areas and clearer districts represent less populated areas.

Figure 1: Population in Mérida

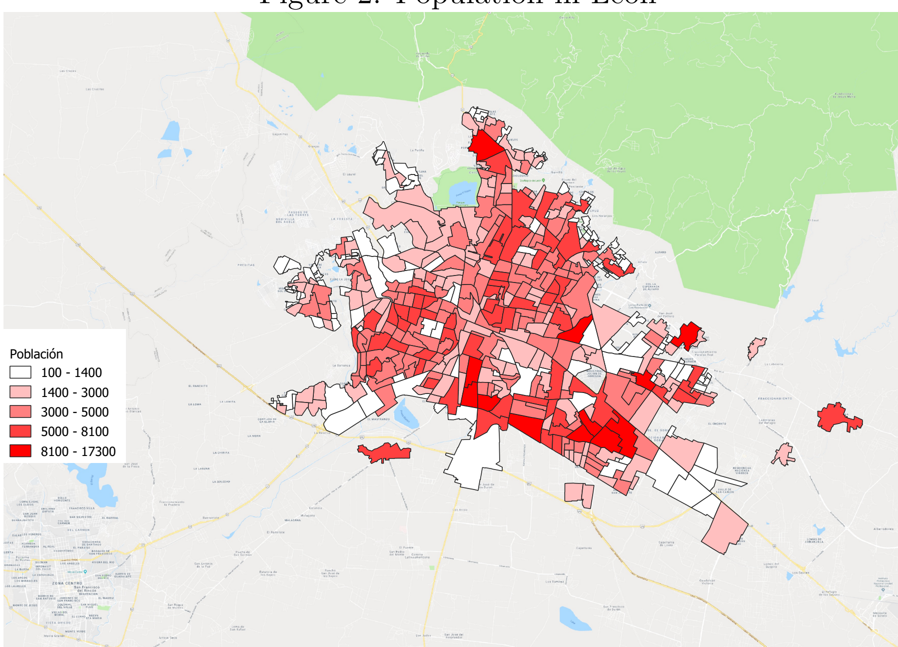


LEON

About 25% of the population of the state of Guanajuato lives in León (INEGI, 2015). León is part of a region known as Bajío Mexicano, which conglomerates an important number of manufacturers, especially auto-makers. This industrial belt, together with the rising traffic congestion has derived in one of the worst air qualities in the country. On the other hand, the government in León is actively promoting the use of bike as a transportation mode. They already have one of the most successful Bus Rapid Transit Systems, Optibus, in place since 2003.

The city is characterized by steep slopes in the North and plains in the Center and the South. The average temperature oscillates between 13 and 26 celsius degrees.

Figure 2: Population in León



GUADALAJARA

Guadalajara is the second biggest city in Mexico and the biggest city in this study. Still, with a population of 5 million people, it is not considered a Mega-City (for example, Mexico City has 21 million people, Tokio 38 million, Delhi 26 million The World Bank (2018)). As in the other cities considered in this study, social participation has been key to stimulate the use of bikes.

Together with Mexico City, Guadalajara was one of the first cities to introduce a bike sharing system (Montero, 2017). Guadalajara also has a mild weather that goes from 10 to 27 celsius degrees in a given day.

Figure 3: Population in Guadalajara

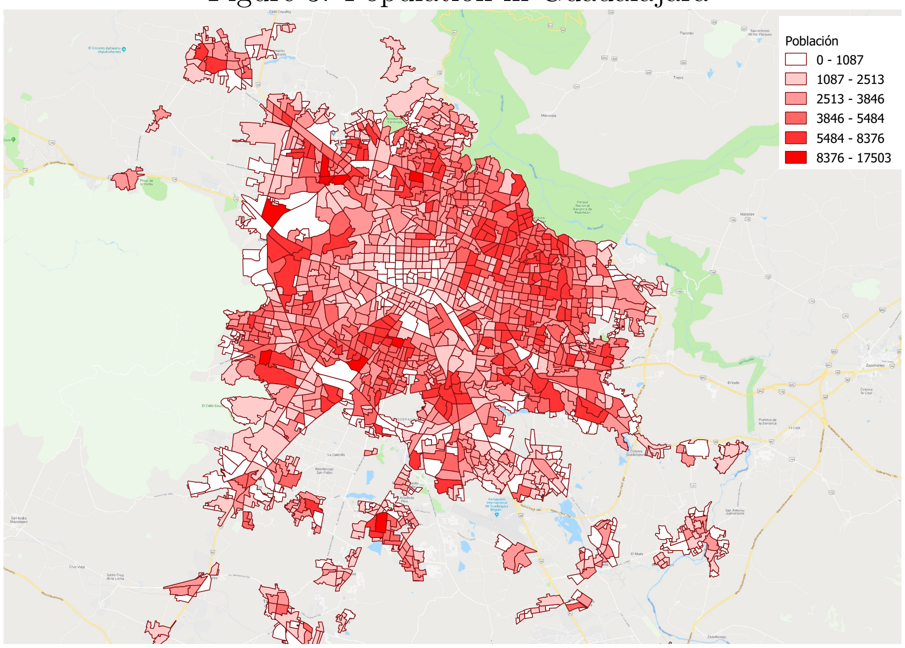


Table 2 shows summarizes variables that characterize each city and compares them with cities in other parts of the Globe. In terms of population, the cities that we study here are much smaller than Mumbai (Mumbai is twenty times as big as Mérida and León and almost four times as big as Guadalajara). Their densities are similar to a city like Pune, India. In terms of extension, all three cities are larger than London, but in terms of density, Mérida and León have less than half the density of London.

Table 2: Caption

Variable	Mérida	León	Guadalajara
Population	1,058,764	1,967,501	5,156,603
Extension (km^2)	1,528	5,465	2,385
Density	692 per km^2	360 per km^2	2,162 per km^2
Average educational level	8.8 years	9.22 years	9.16 years
Average quarterly income [a]	36,562	47,977	47,585
Average quarterly income [b]	13,611	17,863	30,558

[a]With data coming from National Household Income-expenditure survey (ENIGH) by INEGI. This survey is statistically significant only at state scale. Mexican pesos per household

[b]Our survey. Mexican pesos per household

Table 3: Other cities

Variable	Mumbai	Pune	London
Population	18,702,740	3,402,000	14,302,930
Extension (km^2)	603 km^2	331 km^2	1,572 km^2
Density	26,600 per km^2	10,227 per km^2	9,098per km^2
Average educational level	5.1 years		
Average quarterly income[a]	14,225	10,575	210,416

[a]Mexican pesos per inhabitant

4 The Model

Latent Class Models divide decision makers into groups using a probabilistically segmentation. By dividing the sample into groups the models reduce unobserved heterogeneity (Walker et al., 2011). The origin of the model is McFadden's Random Utility Model (RUM) (McFadden et al., 1973). The RUM assumes that agents choose from a choice set the alternative that maximizes their utility function. This utility function has two components, one that is observed by the researcher and one that is not (McFadden et al., 1973). The utility that agent n obtains from the alternative i can be represented by the following equation:

$$U_{ni} = V_{ni}(x_{nj}; p_i; \beta) + \epsilon_{ni}$$

For n=1,2,. . . N and i=1,2,. . . I (1)

Where U_{ni} is the true, but unobservable (to the researcher) utility function; V_{ni} is the deterministic component of the utility. The utility is assumed to be linear in parameters (McFadden et al., 1973; Ben-Akiva et al., 2002a). x_{ni} is a vector with all the observed variables from alternative i for agent n; p_i is the price of the alternative; and β is a vector that reflects the tastes of the agents. The agent n chooses the alternative i over the alternative k if $U_{ni} > U_{nj} \forall i \neq j$. McFadden et al. (1973) has shown that when ϵ_{ni} are independent and identically distributed (iid) with zero mean, and behave according to an Extreme Value distribution, then the probability that an agent chooses the alternative that provide her the highest utility,

$$P(i|C) = P(U_i > U_j) = P(v_i + \epsilon_i > v_j + \epsilon_j) \forall j \in C, \tag{2}$$

can be estimated via a conditional logit model:

$$P(i|C) = \frac{exp(v_i)}{\sum_{j \in C} exp(v_j)} \tag{3}$$

Concretely, a latent class model consists of two separate models: the choice model and the class membership model. The first component estimates the probability of agent n choosing alternative i which is conditional on the segment that each agent belongs to. The second component estimates the probability that agent n belongs to class s. Equation (3) can be expressed as:

$$P_{n|s}(i) = \frac{exp(v_{ni|s})}{\sum_{jtoC} exp(v_{nj|s})} \tag{4}$$

where $x_{ni|s}$ is a vector of alternative-specific variables associated with alternative i and individual n, β_s is a vector of segment parameters to be estimated. The membership component, the probability that individual n belongs to segment s, is estimated based on the agent's idiosyncratic variables or infrastructure characteristics. This probability can be expressed as:

$$P_{ns} = \frac{exp\gamma_s z_n}{\sum_l^S exp\gamma_l z_n} \tag{5}$$

where γ_s is the parameter vector associated with class s and z_n is a vector of observable individuals characteristics such as age, sex, income, etc. Using equation 4and equation 5 the unconditional probability of individual n choosing mode i from the choice set C can be written as:

$$P_n(i) = \sum_{s=1}^{S} P_{ns} * [P_n(i)|s] \tag{6}$$

Each individual is assigned to a class through equation 5. Strictly speaking every agent has a probability of belonging to every class. However, the researcher may assign each agent to the class to which it belongs with the highest probability. The parameters β_s and γ_s are simultaneously estimated by maximum likelihood. The individual characteristics and behavioral attitudes that identify each segment can be inferred from the signs of the coefficients in equation 5. All these coefficients are relative to a reference class for which all parameter values are set to zero.

As the number of classes needs to be specified a priori by the researcher, the model is estimated as many times as number of classes are tested. The optimal number of classes is chosen based on likelihood criteria that weight the improvement in the likelihood function by penalizing the specification with more parameters in it. The two most used criteria are the Bayesian Information Criterion (BIC) Schwarz et al. (1978), and the Akaike Information Criterion (AIC) (Akaike, 1998). They can be expressed as follows

$$AIC = -2LnL_s + 2K_g \quad (7)$$

$$BIC = -2LnL_s + K_g lnN \quad (8)$$

where LnL_s denotes the maximized log-likelihood of the model with s classes; K_s is the number of parameters to be estimated in the model with s classes and N is the sample size. According to Bhat and Guo (2007) the AIC tends to favor a model with more classes in large data samples. In any case, smaller values of AIC and BIC indicate better models.

Latent Class have been used in several discrete choice experiments, for example, Martínez-Cruz (2015) improves welfare measurements derived from the use value of natural resources and Walker et al. (2011) analyze the influence of lifestyle preferences in household location decisions. The use of Latent Class Models in travel studies is extensive. Ben-Akiva et al. (2002b) combine the Latent Class choice model with hybrid travel choice models. Greene and Hensher (2003) introduce latent class analysis to decision making of drivers, drivers are able to pick a different rout depending on the class they belong to. Rossetti et al. (2017) use latent class to study preferences for types of bike lane. Motoaki and Daziano (2015) derive two groups of bike users: skilled and not-skilled with the use of a latent class model.

5 Data

We take advantage of a survey conducted in June 2017 in households, which is representative of each city. The survey asks for the four most important trips on weekdays. In order to identify the main traveling behaviors, we focus on what the person considers the most important trip. In most cases, this means a morning trip to school or work. Thus, the study analyzes regular, unavoidable commutes.

In all three cities, the sample was gathered using the last federal election data from the year 2016. Within each primary unit of survey the same number of interviews were applied, ten interviews per unit. The units were randomly selected using the catalog of the National Institute of Statistic and Geography. In each household, only one person above 18 years old was interviewed. After accounting for missing data, the samples for each city were

800 observations for Guadalajara, 1,200 observations for León, and 804 observations for Mérida.

In table 5 we present the summary statistics of each variable. The mean age of respondents is 43. 65% of respondents are women. This might be due to the fact that the survey took place at homes, and in Mexico, it is more likely to find a female adult during the day than a man adult. The average education level is 9. Thus, on average, our sample is in 10th grade. The average monthly income of our sample is 5,225 pesos equivalent to 260 USD. This income is below the national average obtained in the 2016 National Survey which was 498 USD per month [2].

The idiosyncratic variables were captured with the following questions: a) As soon as I was able, I bought a car or, as soon as I am able, I will buy a car, b) Nowadays it is necessary to own an automobile, c) I would like to have a bike path built near my house, d) bike riding is just a fad, e) people who bike to work do it because they cannot afford another form of transportation. According to bicitekas (bicitekas.org) these reasons are frequently exposed as a belief of those who avoid using bikes to commute. The questionnaire allowed for four answers: I strongly agree, I agree, I disagree and I strongly disagree . Due to the lack of variation between alternatives, we assigned 1 if the person agrees and 0 if the person disagrees.

78% of the people in our sample believe that the car is necessary, 74% of the people claim to have bought a car as soon as they were able or will buy a car as soon as they are able; 71% believe that biking is for poor people and 26% believe that biking is a fad.

The effect of the built environment is captured with two variables: distance to the core of the city and whether or not there is a bike lane nearby the house. As Ewing and Cervero (2010); Cervero et al. (2009) suggest, distance to the core this variable captures several qualities of infrastructure which are difficult to separate: density, diversity (different land uses), design (block size, interconnected grids or suburban curved networks, intersections per square mile), destination accessibility. When researchers have tried to separate these variables it is important to avoid multicollinearity problems.

[2]Data from ENIGH 2016 considering income from work

Table 4: Variable description and their measurements.

Variable	definition	measurement
age	age of the commuter	years
female	gender of the commuter	nominal (two categories): Female=1 and male=0
education	number of years in school that the commuter has studied	years of schooling. Min=0, Max=22
income	earnings and wages of the household	pesos per month
car	if someone in the household owns a car	nominal (two categories): yes=1 and no=0
ncar	if someone in the household owns a new car, 2015 or newer	nominal (two categories): yes=1 and no=0
moto	If someone in the household owns a motorcycle	nominal (two categories): yes=1 and no=0
h_bike	If there is a bike in the household that the commuter could use	nominal (two categories): yes=1 and no=0
cel_int	If the commuter owns a smart phone	nominal (two categories): yes=1 and no=0
city	The city where the survey was conducted	nominal (three categories): Guadalajara=1, León=2, Mérida=3
idiosyncratic variables		
buy_car	Owning a car is a priority	nominal (two categories): yes=1 and no=0
necessary_car	Considers that the car is a necessity	nominal (two categories): yes=1 and no=0
build_bike	Would like to have a bike path built near his-her house	nominal (two categories): yes=1 and no=0
trend_bike	Considers that bike commuting is just a passing fad	nominal (two categories): yes=1 and no=0
poor_bike	Considers that bike commute is for poor people	nominal (two categories): yes=1 and no=0
infrastructure variables		
distance	Distance from home to the center of the city	meters
bike path	If the household has a bike lane nearby	nominal (two categories): yes=1 and no=0

Table 5: Statistical Summary of Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
age	2,804	42.7	16.3	18	95
female	2,804	.646	.487	0	1
education	2,804	9.32	4.01	0	22
income	2,804	5224.5	12835.6	0	200,000
car	2,804	.405	.491	0	1
ncar	2,804	.032	.177	0	1
moto	2,804	.106	.307	0	1
h_bike	2,804	.440	.496	0	1
cel_int	2,804	.455	.498	0	1
city	2,804	2.01	.756	1	3

6 Results

LINEAR MODEL

As a first approximation, to measure the effect of the variables on the possibility to use a bike to commute, we run a linear model where the dependent variable takes the value of 1 if the person commutes by bike and 0 if she doesn't (see Table 9). In all three cities, age and gender have the expected signs. Income is significant and positive only for Mérida. Owning a car has the expected negative effect in Guadalajara, no effect in León and a positive effect in Mérida. None of the idiosyncratic variables results significant.

The infrastructure variables have the expected influence, being farther from the core has a negative effect on bike use and having a bike lane close to home has a positive effect. This idiosyncratic variables are not significant, which is a hint of results from the Latent Class Model.

LATENT CLASS MODEL

Table 8 reports the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) of four latent class specifications. The AIC value refer to specifications that assumes the probability that individual n

Table 6: Variables

Variable	Obs	Mean	Std. Dev.	Min	Max
Guadalajara	800				
age		41.89	15.73	18	86
female		.635	.482	0	1
education		9.51	4.05	0	22
income		7,310	22,660	0	200,000
car		.425	.495	0	1
new car		.046	.210	0	1
moto		.086	.281	0	1
household bike		.4625	.499	0	1
cel int		.522	.499	0	1
Leon	1,200				
age		43.40	15.90	18	89
female		.657	.475	0	1
education		9.13	4.26	0	22
income		4,401	5,243	0	25,000
car		.444	.497	0	1
new car		.022	.148	0	1
moto		.088	.283	0	1
household bike		.432	.496	0	1
cel internet		.382	.486	0	1
Mérida	804				
age		42.62	17.30	18	95
female		.641	.480	0	1
education		9.40	3.54	0	22
income		4,376	4,130	0	15,575
car		.326	.469	0	1
new car		.032	.177	0	1
moto		.150	.357	0	1
household bike		.428	.495	0	1
cel internet		.495	.500	0	1

Table 7: Linear model

	Guadalajara	León	Merida
age	-0.00335***	-0.00213***	-0.00757***
	(0.000976)	(0.000771)	(0.000945)
female	-0.209***	-0.303***	-0.220***
	(0.0314)	(0.0250)	(0.0270)
income	-3.86e-08	-0.00000342	0.00000719**
	(0.000000752)	(0.00000219)	(0.00000317)
education	-0.000679	0.00494	0.00470
	(0.00390)	(0.00311)	(0.00468)
social_class	0.0136	0.00370	-0.0153
	(0.0137)	(0.0115)	(0.0154)
weekly_cost	0.0000314	-0.0000162	0.00000459
	(0.0000400)	(0.0000527)	(0.0000203)
car	-0.0605*	0.0369	0.109***
	(0.0311)	(0.0246)	(0.0287)
ncar	-0.0147	-0.0503	-0.176***
	(0.0673)	(0.0678)	(0.0646)
moto	-0.0400	0.0120	0.0530
	(0.0600)	(0.0428)	(0.0349)
h_bike	0.406***	0.343***	0.109***
	(0.0308)	(0.0236)	(0.0261)
cel	-0.0272	0.0259	0.0955**
	(0.0399)	(0.0263)	(0.0435)
cel_int	0.0365	-0.00913	-0.00827
	(0.0385)	(0.0307)	(0.0354)
uber	0.00478	-0.00970	0.0400
	(0.0349)	(0.0245)	(0.0323)
buy_car	-0.0292	0.0260	0.0320
	(0.0312)	(0.0283)	(0.0359)
necessary_car	0.0383	-0.0100	-0.0380
	(0.0334)	(0.0295)	(0.0345)
bike_path	0.166***	0.0452	0.175***
	(0.0509)	(0.0457)	(0.0557)
build_bike_path	0.118**	0.0125	0.132**
	(0.0464)	(0.0448)	(0.0517)
trend_bike	-0.0138	-0.00915	0.00551
	(0.0311)	(0.0240)	(0.0317)
poor_bike	-0.0216	0.00635	-0.00250
	(0.0301)	(0.0262)	(0.0295)
dist_comm	-0.0146	-0.0569**	-0.0358
	(0.0373)	(0.0234)	(0.0288)
_cons	0.277***	0.342***	0.881***
	(0.0954)	(0.0858)	(0.103)
N	800	1200	804

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

belongs to class g.

The first two rows show a division by classes without using idiosyncratic or infrastructure variable. When idiosyncratic and infrastructure variables are introduced, the model converges into two or three classes. According to the Bayesian Criteria, two classes are more congruent with the nature of this sample.

We decide then, to use two classes. The results are in table 11. The division of our universe into two classes results congruent in the sense that they capture differences in the population that respond to theoretical and empirical considerations from other studies. The variables that result significant to divide the population into two classes are: distance to the core and closeness to a bike path. Among the idiosyncratic variables none is significant except for -desire to have a bike path built nearby-.

Table 8: Akaike bayesian criterion

Number of classes	Membership equation is informed[a]	ll(model)	df	AIC	BIC
2	No	-1305.947	19	2649.9	2762.7
3	No	No Convergence			
2	Yes	-1248.999	26	2549.9	2704.4
3	Yes	-1221.998	43	2529.9	2785.3

[a]The equation was informed with idiosyncratic and infrastructure variables

In Table 9, we predict the probability of using bike to commute. For class one, the class with worse infrastructure, the probability to bike is 0.5 while for the class with better infrastructure, the probability to bike is 0.96.

Table 9: Delta Method

Delta-method				
class	Margin	Std. Err.	[95% Conf.	Interval]
1 commute	.551	.050	.454	.645
2 commute	.967	.010	.939	.982

Table 10 shows the percentage of the population that belongs to class one, the class who faces worse infrastructure. 38% of the people in Mérida, León and Guadalajara belong to class one and thus, face worse conditions. 61% of the people face better infrastructure.

Table 10: Percentage of class

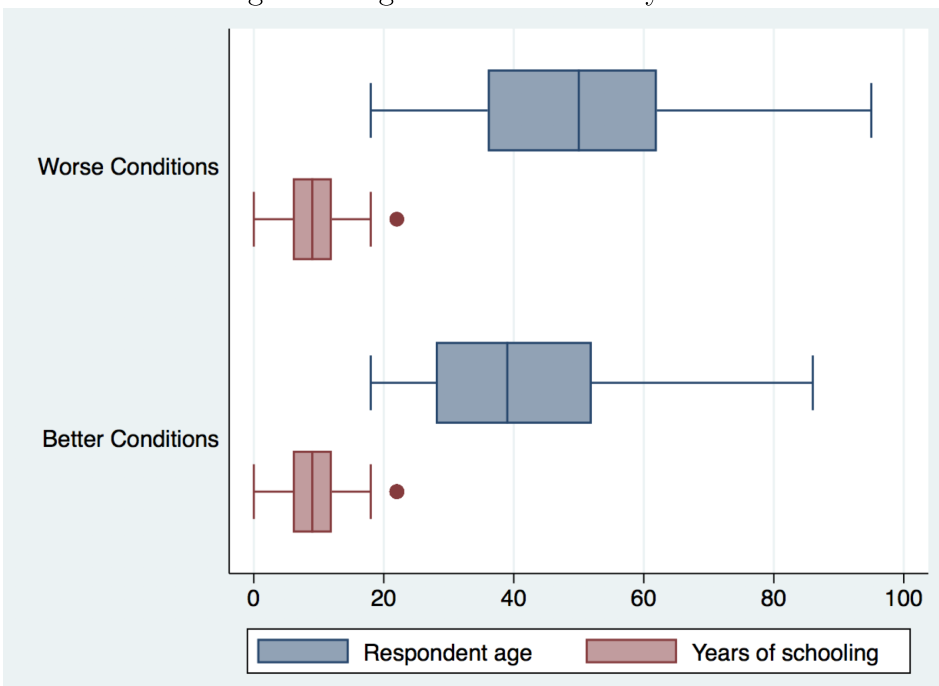
	Delta-method			
class	Margin	Std. Err.	[95% Conf.	Interval]
1	.386	.045	.301	.478
2	.614	.045	.522	.699

The influence of the built environment in travel demand is "the most researched subject in urban planning" (Ewing et al., 2009; Cervero and Kockelman, 1997; Ewing and Cervero, 2010). The features of urban infrastructure that have an influence in travel demand tend to be correlated, so multicollineality problems arise in models that try to separate them. Cervero and Kockelman (1997) identified three D's: density, diversity and design. Density tends to be measured with population per square mile, hectare or Kilometer. Diversity measures how mixed the land use is. Design refers to features such as how interconnected the grid is, measures of block size, number of intersections. Distance to the core (or downtown) is a proxy of those amenities. The closer the dwelling is to the core, the more dense, diverse and interconnected the space is. It is not a surprise then, to have distance as an important criteria to divide the universe into classes. Closeness to a bike lane complements the density, diversity and design. The sample is then divided into those with access to better infrastructure and those without. We name them: better conditions group and worse conditions group.

With this artificial division, we have a novel result: Among those "exogenously" exposed to better infrastructure conditions, the likelihood of bike use rise with age and women are more likely to bike than men. It is also the case that more educated people are less likely to bike.

The other group, those with worse infrastructure conditions, has the results usually found in the literature: age reduces the likelihood to bike and men are more likely to bike instead of women. Figure X depicts age and schooling of both groups. Both groups are similar, but those with better infrastructure are slightly younger.

Figure 4: Age and Education by Class



In figure 5, we include income. As the graph shows, some outliers of higher income rise the income level of those with better infrastructure conditions. However, income is not significant as a determinant of bike use in any case.

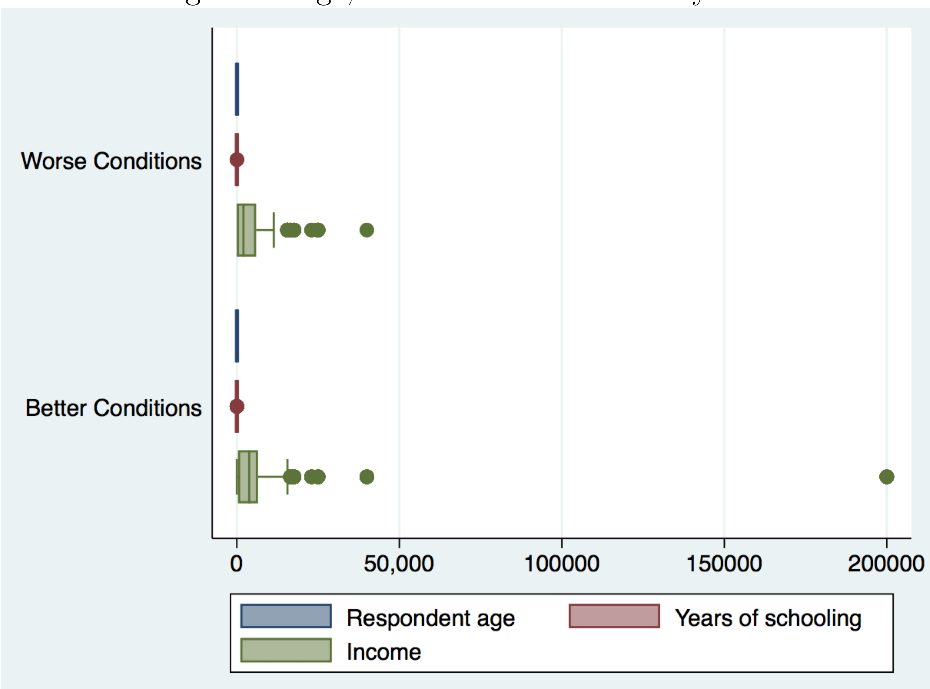
Table 8 presents the results and illustrates that, commuters in the second class are more likely to commute in bike than commuters in class one.

Table 11: Latent class estimation

Explanatory variables	Latent class model	
	Class 1	Class 2
age	-.054***	.078**
	(.012)	(.032)
female	-1.086***	1.728**
	(.347)	(.806)
education	-.048	-.179**
	(.031)	(.072)
income	.00001	2.82e-06
	(.000)	(.000)
car	-.240	-.153
	(.221)	(.514)
new car	-1.245*	.359
	(.703)	(1.089)
moto	.507	-1.303**
	(.348)	(.585)
household bike	.949***	.873*
	(.215)	(.494)
cel internet	-.099	-.778
	(.244)	(.633)
$_cons$	3.369***	2.493**
Membership equation	Base outcome	
Buy_car	0	.261
		(.185)
Necessary_car	0	.258
		(.202)
Build_bike_path	0	3.566*
		(2.083)
Trend_bike	0	.237
		(.172)
Poor_bike	0	-.181
		(.185)
Dist_comm	0	-.393**
		(.156)
Bike_Path	0	3.437*
		(2.084)
State	0	-.051
		(.107)
_cons	0	-2.902

Standard errors in parentheses
* $p < .10$, ** $p < .05$, *** $p < .01$

Figure 5: Age, education and Income by Class



7 Discussion

Commuters can be characterized based on one or several features across classes. We used three characteristics that the literature has regarded as fundamental and that happen to be exogenous at least to the short term travel mode decision[3]. The three characteristics that we explore as leading to a division by classes are: the distance to downtown that represents an infrastructure level (closer to the core, there is more density, more diversity in land use, grids might be more connected), closeness to a bike lane, and attitudes. The attitudes or idiosyncratic variables that we explore are attitudes with respect to automobile and bike use. We also consider the city as a determinant of class division.

None of our idiosyncratic variables was significant. Certainly, this result does not mean that other idiosyncratic variables could determine a -type- of commuter. Heinen et al. (2011b) find that some idiosyncratic variables influence the decision to cycle such as: perception of safety or perception of direct benefits (convenience, low cost, health benefits). The idiosyncratic variables included in this study are better described as social perceptions of bike users and car users. In contrast with the common belief, we find that it does not matter if the commuter believes that the bike is for poor people, if cycling is a fad, if cars are necessary or if they consider that owning a car is a priority[4]. The characteristics that do exert an influence in the type of commuter are related with the built environment. This is good news for policy making. If decision makers are able to increase the number of citizens that are exposed to better infrastructure, then the likelihood of bike use is likely to grow in the most unexpected places: among women and among older commuters.

The main contribution of this paper is the reduction in heterogeneity in the unobserved utility function that allow us to identify two classes of commuters: those with better and those with worse infrastructure levels. The literature has seldomly found that women are more likely to bike(Diaz and Rojas, 2017; Garrard et al., 2012b; Pucher and Buehler, 2012). We are able

[3]The effect of self-selection is not discussed in this paper: some people decide to move to a certain neighborhood because they are of a certain -type-, those who hate commuting, for example.

[4]This set of beliefs was obtained from chats with urban biking activists and is evident in several mediums such as**?**

to find a class of commuters where women are more likely to bike: those with better infrastructure. This is a hopeful result for cities where cycling is still a low percentage of trips and where gender roles are heavily influenced by stereotypes and very real circumstances of oppression that place a heavy burden on women (Pucher et al., 2011; de la Paz Díaz et al., 2017). Better infrastructure means having bike lanes, but also being closer to downtown, where the grid is more interconnected, the land use tends to be mixed and density tends to be higher.

Together with women, older people are more likely to bike within this class. Developing countries as México, China, India and Brazil experience a shift in demographics, where the population as a whole is getting older: less children are being born while life expectancy is increasing (ONU Habitat, 2018). With this perspectives, the fact that within a certain class, cycling increases as people age, is certainly a good outcome. We find that income, education and the city are not determinants of the likelihood to bike or the class that they belong to.

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