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Lessons from 3 Latin-American Cities

Transport Division

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Acronyms

BRT	Bus Rapid Transit
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
HOH	Head of the household
MSA	Metropolitan Statistical Area
OLOGIT	Ordered Logit Model
SES	Socioeconomic Stratum
RMSEA	Root Mean Square Error of Approximation
SC	Standardized solution
SEM	Structural equation model
SRMR	Standardized Root Mean Square
TLI	Tucker-Lewis index
TNC	Transportation Network Company
USA	United States of America

Content

Can ride-hailing services reduce car ownership? Lessons from three Latin-American cities

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Abstract

App-based ride-hailing is no longer a new transportation phenomenon. Yet much remains unknown about its influence on user behaviors associated with the decarbonization of urban mobility, such as the reduction of car dependency and car ownership. This knowledge gap stands in contrast with efforts in the literature to understand whether ride-hailing substitutes or complements public transit, or the determinants of its adoption. Against this backdrop, this study interrogates the role of app-based ride-hailing on attitudes and perceptions about private car-based mobilities in three large Latin American metropolitan areas. The paper builds on survey data of representative samples of both users and non-users to explore the influence of ride-hailing over the perceived need of owning private vehicles and the likelihood of purchasing or selling a private vehicle. The paper uses logistic regression models to empirically explore how ride-hailing changes the perceived necessity of car ownership, pinpointing different effects between cities and groups of current car users and non-users. Moreover, our results suggest that individuals who use ride-hailing more frequently are also more likely to believe it can reduce their need for personal car ownership. Findings in this paper hold significant potential for policy and regulation in a region marked by uncertainty regarding the optimal approach to regulate app-based services to foster more sustainable urban mobility. It contributes to ongoing debates about the role of app-based mobilities in the transition to low-carbon transportation, particularly in Latin American cities.

JEL classification: J16, N76, 032

Keywords: Car ownership, Ride-hailing, Sustainability, Structural Equation Models SEM, Transportation Network Companies TNC

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1. Introduction

The decarbonization of transportation is currently a key global policy priority (Arsenio et al., 2016; Cavoli, 2021; Jennings, 2020; Mullen and Marsden, 2016). Cities in the global south are currently at a crossroads whereby they face the choice of continuing to support automobile-oriented urban development patterns or adopting low-carbon transportation policies and systems that reduce car dependency (Oviedo et al., 2022; Teoh et al., 2020). In this context, multi-modal transportation solutions are essential for the transition to a more sustainable urban mobility to effectively materialize. The bulk of policy alternatives have focused on developing an enabling environment for more sustainable travel alternatives such as walking, cycling and mass transit (Buehler et al., 2017; Oviedo and Sabogal-Cardona, 2022; Sattlegger and Rau, 2016). However, considering recent developments in technology and shared mobility alternatives, several authors have argued in favor of digital tools and shared mobility's potential for incentivizing low-carbon transportation and reducing private car use (Abduljabbar et al., 2021; Gebresselassie and Sanchez, 2018; Tirachini, 2020; van Wee and Handy, 2016).

In Latin America, a recent publication by the Inter-American Development Bank identifying pathways for a more sustainable and inclusive urban mobility has suggested that, under the appropriate conditions, shared mobility can play a role in filling gaps in urban transport systems in the region (Scholl et al., 2022). Such conditions require implementing policies and regulations aimed at reducing private car use and structural investments for the promotion of sustainable transportation. Previous research supports the idea of shared mobility working as a complement to sustainable transport in specific contexts, suggesting ride-hailing can reduce car-based mobilities by enabling alternative means of transportation for otherwise captive car trips (Barajas and Brown, 2020; Brown, 2019; Sabogal-Cardona et al., 2021).

For example, ride-hailing could improve the efficiency of large mass transit systems by helping to serve first-mile and last-mile trips. Similarly, they may complement transit by serving trips in schedules or areas when or where public transit is not operating or in transit desserts (Barajas and Brown, 2020; Young et al., 2020). Nevertheless, the convenience of working on flexible schedules can be an incentive for investors to buy cars, something that has been observed in low-income developing countries (Gong et al., 2017).

There are many other mechanisms through which ride-hailing could lead to reduced car ownership. For example, individuals with access to well-functioning, integrated, safe, and affordable public transportation could be attracted to ride-hailing for non-regular trips such as leisure trips, trips to visit friends and family, or health trips. In the presence of high-quality public transportation and interconnected and integrated non-motorized transport infrastructure, ride-hailing could serve occasional trips and enable a car-free lifestyle.

For trips that urban dwellers cannot complete in their regular commute mode, ride-hailing can be a more affordable option than owning a car. Nevertheless, this implies that ride-hailing should have the flexibility of car-based mobility and compensate for the benefits car owners find in private vehicles. An issue here would be to overcome the cultural appropriation of cars as a symbol of wealth and status (Moody and Zhao, 2019). A study in the USA (Moody et al., 2021) showed that car ownership is not only influenced by its cultural configuration and, on the contrary, it is a rational decision also motivated by the value derived from the flexibility of using a personal car at any moment. The work by Moody et al. (2021) also explored why car owners have not been more attracted to app-based mobility services as a mechanism to replace cars and concluded that reliability and flexibility of ride-hailing are not perceived as valuable as in car ownership (Moody et al., 2021).

The aim of this article is to explore how ride-hailing services may be affecting attitudes and beliefs towards car ownership in Latin America. More specifically, we hypothesize three potential attitudinal effects: (i) that owning a car is no longer necessary due to the presence of ride-hailing (substitution effect); (ii) availability of ride-hailing services has influenced them in the behaviour of not buying a car (not buying effect); and (iii) if people think that the presence of ride-hailing services has influenced them in the behaviour of selling their private vehicle (selling effect). We disseminated a survey in the cities of Bogota, Medellin, and Mexico City including sociodemographic questions, questions to study perceptions of car-based mobility, and the level of adoption of ride-hailing services expressed as frequency of use per week. Ordered logit (OLOGIT) models and logit models were fitted for each of the three mentioned potential effects (substitution, not buying, and selling) by city and by groups of people who do not use private vehicles for their most regular trips and people who use private vehicles for their most regular trips.

Results indicate that engaging in ride-hailing services is associated with agreeing on the possibility of substitution, on not buying a car, and on selling a car. For regular car commuters, car dependence is one of the strongest predictors with a negative effect on reducing car ownership. Having more than one car (at the household level) negatively affects the possibility of substitution, regardless of being a regular car user. The presence of kids and elders in the household shows interesting results. Having more than two kids in the household or one elder in the household seems to induce agreement on substitution only for non-regular car commuters and having one elder or more in the household seems to also refrain people from buying a car. For the case of substitution, more than one elder in the household seems to induce agreement (positive association) on substitution for non-regular car users and to induce disagreement (negative association) for regular car users.

In the next section we present a literature review on the determinants of car ownership and on research showing that ride-hailing has increased motorization rates in some contexts but decreased it in others. After that, we move to explain the data and the methods used, and then to formally introduce the results. Finally, a set of conclusions and policy implications are presented.

2. Literature review

In this section we firstly present previous works analyzing the reasons behind the uptake of motorization rates in different cities worldwide, as well as successful policies to overcome this trend. Then, we move to specific research on the interaction between ride-hailing and car ownership. As will be shown, most of the research concentrates in China and the United States of America (USA). Moreover, whether ride-hailing can rise levels of car ownership seems to very context specific to each city.

2.1. Determinants of car ownership

Ways of reducing car mobilities have been researched and tested in the past. A review by Buehler et al. (2017) analyzed policies that have been implemented in Munich, Berlin, Hamburg, Vienna, and Zurich, since 1990 and finds that cities that employ a complementary and coordinated set of transport and land-use policies are associated with a reduced car-dependence (Buehler et al., 2017). In general terms, what seems to be effective across the five European zones evaluated by Buehler et al. (2017) is to make all transport modes (including cars) safer and affordable. More specifically, policies to manage parking (mainly in central areas) and improving walking infrastructure with policies like car-free areas and zones with 30 km/h of maximum speed were documented to work in the five cities.

Determinants of car ownership have also been studied in several contexts in the Global North. For example, a longitudinal analysis in Ireland (from 1995 to 2001) found that income and previous car ownership are strongly related to car ownership (Nolan, 2010). Other studies have shown that car ownership could be influenced by certain specific moments in life (Klein et al., 2019; Zhang et al., 2014; Zhao and Zhang, 2018) such as becoming a parent, moving to a new city, or getting a new job. Another strand of literature finds that car ownership is driven due to their association with status and wealth. Moody et al., (2019) defined car pride as "a symbol of individual's social status or personal image" and in a cross-sectional study in the New York and Houston metropolitan areas find a positive and significant association among car pride and car ownership (Moody and Zhao, 2019). An extension of this work shows that ownership derived from higher car pride is also associated with more use and that there is a feedback loop where people who use their car more frequently seem to be generating more car pride (Moody and Zhao, 2020a).

2.2. Ride-hailing and car ownership

There are two central strands of research studying the intersection between car ownership and ride-hailing. The first strand is composed of works statistically modelling adoption of ride-hailing services by taking as the main explanatory variable if the person is or is not an adopter. Some works use the number of ride-hailing trips performed during a certain timeframe as the explanatory variable. The models in this strand of research include car ownership as a regressor regularly finding a positive association, implying that individuals that already own cars are more likely to be frequent users of ride-hailing. Nevertheless, other variables like higher levels of education and degree of technological savviness often show a stronger association. A wide range of research explores the effect of car ownership on ride-hailing adoption and many regions around the world have been study cases, such as California (Alemi et al., 2018a), Nigeria (Acheampong et al., 2020), Iran (Etminani-Ghasrodashti and Hamidi, 2019; Lesteven and Samadzad, 2021), South Africa (Vanderschuren and Baufeldt, 2018), Chile (Tirachini and del Río, 2019), and Mexico (Sabogal-Cardona et al., 2021). An overall limitation of these articles is that they show an association between owning cars and using ride-hailing but are not aimed at understanding if ride-hailing can be linked to changes in car ownership.

The second strand of research measures more directly the impact of ride-hailing services on car ownership by looking at changes in car sales or car registration. Methodologically, most of the studies in this strand use a difference-in-differences model taking the entry of ride-hailing in some country or city as the start of the treatment, with most studies being concentrated in China and the USA. One of the first studies from China (Gong et al., 2017) found that Uber was responsible for around 11% of additional vehicle registration. Another study analyzes the period spanning from January 2015 to December 2015 in 51 Chinese cities where DiDi, the leading competitor, started operation and 51 cities where did not start operation (Guo et al., 2018). The study found an increase of 6.5% (that could go to 21.4% when limiting the model to cities with similar characteristics). Nevertheless, the authors acknowledge that this could be a transitory effect that could be driven by the presence of a single dominant competitor. Another study (Guo et al., 2019) considered the period between 2013 and 2015, 32 cities with exclusive presence of DiDi, and 18 cities where DiDi and Uber were competing. Findings in Guo et al., (2019) suggest that, in periods longer than one year, the effect on car ownership in cities where one single Transportation Network Company TNC operating (dominant TNC) is negative (ride-hailing decreases car ownership). In this case, a 14.2% decrease was estimated for cities where only DiDi started operation (Guo et al., 2019). Results also suggest that in places where two TNCs operate and thus are competing between them, there is not a significant effect of ride-hailing on car ownership (or there is a very small negative effect).

A study (Guo et al., 2020) analyzed the evolution of car sales in China and USA after ride-hailing services started operation. Guo et al. (2020) used aggregated data for 16 provinces in China and 22 states in the USA. This study found that ride-hailing was associated with an increase of around 9.24% in car sales in China, but a decrease of around 8.1% in the USA. Authors mention that a possible explanation for this differentiated effect could be a lower percentage of car ownership in China (compared to USA), and that in developing countries with low income the opportunity of working in ride-hailing can be an incentive to purchase cars. Another study focusing only on the USA suggested a decrease of 3.1% in per-capita vehicle ownership between 2005 and 2015 (Ward et al., 2019), something aligned with results in Guo et al. (2020).

A more recent work in the USA (Ward et al., 2021) finds evidence supporting a positive association between ride-hailing and car ownership. Considering data from 2010 to 2017, the study estimates a heterogeneous effect of 0.7% increase in vehicle registration, with larger increases observed in cities with prior high motorization rates and in cities with lower population growth (Ward et al., 2021). Authors of the work note that when data is aggregated at the state level, the average effect become negative as in the study by Ward et al., (2019) discussed before. Another recent study in the USA at the Metropolitan Statistical Area MSA (Diao et al., 2021) found a non-significant average effect of TNCs on car ownership, though there was a 1% reduction in the 10 metropolitan areas with more public transit use.

Probably the only literature on this topic outside of China and the USA has been conducted in Colombia (Granada et al., 2018). This work found a decline in taxis, a rise in the registration of small-size cars (that are preferred to TNC operation), and no effect on large or medium vehicles. Moreover, the article suggests a relocation effect where taxi investors and drivers could be switching towards buying cars and working in the ride-hailing industry. The final estimation is an increase of 2.7% in the share of total vehicles after 3 years that Uber, the first TNC in Colombia, launched operation.

3. Data and methods

As presented in the last section, the breadth of research suggests that a boost in car ownership, as well as a decrease, are possible once ride-hailing services are launched in cities, though it seems that increases have been more frequently documented than reductions. Nevertheless, most of the studies in the literature rely on aggregated data for car sales or car registrations. These statistics can be influenced by investors purchasing vehicles to profit from ride-hailing, and not necessarily by urban dwellers combining ride-hailing trips with car-based trips or deciding to buy cars after experiencing ride-hailing. Moreover, aggregated data in previous works is very efficient in showing general trends but does not enable to break down what might be happening at the individual level and analyze why people are changing their car ownership patterns due to ride-hailing. By the same token, most of the research is concentrated in the USA and China, leaving out developing countries in the Global South, where owning and sustaining a car is more expensive and, as a consequence, ride-hailing could become an instrument to avoid car ownership.

The main hypothesis in this research is that ride-hailing services can help to change perceptions about car ownership. More specifically, we are interested in assessing the potential of ride-hailing to make people believe that owning a car is not as necessary as before, to make them refrain from buying a private vehicle, and to consider selling their cars. This is tested by analyzing three variables. The first variable reflects if, because of the presence of ride-hailing services, people are changing attitudes towards car ownership and think that owning a private vehicle is no longer necessary. The second and third variables are related to the likelihood of engaging in the behaviors of buying a car or selling a car (if already an owner). Considering these three variables as outcome variables, we fit several categorical models. Standard demographic variables are included as regressors, along with variables expressing perceptions people have about car-based mobility. Moreover, and of particular interest, the stated frequency of use of ride-hailing services is also included as an explanatory variable.

In this section, we first provide an overview of the three selected case studies. Next, we explain how data were gathered and present the characteristics of the sample. The distribution of the outcome variables mentioned below are also presented. Finally, we provide details of statistical models used for modeling the outcome variables.

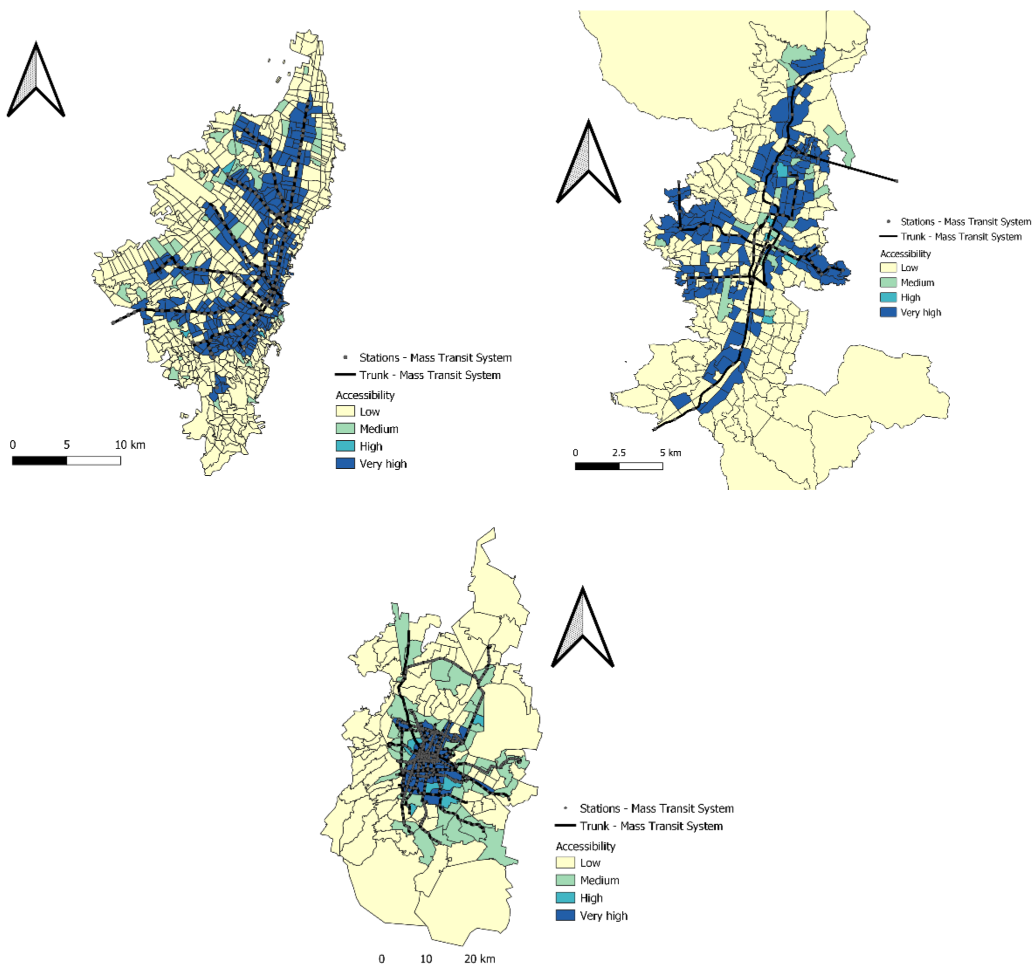
3.1. Selected case studies

We selected the metropolitan areas of Bogota (Colombia), Medellin (Colombia), and Mexico City (Mexico) as case studies, given that these are large urban agglomerations with diverse mass transit systems and where several transport innovations have arisen. Moreover, major TNCs have entered the market in each of the three cities including a range of several local app-based mobilities innovations. For example, before the pandemic the “microtransit” services were gaining popularity in the city and changing the way public transportation was being delivered (Flores-Dewey, 2019).

Mexico City is the larger urban agglomeration of the three cities with more than 21 million inhabitants at the metropolitan scale — almost twice the population of the metropolitan area of Bogota (around 11 million inhabitants) and approximately five times the population of Medellin (around 4.1 million inhabitants).

The transportation systems for each of the three cities are also quite distinct. Bogota became famous in the urban planning sphere thanks to several innovative initiatives. The most notorious was the launch of Transmilienio in the year 2000, the first Bus Rapid Transit (BRT) system used as the main transit option in a city and that has been replicated in many other cities around the world, including Medellin and Mexico City. According to BRT Data, Bogota boasts more than 113 Km of exclusive BRT infrastructure on 6 main corridors and moves on average 2.1 million passengers per day. The metropolitan area of Mexico City has three corridors with 140 km and an average of 380,000 passengers per day. Medellin reports 2 corridors, 18 Km, and 60000 passengers. Bogota does not have a Metro, as it is the case of Medellin and Mexico City. A distinguishing feature of Medellín is the presence of a solid cable system integrated into the Metro. The cable system in Medellin has 6 lines and nearly 15 km that move around 16 million passengers per year. In 2019 Bogota launched its first cable system integrated into the city BRT.

Figure 1. Maps of Bogota, Medellin, and Mexico



3.2. Survey data

We disseminated a web-based survey using panel services during the last quarter of 2020 when cities were still facing the Coronavirus pandemic. Given the risk of the Coronavirus and a range of mobility and social distancing policies that were in place at the time of the data collection, face-to-face surveys were not feasible and were not recommended. On the contrary, web-based surveys were a safe option that did not compromise the integrity of the respondents. Panel services provide access to a synthetic representation of the population under study by ensuring a sample with similar characteristics as in the original population for key demographic variables. For this research, panel services were asked to provide a sample imitating the gender, age, and income distribution of each city. The survey was in Spanish and respondents received a payment, something that facilitated data collection and incentivized answering the whole survey, but that induces some bias in the data. Panel services and web-based surveys gained popularity in transportation research amidst of the coronavirus pandemic, yet they were already popular in ride-hailing research before the pandemic (Alemi et al., 2018b, 2018a; Fu, 2020; Lee et al., 2019; Moody and Zhao, 2020b). The survey had different purposes beyond studying car ownership. It included standard demographic questions, questions about the household composition of the respondent, a discrete choice experiment to assess the viability of integrating ride-hailing services within mass transit systems, questions to measure perceptions of public transit, and questions to measure perceptions of ride-hailing.

Table 1 shows the main characteristics of the sample for each city, divided by people who do and do not use cars for their most regular trips. The sample size for non-car commuters is higher than the sample size for car commuters in the three cities.

Table 1. Description of the sample

	Non-car commuters (%)			Car commuters (%)			Total sample (%)		
	Bogota	Medellin	Mexico City	Bogota	Medellin	Mexico City	Bogota	Medellin	Mexico City
Total Sample	1537	1563	1393	347	238	349	1884	1801	1742
Main transport mode									
Public Transit	74	76.10	81.40	---	---	---	60.37	64.94	71.82
Walking/Cycling	10.40	4.73	4.52	---	---	---	8.48	4.04	3.99
Other	15.55	19.15	14.07	---	---	---	12.69	16.34	12.41
Gender									
Male	51.50	53.00	51.50	42.40	47.90	46.10	49.82	52.33	50.42
Female	48.50	47.00	48.50	57.60	52.10	53.90	50.18	47.67	49.58
SES									
Low	53.80	38.80	15.40	30.30	15.50	4.30	49.47	35.72	13.18
Medium	39.10	52.30	42.90	50.70	55.90	19.80	41.24	52.78	38.27
High	7.09	8.89	41.70	19.00	28.60	75.90	9.28	11.49	48.55
Education level									
Low	30.10	33.60	46.20	18.40	18.10	27.80	27.95	31.55	42.51
Medium	35.10	34.00	17.60	20.50	24.80	15.50	32.41	32.78	17.18
High	34.70	32.40	36.30	61.10	57.10	56.70	39.56	35.66	40.39
Age									
15 to 20 years old	9.63	11.20	12.60	9.51	9.24	8.60	9.61	10.94	11.80
20 to 30 years old	32.30	39.40	29.30	19.30	19.70	12.60	29.91	36.80	25.95
30 to 40 years old	24.50	24.30	29.10	20.20	28.20	32.70	23.71	24.82	29.82
40 to 50 years old	21.20	16.50	19.50	25.90	26.90	26.10	22.07	17.87	20.82
50 to 60 years old	9.11	7.10	6.89	17.30	13.40	11.70	10.62	7.93	7.85
60 to 70 years old	3.25	1.47	2.58	7.78	2.52	8.31	4.08	1.61	3.73

	Non-car commuters (%)			Car commuters (%)			Total sample (%)		
	Bogota	Medellin	Mexico City	Bogota	Medellin	Mexico City	Bogota	Medellin	Mexico City
Cars									
None	58.20	63.70	54.10	10.40	5.04	4.87	49.40	55.95	44.24
One	32.50	28.30	34.40	62.20	71.80	63.00	37.97	34.05	40.13
More Than one	9.30	8.06	11.50	27.40	23.10	32.10	12.63	10.05	15.63
Relationship With the Head of Household (RHH)									
Head of Household	48.60	43.50	44.80	56.80	55.50	59.90	50.11	45.09	47.83
Partner	19.70	18.30	17.90	23.30	19.70	20.10	20.36	18.49	18.34
Child	26.40	32.10	32.70	17.60	22.30	16.90	24.78	30.80	29.53
Other	5.34	6.08	4.59	2.31	2.52	3.15	4.78	5.61	4.30
Kids in the Household									
None	60.10	64.70	62.40	68.30	69.30	65.90	61.61	65.31	63.10
One	27.30	24.50	24.40	19.90	22.70	20.30	25.94	24.26	23.58
Two	10.10	8.89	9.26	8.07	6.30	11.20	9.73	8.55	9.65
More Than two	2.54	1.86	3.95	3.75	1.68	2.58	2.76	1.84	3.68
Elders in the Household									
None	61.90	66.30	58.70	60.20	65.50	65.60	61.59	66.19	60.08
One	26.50	23.00	25.40	24.80	26.90	20.90	26.19	23.52	24.50
More Than one	11.50	10.70	15.90	15.00	7.56	13.50	12.14	10.29	15.42

For the group of non-car commuters, public transit is the main mode used for the most frequent trip (74% in Bogota, 76.1% in Medellin, and 81.4% in Mexico City). There are no significant gender differences in the proportion of women versus men in the sample. Nevertheless, among the three cities, there is a higher proportion of males for the non-car commuter groups and higher proportion of females for the car-commuter groups. We were expecting a higher proportion of females in the non-car commuter group given that women are more prone to be public transit users and, as we mentioned before, we prioritized people using public transit in the sample composed through the panel services.

Socioeconomic stratum (SES) is an index calculated by the national government in each country at the neighborhood level used to measure the economic conditions of populations based on the built environment and housing characteristics of the neighborhood. It is often used as a proxy to income and wealth. Here we classified SES into low, medium, and high categories. Among non-car commuters, Bogota and Medellin have a small proportion of people in the high SES category (7.09% and 8.89%, respectively); proportion in the two cities increases for the car user groups (to 19% in Bogota and 28.6% in Medellin). This rise is expected and consistent with previous literature, and a plausible explanation is that people with more income and wealth are more likely to own and use cars. For Medellin, the proportion classified as medium SES is similar when comparing non-car users and car users (52.30% and 55.9%, respectively). In Bogota we observe an increase from 39.1% in the non-car users' group to 50.7% in the car-users group. Mexico City shows a different distribution of SES: in the non-car users' group people are concentrated in the medium (42.9%) and high (41.7%%) categories, and most of the people (75.9%) in the car-users' group are part of the high category (a small share of 4.3% are in the low SES category).

Education level was also categorized into low, medium, and high. As suggested by previous literature, and articulated with previous description of SES, education levels tend to be higher among respondents owning cars than among respondents not owning a car. Results display a similar behavior for the three cities. The proportion of highly educated people in the non-car user group is 34.7% for Bogota, 32.4% for Medellin, and 36.30% for Mexico City. These numbers increase for the car-user group to 61.1% in Bogota, 57.1% in Medellin, and 56.7% in Mexico City. Age distribution is similar for the three cities, with people in the cohort from 20 to 30 years old being the majority in the non-car user group and people in the cohort from 30 to 40 years old being the majority in the car user group.

As expected, non-car commuters are mainly non-car owners. In Bogota, 58.2% of non-car commuters do not own a vehicle. The percentage is 63.7% for Medellin and 54.1% for Mexico City. Despite this, the amount of people owning a vehicle is higher than expected for a group of people not using cars for their most regular trips (an average of 31.7% across the three cities). An explanation for this situation is that in households with more than one adult, the use of the vehicle is shared or concentrate on a specific adult. More surprisingly, an average of close to 10% of non-car commuters said to own more than one car. On the other hand, most of the people using cars for their most regular trips own one or more vehicles.

Respondents were mainly the head of the household (HOH), followed by the partner of the HOH and children. The household composition is similar for the six cases shown in Table 1. Most of the households do not have kids, followed by households having one kid, two kids, and a small proportion having more than two kids. Likewise, most of the households do not have elders, followed by households having one elder and households having more than one elder.

3.3. Outcome variables

As mentioned previously, we analyze the effect of ride-hailing services on attitudes towards car ownership through three outcome variables: (i) the need for car ownership (first outcome variable); (ii) the intention to forgo car ownership; and (iii) the intention to sell an existing car. The first two outcome variables were asked in the survey in terms of the level of agreement with two statements using a scale ranging from "1: completely disagrees" to "5: completely agrees" with "3" as a neutral value. The wording for the first variable was *"With the current offer of app-based services for transport it is not necessary to own a vehicle"* and the wording for the second variable was *"Do you think that having the possibility of using ride-hailing has influenced you in not buying a car or a moto?"*

The third outcome variable is only asked to people who declared to own a vehicle in the form of *"Given the availability of ride-hailing services in your city, you or any member of your household has considered or is considering selling the private vehicle?"* A limitation with this third outcome variable is that, by extending the question to the perceptions of other members of the household, a bias might be introduced because the respondent could not be completely aware of what other members of the household are thinking. More importantly, as all the explanatory variables are about the individual responding to the survey, it is difficult to establish to what extent this individual-level variables can impact what other members of the household would do. For the sake of simplicity, we will refer to the three outcome variables as "substitution", "buying", and "selling".

Table 2. Attitudes towards car-ownership given the availability of ride-hailing services (Outcome variables)

With the current offer of app-based services in your city for transport it is not necessary to own a vehicle.

	Non-car commuters		Car commuters	
City	**mean**	**sd**	**mean**	**sd**
Bogota	2.990	1.150	2.640	1.100
Medellin	3.070	1.200	2.650	1.160
Mexico City	3.140	1.150	2.730	1.150

Do you think that having the possibility of using ride-hailing has influenced you to not buy a car or a moto?

	Non-car commuters		Car commuters	
City	**mean**	**sd**	**mean**	**sd**
Bogota	2.790	1.100	2.470	1.070
Medellin	2.670	1.120	2.380	1.020
Mexico City	2.880	1.100	2.620	1.120

Given the availability of ride-hailing services in your city, you or any member of your household has considered or is considering selling the private vehicle?				
			Car commuters	
City	**---**	**---**	**Yes**	**No**
Bogota	---	---	18.10%	81.90%
Medellin	---	---	8.85%	91.20%
Mexico City	---	---	13.70%	86.30%

Notes: Level of agreement with two statements using a scale ranging from "1: completely disagrees" to "5: completely agrees" with "3" as a neutral value.

In Table 2 we present the mean and standard deviation of the three outcome variables by city and making a distinction between non-car commuters and car commuters. As expected, non-car commuters have higher mean values than car commuter for thinking that owning a car is no longer necessary and for the influence of ride-hailing in not buying a car.

Even though there are similarities among the three cities, it is important to highlight that Mexico City is consistently suggesting a higher impact of ride-hailing on car ownership than the other two cities. Mexico City has the highest mean values for the first two outcome variables in the non-car and car user groups. For the case of car selling, Bogota has the highest proportion (18.1%) followed by Mexico City (13.7%) and Medellin (8.85%).

The overall distribution of the three outcome variables per city are plotted in Figure 2 (first outcome), Figure 3 (second outcome), and Figure 4 (third outcome).

Figure 2. Distribution of the first outcome variable: substitution

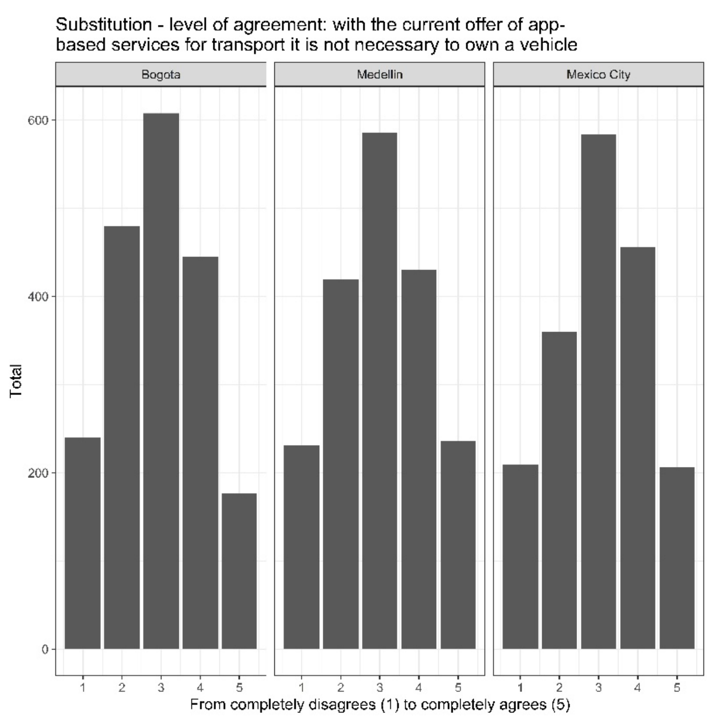


Figure 3. Distribution of the second outcome variable: buying

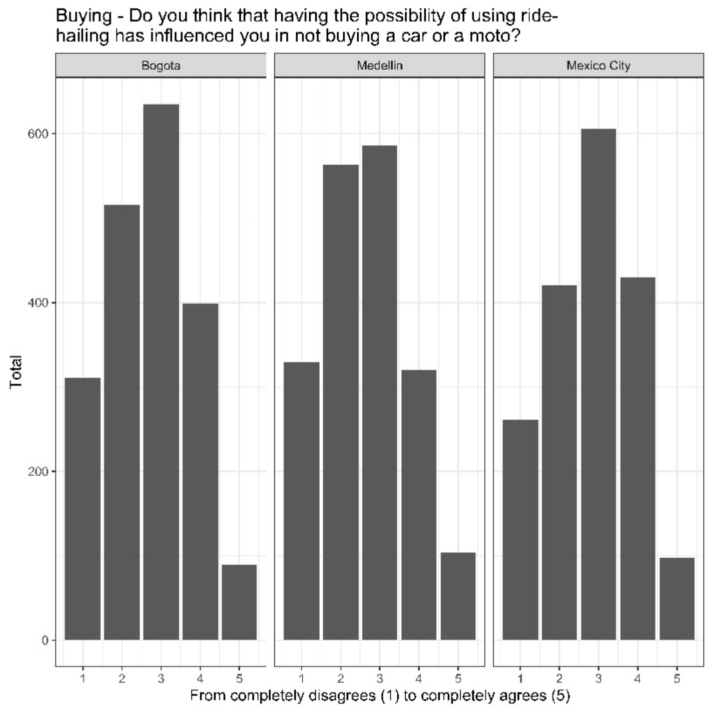
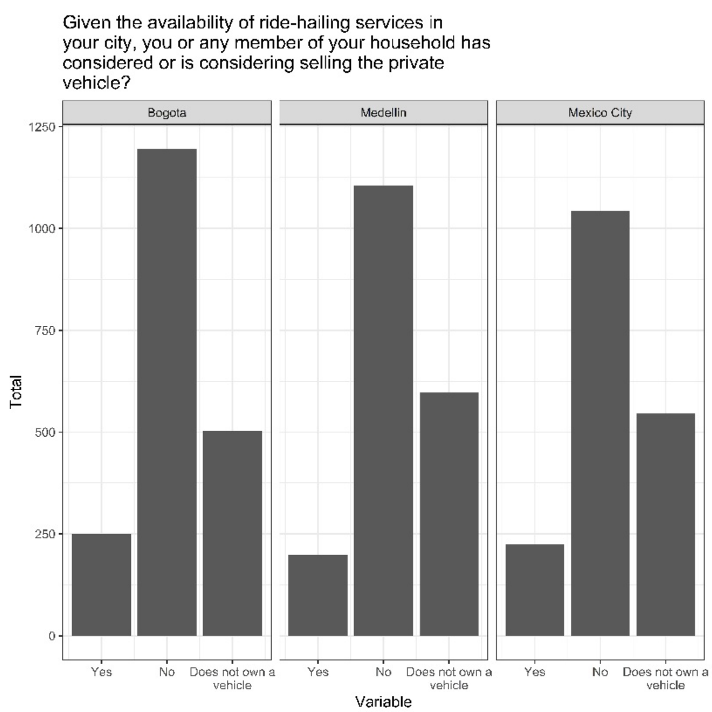


Figure 4. Distribution of the third outcome variable: selling



3.4. Statistical modeling

We employ OLOGIT and logistic regression models (Williams, 2016) to understand how ride-hailing services affect attitudes towards their own car dependency. Given that the first and second outcome variables are ordinal variables with five categories, we estimate OLOGIT models by city and by subgroups of non-car commuters and car commuters, resulting in six models for the first outcome variable (substitution) and six models for the second outcome variable (buying). We utilize a logistic regression model for the third, and binary, outcome variable (to sell or not to sell a personal vehicle). In this case, we only consider individuals who own one or more vehicles and currently commute by car. We fit separate models by city, instead of an aggregated model with city fixed effects and city interactions, to estimate unique parameters by city for all the regressors and make comparisons across cities.

Similarly, we compare how the effects of the explanatory variables vary among those who rely on cars versus those who do not for their daily mobility. For the group of non-car commuters, ride-hailing could enable them to maintain a car-free lifestyle. As presented in Table 1, there are non-car commuters in households without cars, but there are also car commuters in households with one or more cars. On the contrary, car-commuters may be less likely to change their attitudes towards car ownership if they have preexisting preference for private vehicles or tend to live in neighborhoods lacking adequate coverage and quality of public transportation services. Moreover, for car-commuters survey questions were included regarding the perception of car-based mobility. We hypothesize that these perceptions will have an additional and unique influence compared to non-car commuters.

Three groups of explanatory variables are included. The first group relates to the "Frequency of use of ride-hailing services," with the hypothesis that people making more ride-hailing trips should have more tendency to believe that car ownership is not necessary and to declare that are considering not buying cars and, if owning a car, to selling it. A significant and strong effect would be interpreted as ride-hailing having the potential to change perception around car ownership and non-significant estimates would be interpreted as people engaging more with ride-hailing not changing their perceptions of car ownership when compared to people with lower levels of ride-hailing adoption, even if they declare to change their perceptions due to ride-hailing. A negative and significant effect would imply that people use ride-hailing and start considering buying a car. This last scenario would speak in favor of people using ride-hailing as a transitory solution while switching completely to a car-based mobility.

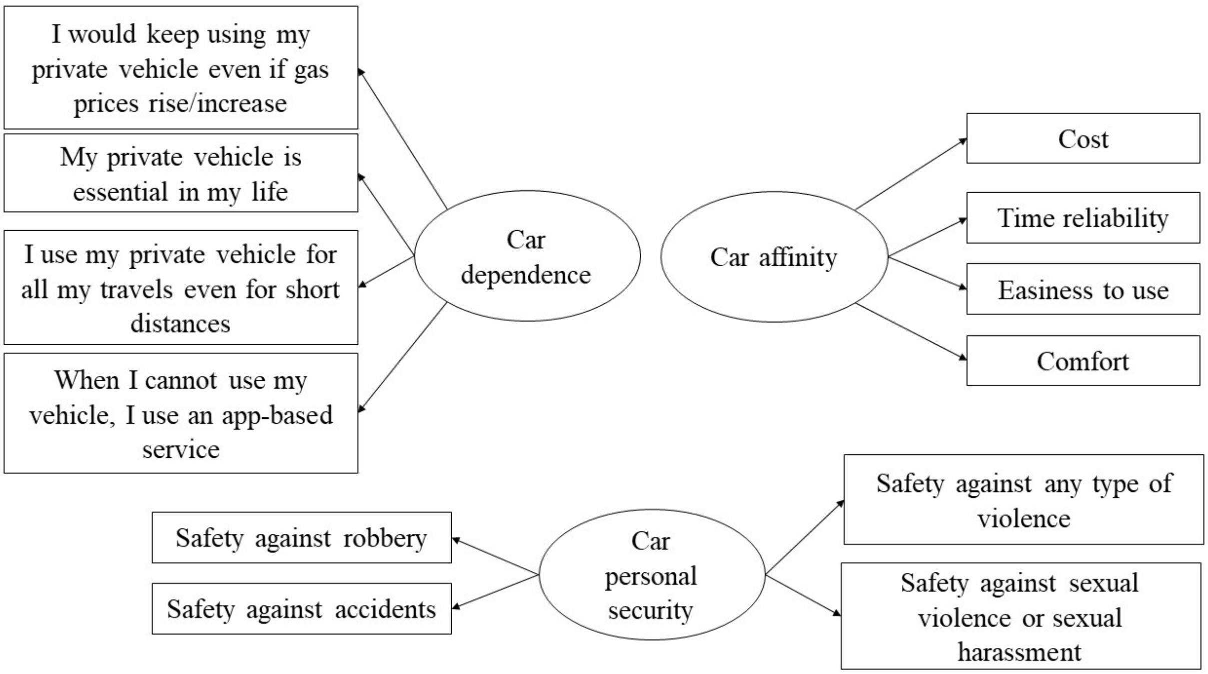
The second part of the model is based on the perception questions asked to car commuters about car-based mobility and is exclusively for the models considering car-commuters. More formally, we calculate three latent variables using Confirmatory Factor Analysis (CFA). A latent variable, also called construct or factor, is an unobserved variable that cannot be measures in the survey but that is theorized to exist and to cause the observed values and correlations among variables measured in the survey (often called indicators). Latent variables add theoretical value to the models and at the same time solve problems of multicollinearity among the indicator variables. The use of latent variables in transport research and travel behavior models is a regular practice.

Table 3. Description of the indicator variables used to calculate the latent variables

	Bogota		Medellin		Mexico City	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Car - Dependence						
I would keep using my private vehicle even if gas prices rise/increase	3.200	1.240	3.330	1.210	3.270	1.300
My private vehicle is essential in my life	3.620	1.210	3.490	1.170	3.650	1.190
I use my private vehicle for all my travels even for short distances	3.220	1.290	3.130	1.290	3.080	1.270
When I cannot use my vehicle, I use an app-based service	3.910	1.020	3.820	1.140	3.960	1.110
Car - Affinity						
Affordability	3.950	0.992	4.120	0.894	3.940	0.966
Travel time reliability	4.280	0.899	4.410	0.836	4.340	0.845
Easiness to use	4.410	0.864	4.540	0.755	4.530	0.778
Comfort	4.750	0.593	4.740	0.560	4.710	0.651
Car - Personal security						
Safety against robbery	4.070	1.010	4.060	0.983	4.000	0.981
Safety against accidents	3.820	1.040	3.780	1.090	3.840	0.986
Safety against any type of violence	3.990	1.040	3.960	1.030	3.900	1.060
Safety against sexual violence or sexual harassment	4.180	1.100	4.200	1.070	4.170	1.040

We consider three latent variables: (i) *"car dependence"*, the degree to which individuals are attached to their cars; (ii) *"car affinity"*, encompassing characteristics of cars that car users can find instrumental to keep using cars; and *"car personal security"*, shedding light on the fact that people can see cars as a safer mobility in contrast to other forms of transportation and that is relevant for Latin-American cities experiencing high crime rates and crime problems in public transportation systems. In Table 3 we show the mean value and standard deviation of all the indicator variables used for the CFA. By the same token, Figure 5 shows the path diagram of the CFA.

Figure 5. Path diagram for the CFA.

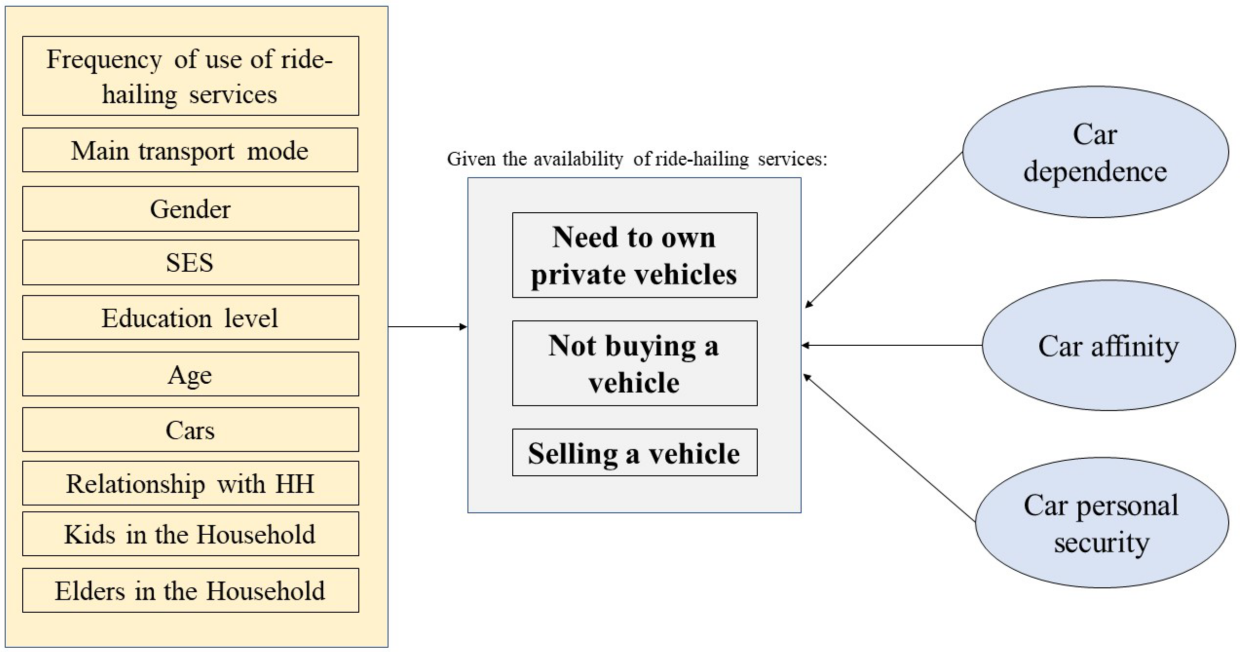


Note: An oval represents a latent variable, and a square represents and indicator variable. Arrows go from the latent variable to the because the latent variables cause the score observed in the indicator variables and the correlation among the indicators.

CFA is assessed by looking at the strength and significance of the factor loadings (the arrows from the latent variables to the indicators in Figure 5), the explained variance in the factor loadings (communalities), and the overall logic of the proposed model. Also, several goodness of fit measures must be revised. We follow Brown (2015) and use the Standardized Root Mean Square (SRMR), the Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index CFI and the Tucker-Lewis index TLI (Brown, 2015). There are several guidelines on what thresholds to use for each index (Brown, 2015; Kline, 2016). We decided to go with the standard approach of a SRMR below 0.08, an RMSEA below 0.06, and CFI and TLI above 0.95 (Brown, 2015; Hu and Bentler, 1999).

The third part of the model is a set of demographic controls. We incorporated all variables presented in the description of the sample (see Table 1). The final representation of the model is presented in Figure 6.

Figure 6. Path diagram for the statistical models.



Note: For the models analyzing non-car commuter the latent variables (Car dependence, Car affinity, and Car personal security) are not calculated. For the models of "Selling" the regressor "Cars" is not included.

For the first two outcome variables there are other two alternatives that we tested. The first alternative is to aggregate the original five categories into three categories and fit an OLOGIT. The second alternative is to treat the variables as continuous variables in a linear regression approach, and as we are including latent variables, the most natural step is to use Structural Equation Models SEM. We test the two alternatives for all the specified models (by city and by non-car and car commuters). Results (not included here) for the OLOGIT with three categories show similar estimates and significance levels than the models considering five ordinal categories (and presented in the next section). Regressors showing significant estimates in the OLOGIT models are also significant in the SEM. The reason for preferring the OLOGIT over the SEM is that the estimates of the OLOGIT can be interpreted in terms of odds ratio, while the standardized estimates of the SEM are interpreted as changes in standard deviations.

As a robustness check and with the purpose of identifying any endogeneity, omitted variable bias, and multicollinearity, we tested all the models without the variable "Frequency of use of ride-hailing services." The logic with these robustness checks is that many of the variables included in the models might at the same time influence the outcome and the usage of ride-hailing services. For example, it has been consistently reported that highly educated people are more likely to use ride-hailing, and at the same time, it would be expected that they are more prone not to switch from car ownership.

4. Results

In Table 4 we present the results for the CFA used to compute the three latent variables related to car ownership perceptions, including the features provided by cars, and the perception of personal security people experience from owning and using a car, which are included for all the models using the database of only car commuters. In Table 4 we present the unstandardized solution (column estimate) and the standardized solution (column SC) of the factor loadings, which are interpreted as the effect of the latent variable on each indicator variable. Following standard CFA methodology, the first indicator on every latent variable is forced to be one in the unstandardized solution. All factor loadings have statistically significant p values below 0.001, and more importantly, all the goodness of fit measures considered to assess the model are within the recommended thresholds. Table 5 shows the results for the "substitution" models (first outcome variable) and Table 6 presents the results for the "not buying" models (second outcome variable). Table 7 displays the results for the "selling" model (third outcome variable), where, as mentioned previously, models are only fitted for regular car commuters but the division by city is kept. Estimates in Tables 5 to 7 are presented as log odds of the OLOGIT and logistic models.

The "Frequency of use of ride-hailing services" is associated with a large and significant upward effect on the willingness to forgo auto ownership. In the non-car commuter group, the log odds estimates are 0.107 for Bogota, 0.131 for Medellin, and 0.095 for Mexico City. In terms of odds ratio, the association with the outcome variables is 11.3% in Bogota, 14% in Medellin, and 10% in Mexico City. This suggests that more frequent users of ride-hailing services are more likely to believe that they can, at some extent, not need to own a car. The level of adoption of ride-hailing services could be influenced by demographic variables such as education, income, and gender. Therefore, there could be a confounding effect. To assess this, we run the same models taking out the "Frequency of use of ride-hailing services" finding similar estimates and p values in all the other variables that remained in the model. The effect of ride-hailing frequency is higher for the group of car-commuters. The estimate for Bogota is 0.115 (p values equals to 0.057), for Medellin is 0.271, and for Mexico City is 0.161. The higher estimates for car commuters than for non-car commuters might point at people regularly using cars experiencing most of the burdens and benefits of car-based mobility and, when using ride-hailing, having more instruments to think that owning a car is no longer necessary. Also, Medellin shows higher estimates, something that could be linked with that city having a diverse public transit system with better levels of quality and coverage than Bogota and Medellin. This could reinforce the idea that people could avoid car ownership if there is a combination of using public transit (or walking and cycling) for their most regular trips and ride-hailing for non-typical and less frequent trips.

For the group of non-car commuters, and taking public transit as the reference category, walking or cycling do not show a significant effect. The category "other" (that includes modes like taxi or informal transportation) is significant only for Medellin and the effect is considerably high (-0.361). Gender, education level, and relationship with the head of the household do not show any significant effect on any of the six models in the "substitution" outcome. The SES variable has heterogenous effects across the three cities. For the non-commutes group the only significant result is for the high SES category in Medellin with a high estimate of 0.390, something that contrasts with the -0.928 significant effect for the SES in the Bogota's car commuter group. The only other estimate in the car commuter group is the medium category in Mexico City (0.112).

Table 4. Results for the CFA

	Estimate	SE	SC	R2
Car - Dependence				
I would keep using my private vehicle even if gas prices rise/increase	1	---	0.570	0.325
My private vehicle is essential in my life	1.177	0.094	0.707	0.500
I use my private vehicle for all my travels even for short distances	1.235	0.098	0.689	0.475
When I cannot use my vehicle, I use an app-based service	0.403	0.062	0.266	0.071
Car - Affinity				
Affordability	1	---	0.587	0.345
Travel time reliability	1.035	0.074	0.675	0.456
Easiness to use	1	0.07	0.699	0.488
Comfort	0.595	0.052	0.554	0.307
Car - Personal security				
Safety against robbery	1	---	0.732	0.536
Safety against accidents	1.016	0.049	0.714	0.51
Safety against any type of violence	1.277	0.051	0.886	0.786
Safety against sexual violence or sexual harassment	1.109	0.050	0.754	0.569

Estimates of the factor loadings are presented in column Est. All factor loadings are significant (p value < 0.01)
SE stands for standard errors
SC stands for standardized coefficient
SRMR: 0.036; RMSEA: 0.05 (0.041, 0.058); TLI: 0.954; CFI: 0.966

Table 5. Ride-hailing effects on attitudes towards private vehicle substitution

	Non-car commuters			Car commuters		
	Bogota	Medellin	Mexico City	Bogota	Medellin	Mexico City
	Est	Est	Est	Est	Est	Est
Car Dependence	---	---	---	-0.732 ***	-0.409 .	-0.644 ***
Car Affinity	---	---	---	0.057	-0.344	-0.380
Car Personal Security	---	---	---	-0.039	0.402	0.402 .
Frequency of use of ride-hailing services	0.107 ***	0.131 ***	0.095 ***	0.115 .	0.271 ***	0.161 **
Main transport mode						
Public Transit	ref	ref	ref	---	---	---
Walking/Cycling	-0.212	0.042	-0.093	---	---	---
Other	-0.023	-0.361 **	0.238	---	---	---
Gender						
Male	ref	ref	ref	ref	ref	ref
Female	0.154	-0.003	0.099	-0.258	0.271	0.005
SES						
Low	ref	ref	ref	ref	ref	ref
Medium	0.112	0.022	-0.167	-0.061	0.690 .	0.112 *
High	0.139	0.390 *	-0.218	-0.928 **	0.054	0.100
Education level						
Low	ref	ref	ref	ref	ref	ref
Medium	-0.225 .	0.056	-0.169	0.184	-0.455	-0.239
High	-0.146	0.106	0.093	0.017	0.194	-0.554
Age						
15 to 20 years old	0.029	-0.468 **	-0.271	-0.245	0.508	0.270
20 to 30 years old	0.119	-0.377 **	-0.015	-0.052	0.444	-0.153
30 to 40 years old	ref	ref	ref	ref	ref	ref
40 to 50 years old	0.163	0.203	0.130	0.619 *	0.375	-0.264
50 to 60 years old	0.218	0.418 *	0.451 *	0.722 *	0.600	-0.332
60 to 70 years old	0.178	0.383	-0.444	0.604	1.252	-0.027

	Non-car commuters						Car commuters					
	Bogota		Medellin		Mexico City		Bogota		Medellin		Mexico City	
	Est		Est		Est		Est		Est		Est	
Cars												
None	ref		ref		ref		---		---		---	
One	-0.314	**	-0.113		-0.315	**	ref		ref		ref	
More Than One	-0.371	*	-0.132		-0.161		0.170		-0.441		-0.070	
Relationship With the Head of Household (RHH)												
Head of Household	ref		ref		ref		ref		ref		ref	
Partner	-0.143		-0.243	.	0.019		-0.085		0.137		-0.161	
Child	-0.189		-0.042		-0.052		0.553		0.177		-0.396	
Other	-0.071		0.166		-0.168		-0.593		0.010		0.048	
Kids in the Household												
None	ref		ref		ref		ref		ref		ref	
One	0.056		-0.058		-0.014		0.517	.	0.181		0.002	
Two	0.213		0.459	**	-0.242		0.763	*	0.256		0.431	
More Than Two	0.437		0.738	*	-0.024		0.907		-1.164		0.357	
Elders in the Household												
None	ref		ref		ref		ref		ref		ref	
One	0.151		0.039		0.370	**	-0.266		0.168		-0.001	
More Than One	0.163		0.318	*	0.554	***	-0.575	.	0.249		-0.481	
Sample size	1537		1563		1393		347		238		349	

Estimates are presented as log odds.
Statistical significance as follows: *** p<0.01, ** p<0.05, * p<0.1

For age, Medellin once again shows an interesting partner in the non-car commuter group. Younger people (between 15 and 30 years old) are least likely to agree to not needing a car due to the presence of ride-hailing services and people between 50 and 60 years are more likely to agree. These results could reflect an aspirational attitude of younger people. Among car commuters, the only significant effects are observed for Bogota in the 40 to 50 years old cohort (0.619) and the 50 to 60 years old cohort (0.722).

Results in Table 5 show that, as expected, owning a car is not associated with the perception about substitution of car commuters. For the case of non-car commuters owning vehicles, current car ownership is negatively associated with the perception of substitution. In other words, people owning cars but not regularly using them might still not believe that ride-hailing is not flexible enough to replace having a car available when needed.

Household composition seems relevant for Medellin and Mexico City. In Medellin, having two or more than two kids in the household, as well as having more than two elders is significant for the non-car commuter models. In Mexico City, having one or more than one elder is significant.

Table 6. Effects on stated intentions regarding buying a personal vehicle

	Non-car commuters						Car commuters					
	Bogota		Medellin		Mexico City		Bogota		Medellin		Mexico City	
	Est		Est		Est		Est		Est		Est	
Car Dependence	---		---		---		-0.801	***	-0.755	**	-0.24	
Car Affinity	---		---		---		0.569	.	-0.349		0.09	
Car Personal Security	---		---		---		-0.526	*	0.093		-0.18	
Frequency of use of ride-hailing services	0.145	***	0.174	***	0.145	***	0.176	**	0.223	**	0.09	
Main transport mode												
Public Transit	ref		ref		ref		---		---		---	
Walking/Cycling	0.056		0.092		0.386	.	---		---		---	
Other	-0.310	*	-0.064		-0.004		---		---		---	
Gender												
Male	ref		ref		ref		ref		ref		ref	
Female	0.017		0.035		-0.121		0.177		0.107		-0.479	*
SES												
Low	ref		ref		ref		ref		ref		ref	
Medium	-0.089		-0.045		0.236		-0.154		0.457		-0.455	
High	0.044		0.141		0.438	**	-0.487		-0.387		-0.61	
Education level												
Low	ref		ref		ref		ref		ref		ref	
Medium	0.189		-0.172		-0.050		-0.040		0.626		-0.33	
High	0.182		0.033		0.076		0.000		0.349		-0.055	
Age												
15 to 20 years old	0.164		-0.329	.	-0.060		-0.292		0.254		1.664	***
20 to 30 years old	0.131		-0.135		-0.081		-0.031		0.438		0.591	.
30 to 40 years old	ref		ref		ref		ref		ref		ref	
40 to 50 years old	0.309	*	0.161		-0.309	*	0.261		0.654	.	-0.337	
50 to 60 years old	0.359	.	0.362	.	-0.080		-0.195		0.210		-0.244	
60 to 70 years old	0.425		-0.325		-0.449		0.236		-0.611		0.107	
Cars												
None	ref		ref		ref		---		---		---	
One	-0.113		-0.028		0.066		ref		ref		ref	
More Than One	-0.373	*	-0.147		-0.177		-0.194		-0.202		-0.401	.
Relationship With the Head of Household (RHH)												
Head of Household	ref		ref		ref		ref		ref		ref	
Partner	-0.005		-0.060		0.029		-0.240		-0.339		-0.208	
Child	-0.094		0.052		-0.016		0.278		-0.348		-0.318	
Other	-0.114		0.005		-0.315		-0.374		0.633		-0.422	

	Non-car commuters						Car commuters					
	Bogota		Medellin		Mexico City		Bogota		Medellin		Mexico City	
	Est		Est		Est		Est		Est		Est	
Kids in the Household												
None												
One	0.188	.	-0.124		0.028		0.098		0.150		-0.342	
Two	0.353	*	0.491	**	0.085		0.189		0.656		-0.075	
More Than Two	0.614	*	-0.217		0.002		1.061	.	-0.308		-0.784	
Elders in the Household												
None	ref		ref		ref		ref		ref		ref	
One	0.314	**	0.299	**	0.049		-0.037		-0.159		0.515	*
More Than One	0.470	**	0.351	*	0.036		0.071		-0.608		0.124	
Sample size	1537		1563		1393		347		238		349	

Estimates are presented as log odds.
Statistical significance as follows: *** p<0.01, ** p<0.05, * p<0.1

For the "not buying" variable (Table 3), the association of frequency of use of ride-hailing services is also strong and significant in most of the cases. The estimates for this variable in the non-car commuter models are 0.145 for Bogota, 0.174 for Medellin, and 0.145 for Mexico City. For the car commuters the estimates for Bogota and Medellin are higher (0.176 and 0.223, respectively) and not significant for Mexico City. As in the "substitution" outcome, the estimates for ride-hailing usage in the "not buying" outcome is higher for Medellin.

Any of the latent variables (in the car commuter models) are significant for Mexico City. The "Car dependence" latent variable is strong, negative, and significant for Bogota (-0.801) and Medellin (-.755). The latent variable "Car personal security" is also strong, negative, and significant for Bogota (-0.526). The other latent variable, "Car features" is not significant in any of the three cities.

As opposed to what we were expecting, results suggest that for non-car commuters in Bogota and Medellin having more kids and elders in the house is associated with agreeing that the presence of ride-hailing services have been an influence in not buying a vehicle. The estimates for having two or more than two kids in Bogota are 0.353 and 0.614, respectively. In Medellin the estimate for having two kids is 0.491. Having two elders in the house has significant estimates of 0.314 for Bogota and 0.299 for Medellin. These estimates show a slight increase for having more than two elders to 0.470 in Bogota and 0.351 in Medellin. For the group of non-car commuters in Mexico City none of the categories of the kids and elders in the household variables are significant. For the car-commuters model, only having one elder in the household is significant (0.515).

Results for the third outcome variable (selling) are presented in Table 7. Mexico City does not show any significant estimate, so the results limit to Bogota and Medellin. The latent variables car dependence and car personal security are significant for Bogota and not significant for

Medellin. The latent variable *car features* is not significant for any of the cities. The frequency of use of ride-hailing services is only significant for Medellin (estimate of 0.5425).

Table 7. Results for the third outcome variable: selling

		Bogotá		Medellin		Mexico City
		Est		Est		Est
Intercept		-1.587	.	-3.317	*	-1.791
Car Dependence		-0.768	*	-0.220		-0.165
Car Affinity		0.936	.	-0.797		-0.192
Car Personal Security		-0.733	*	0.551		0.223
Frequency of use of ride-hailing services		0.147		0.543	**	0.086
Gender						
	Male					
	Female	-0.414		-0.864		-0.444
SES						
	Low					
	Medium	-0.611		-0.336		0.217
	High	-0.586		-1.001		-0.034
Education level						
	Low					
	Medium	0.080		0.843		-0.073
	High	-0.391		1.152		-0.256
Age						
	15 to 20 years old	-2.205	*	1.487		1.118
	20 to 30 years old	-0.872		0.355		0.307
	30 to 40 years old					
	40 to 50 years old	0.136		0.110		-0.533
	50 to 60 years old	0.074		-0.763		0.127
	60 to 70 years old	-0.158		-15.104		0.369
Cars						
	One					
	More Than One	0.959		-2.284		-0.486

	Bogotá		Medellin		Mexico City
	Est		Est		Est
Relationship With the Head of Household (RHH)					
Head of Household					
Partner	-0.880	.	1.292	.	0.260
Child	0.270		-0.188		-0.115
Other	-14.838		-17.067		-0.280
Kids in the Household					
None					
One	0.712	.	1.096		-0.379
Two	-0.064		2.441	*	0.168
More Than Two	1.484	.	-17.343		-0.021
Elders in the Household					
None					
One	-0.116		-2.298	*	-0.861
More Than One	0.378		0.277		-0.084
Sample size	347		238		349

Estimates are presented as log odds.
Statistical significance as follows: *** p<0.01, ** p<0.05, * p<0.1

5. Conclusions and policy implications

Efforts to address the issue of motorization have been undertaken through various measures (Buehler et al., 2017), ranging from significant investments in public transit to policies designed to discourage car use. Despite these attempts, urban development models based on cars have led to the exacerbation of issues such as congestion, poor air quality, urban sprawl, and social inequality in the Latin American and Caribbean (LAC) region over the past two decades (Scholl et al., 2022). For instance, Bogota introduced Transmilenio in the year 2000, the first large scale Bus Rapid Transit BRT system in the world, which quickly became a standard for urban planning and was replicated in other Colombian cities and other developing countries (Gilbert, 2008). However, even with this significant investment in public transit, Bogota continues to struggle with environmental problems and social segregation and remains at the top of congestion rankings (Gómez-Lobo, 2020; Oviedo and Sabogal-Cardona, 2022; Oviedo and Titheridge, 2016). Medellin and Mexico City have also implemented a range of public transit alternatives, including metro, BRT, bikeshare systems, and even aerial cables in the case of Medellin (Brand and Dávila, 2011; Heinrichs and Bernet, 2014; Levy and Dávila, 2017). Despite this, these two cities still suffer from a high level of automobile dependence.

In light of this, promoting public transit, cycling, and walkability should continue to be a priority in the urban mobility agenda (Scholl et al., 2022). Emerging technologies in transportation and the advent of app-based mobility services can be viewed as both a threat and an opportunity. Specifically speaking of ride-hailing, the implications for car ownership and car dependency remain unexamined. This article investigates the impact of ride-hailing services on attitudes and beliefs towards car ownership, examining three attitudinal effects: 1) ride-hailing may lead to a perception that owning a car is no longer necessary, 2) ride-hailing may influence behavior in not purchasing a car, and 3) ride-hailing may influence behavior in selling private vehicles.

The article concludes that ride-hailing is associated with a change in perceptions about car ownership. A large percentage of urban residents believe that the prevalence of ride-hailing services reduces their individual car dependency and need to buy a car; furthermore, a significant share of those who do own cars, are considering selling them due to the availability of ride-hailing services. The study also indicates that, on an individual level, ride-hailing frequency is associated with a lower propensity for car affinity. The central argument in this work is that ride-hailing could reduce car ownership only in the context complementary polices to discourage single occupancy motor vehicle trips, such as pricing policies and investments in the provision of high-quality and affordable public transit systems and adequate infrastructure for walking and cycling in urban areas.

The ideal scenario would be one in which people walk, cycle, or use public transit for their regular trips, and rely on ride-hailing for the least frequent trips that cannot be completed in the aforementioned alternatives (Oviedo et al., 2021; Sabogal-Cardona et al., 2021). This would allow people to avoid owning a car. It also implies that ride-hailing services should offer flexibility, in terms of being available when and where needed, similar to the flexibility people perceive in having a personal car.

If ride-hailing is to be seen as a complement to public transit, then policies should not only aim to expand and improve public transit, but also create scenarios for transit users to remain as such and use ride-hailing when public transit is not an option. Two policies that the authors suggest are: 1) ride-hailing trips that directly compete with public transit should have a higher fare than ride-hailing trips that do not compete with public transit (Young et al., 2020), and 2) regular users of public transit should be offered discounts when requesting ride-hailing services; for example, if someone buys a monthly subscription of mass transit or performs a certain amount of trips, can be offered premium rate for ride-hailing trips. It would be also interesting if the added price to the fare in ride-hailing, whether because the trip is competing with public transit or because it was not requested by a regular public transit user, is invested into funding public transit.

The present study acknowledges the existence of other mechanisms, beyond the scope of this research, which may affect people's decision to own cars through the use of ride-hailing services. For instance, individuals who lead car-free lifestyles may use ride-hailing services to experience the convenience of private mobility, leading to a possible transition towards car ownership. This aspect is particularly relevant for younger generations in the Global South, who not only use ride-hailing services more frequently but also have lower car ownership rates. Thus, ride-hailing services may act as a delaying factor or even a trigger for vehicle acquisition for this segment of the population. By the same token, in the context of a lack of high-quality and well-paid jobs and an ample offer of informal employment, it is expected that some citizens find in ride-hailing a way into increase their wages. Drivers attracted to ride-hailing could purchase cars that, even if they quit working with TNCs and find another economic activity, could preserve. It is anticipated that these unexplored avenues would be considered for future research.

This work and the interpretation of the results have some limitations worth noting. First, we explored changes in perceptions surrounding car ownership and not real or revealed behaviors. Respondents of the survey might believe that owning a car is no longer necessary and may even consider selling their private vehicle, but this does not mean that they will necessarily do so. This could be due to the possibility that the decision to not own a vehicle has to be negotiated with other members of the household, or concerns around the availability and coverage of other transport alternatives (such as public transit) for their primary trips. As shown in the literature review section, the majority of the previous studies were at an aggregated level and used general trends of car sales or car registrations, leaving out the specific behavior of users. We believe that further research should include longitudinal studies at the individual level, measuring personal changes on car ownership. A second limitation is that data was gathered during COVID-19 protocols that included social distancing, stay at home orders, and other restrictions in response to the Coronavirus pandemic were still in place. To some extent, the results could also be influenced by perceptions about the pandemic. Finally, a third limitation is that we only considered large urban areas with several mass transit systems. How ride-hailing is impacting perceptions surrounding car ownership could follow a different trajectory in smaller cities with lower motorization rates and should be examined in future research.

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