Ride-hailing and (dis)Advantage: Perspectives from Users and Non-users

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Contents

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Abstract

The introduction of ride-hailing in cities of Latin America and the Caribbean remains a relatively new topic in regional research and a contentious issue in local policy and practice. Evidence regarding users and how do they differ from non-users is scarce, and there is little documented evidence about how user preferences and perceptions may influence the uptake of ride-hailing. This paper uses primary data from a survey collected from users and non-users of ride-hailing in Bogotá during 2019 to develop a Latent Class Analysis (LCA) to identify clusters of users and non-users of ride-hailing. The paper builds on results from the LCA to reflect on conditions of advantage and disadvantage that may make ride-hailing attractive and beneficial for particular social groups. The paper identifies four unique clusters: Carless middle-income ride-hailing users, Disadvantaged non-users, Young middle-class non-users, and Advantaged ride-hailing users. The research uses data on such perceptions to draw insights that may inform commercial and policy decisions. Findings suggest that issues such as the perception of legality in ride-hailing and aversion to crime play a significant role in the choice of such a mode in the context of Bogotá, particularly among socially and transport advantaged users.

Keywords: Ride-hailing, Transport Disadvantage, Uber, Inequality, Colombia, Latin America

Acronyms

LAC	Latin America and the Caribbean
LCA	Latent Class Analysis
LATAM	Latin America
MAAS	Mobility as a Service
SES	Socioeconomic Strata
TNC	Transportation Network Company

1. Introduction

This paper is part of a broader research agenda led by the Transport Division of the Inter-American Development Bank that seeks to understand the links between new urban mobility services provided by Transportation Network Companies (TNCs) and broader transport-related inequalities in cities of Latin America. The paper is strongly aligned with the Transportation Sector Framework of the Bank's Transportation Division (Roa *et al.*, 2020), which recognizes limited inclusion and sustainability of urban mobility as a key challenge in Latin America. The paper responds to the needs for knowledge and information, and the promotion of technological transformations in the sector, which are identified as key lines of action for the improvement of urban transport in the region. The paper provides concepts, methods, and evidence for addressing inequalities and disadvantages associated with urban mobility.

Ride-hailing companies (e.g., Uber, DiDi) have made a lasting mark in the urban transport marketplace in hundreds of cities worldwide. Features such as real-time tracking of drivers, splitting the fare with other riders, and competitive prices, have contributed to the expansion of ride-hailing, attracting demand mainly from the traditional taxi market (Zha et al., 2016). The introduction of ride-hailing into urban transport markets has met widespread protests from the traditional taxi industry, disputes to define their legal status, and pressure to local and national governments to address understand and regulate its economic, social, and environmental implications.

By 2018, Uber was operating 173 cities in Latin America and the Caribbean (LAC) (Uber, 2018), reporting over 25 million monthly active riders across 15 countries (Moed, 2018). In the same year in Colombia, the number of Uber riders had reached 2.2 million (CNN Español 2018). In Mexico, users are estimated to spend up to US$800 a year in services like Didi, Uber and Cabify (Gutierrez, 2018). In Cancun (Mexico), Uber received one million requests during 2018, although services were not operating locally (El Financiero, 2019). Mainstream media and emerging research suggest that demand increases more notable in cities where traditional taxi services and public transport are perceived to have low quality and crime rates are higher.

The visible growth of ride-hailing in LAC has inspired research aligned with significant themes in the international literature on the subject. Such themes encompass the examination of the links between ride-hailing and travel behavior, the impacts of ride-hailing on issues such as transit use, vehicle-km, congestion, and travel safety, and the analyses of labor conditions and regulation (Tirachini, 2020). While research in LAC has multiplied, most studies to date have examined the average effects and impacts of ride-hailing and treated users as a relatively homogeneous group. Behavioral research on ride-hailing shares common traits such as reliance on survey data and the examination of user behavior based on arbitrary categories focused on differences in variables such as class, age, or transport use. Moreover, despite a large body of research highlighting the social, economic and spatial inequalities in cities of LAC (Niehaus, Galilea and Hurtubia, 2016; Guzman, Oviedo and Rivera, 2017; Blanco and Apaolaza, 2018; Bautista-Hernández, 2020), there has been limited emphasis on distributional perspectives and the social disparities that may influence or be affected by ride-hailing in the region.

This paper seeks to contribute to the above gap by examining ride-hailing users and non-users from a perspective of social and transport disadvantage. The first refers to the combination of social characteristics and conditions that may impair the ability of people to participate in social and economic life (Gleeson and Randolph, 2002; Newburn, 2016). Socially disadvantaged groups include, among others, the poor, women, people with disabilities, ethnic minorities, or even people belonging to some cultural, religious or age group depending on the context. The second is a multi-dimensional construct that focuses on the effects of lack of transport and other external factors on individuals, which limit their ability to reach and be reached from places, thus having limited participation in social, economic, and cultural life (Hurni, 2007; Murray & Davis, 2001). From this perspective, factors such as choice of residential location, the spatial distribution of opportunities, having no access to a vehicle or the requirements to use it, and inadequate transport can lead to specific individuals becoming transport disadvantaged (Murray and Davis, 2001; Combs *et al.*, 2016).

Building on the above definitions, this research examines whether groups of users and non-users of ride-hailing can be characterized as being subject to conditions of social and transport advantage or disadvantage. The paper uses data from a primary survey conducted in 2019 in Bogotá, Colombia, with a sample of 1,390 respondents belonging to different socioeconomic groups and using most forms of motorized transport available in the city. The paper uses a Latent-Class Analysis model (LCA) to identify statistically significant heterogeneous groups of users and non-users. We build on the resulting latent classes to reflect on the typical demographic and socioeconomic characteristics that may place individuals and their transport behavior in particular conditions of (dis)advantage and their links with structural features of cities such as Bogotá. Furthermore, we analyze how different attitudes towards transport in general, and ride-hailing, can differ across groups. Findings seek to provide empirical evidence on the diversity of the demand for these new forms of urban mobility, as well as the different perceptions and experiences that users in different conditions of (dis)advantage have in relation to ride-hailing services. The paper suggests that the degree of advantage and disadvantage lie on a continuum and that different conditions of social and transport advantage and disadvantage can intersect and lead to different travel behaviors. Findings from this paper will inform additional debates in the region around differences in ride-hailing users from a perspective of social and transport inequalities.

The remainder of the paper is organized as follows. Section 2 will present a literature review summarizing ride-hailing research and its progress in Latin America and research exploring transport and social disadvantage. Section 3 will present a summary of data and methods. Section 4 will present findings both from the descriptive analysis and the modelling exercise that allowed the authors to identify the latent classes of users and non-users of ride-hailing in Bogotá. Finally, section 5 will present the study's conclusions and suggestions for avenues for new research.

2. Literature review

2.1. Ride-hailing research and its progress in LAC

The literature on ride-hailing has grown rapidly in recent years. A search for "ride-hailing" in Web of Knowledge shows a rise from 31 articles in 2018 to 774 in 2020, with an accent on research from Transport-related disciplines, Economics, and Engineering, and an emphasis in cities in North America, Europe, and China (Web of Science, 2020). Research has found variables such as income, education, digital connectivity, and proclivity to car ownership are associated with levels of ride-hailing adoption and use (Ma, Ross and Gustafson, 2001; Dias *et al.*, 2017; Etminani-Ghasrodashti and Hamidi, 2019; Alonso-González *et al.*, 2020; Sarjana, Ramadan and Sisiopiku, 2020). Moreover, concern about the impacts of ride-hailing has led a significant body of research to critically examine whether ride-hailing substitutes or complements public transit, finding differences in effects depending on the context, type of public transport systems, and segments of demand (Hall, Palsson and Price, 2018; Wang and Ross, 2019; Young, Allen and Farber, 2020).

Flexible on-demand services may fill significant spatial and temporal gaps left by rigid networks of public transport in contexts of marked spatial and accessibility inequalities such as Bogotá and many other cities in LAC. In the same vein, there is a risk that by substituting rather than complementing public transit, ride-hailing becomes a significant hinderance for accessibility due to affordable concerns and a potential erosive effect on transit. Although the international literature suggests that ride-sourcing services might entail negative social and distributional consequences (Poushter 2016; 2017), particularly in contexts in which it substitutes public transit, there is no explicit evidence of how these dynamics may play out in a context with a high dependency of public transport, and high inequalities in access to employment and education such as Bogotá (see Guzman et al., 2017a). Such hindrance to accessibility is manifested to the extent to which ride-hailing deteriorates ridership and leads to potential revenue shortfalls in public transit that may lead to service cuts that affect users that depend on public transport. Drawing on evidence from the United States, Clewlow and Mishra (2017) have suggested that some ride-sourcing users in areas with lower coverage of public transit can be more socially vulnerable, and that in some communities with lack of access to adequate public transit services in terms of frequency and availability, there is a potential for public transit substitution for short-distances trips where transit coverage is sparce. Other authors have also differentiated between competition and complementarity depending on context-specific conditions for regulation and operation of both ride-sourcing and public transit (Jin et al., 2018). Wang et al. (2019) explored the transport accessibility and social equity implications of Mobility as a Service (MAAS) in the United States, suggesting that flexible and on-demand transportation might respond to the needs of transit-deprived areas of the city if there is available purchasing power in the local population.

Interest in understanding the main drivers of ride-hailing use have led researchers to investigate the effect of individual characteristics and attitudinal variables alike through various analytical approaches. The majority of empirical research builds on survey datasets to apply techniques such as discrete choice modelling (Alemi, Circella, Handy, *et al.*, 2018; Alemi *et al.*, 2019; Habib, 2019; Tirachini and del Río, 2019; Oviedo, Granada and Perez-Jaramillo, 2020), exploration of latent constructs through confirmatory factor analyses and structural equations models (Etminani-Ghasrodashti and Hamidi, 2019; Lavieri and Bhat, 2019; Acheampong *et al.*, 2020), and clustering techniques such as Latent-Class Analysis (LCA) (Porcu and Giambona, 2016; Alemi, Circella, Mokhtarian, *et al.*, 2018; González *et al.*, 2018; Kong, Moody and Zhao, 2020).

A study in the context of Santiago de Chile found that ride-hailing is inversely correlated with riders' income and that more affluent, young travelers tend to use these services more (Tirachini and del Río, 2019). Similar research in Sao Paulo, Brazil, suggests over 80% of current ride-hailing trips used to be made by private car (Haddad *et al.*, 2019). About impacts on transit use, findings in Colombia, Brazil, and Chile suggest mixed results, with potentials for both substitution and complementarity depending on transit coverage, purchasing power and temporal and geographic availability (de Souza Silva, de Andrade and Alves Maia, 2018; Oviedo, Granada and Perez-Jaramillo, 2020; Tirachini *et al.*, 2020). In Bogotá, Oviedo et al. (2020) find that nearly 33% of the demand of ride-hailing can be potentially attracted from public transit, with nearly a third of that demand being direct competition. Moreover, the same study finds similar levels of demand attraction to ride-hailing from private vehicles and traditional taxis.

High rates of unemployment, economic informality, and localized economic downturns, even before the recent pandemic, across LAC may be increasing ride-hailing companies' ability to recruit drivers. In Brazil and Argentina, the growth of ride-hailing drivers has been connected to recent local economic crises (Darlington and Londoño, 2017; Alonso Ferreira *et al.*, 2018; Raszewski, 2018; Raszewski, Cohen and Rochabrun, 2018). In Mexico, around 40% of active Uber drivers in 2018 were unemployed before driving to provide ride-hailing services (Eisenmeier, 2018). In LAC, according to research covering contexts such as Mexico, Panama, Chile, Brazil and Colombia, between half and a third of drivers are working full time and belong to a broad spectrum of socioeconomic conditions, levels of education and degrees of private motorization (Eisenmeier, 2018; Azuara, González and Keller, 2019; Fielbaum and Tirachini, 2020; Tirachini *et al.*, 2020).

Ride-hailing's effects on stability of income, predictability in scheduling and reliability of long-term employment prospects have also been explored in LAC (Johnston & Land-Kazlauskas, 2019). In Mexico City (CDMX), while 29% of Uber's drivers work more than the standard working week (45 hours), Eisenmeier's (2018) findings from 32 interviews with Uber drivers show they attach a high positive value to having flexible hours. However, this is limited when the driver does not own the car and has a limiting arrangement with the owner or has taken a loan to buy the vehicle, a common situation in Mexico, Brazil, and Colombia (Eisenmeier, 2018; Venegas Loaiza, 2019). Such financial obligations not only change income available to the driver but also how flexible his or her working hours can be (Eisenmeier, 2018). In Chile, Fielbaum & Tirachini (2019) found that Easy, Uber y Cabify drivers in Santiago revealed considerable differences between their stated incomes (around $2,800), authors' high and low estimations ($3,072 and $3,974) and companies' promises ($8,823). In Brazil, an Uber driver estimated net income in Sao Paulo is R$54.27 daily (Azuara, O., González, S., & Keller, 2019), while the minimum income is R$ 33.27.

2.2. Transport and social disadvantage and their manifestation in LAC cities

Transport disadvantages and inequalities limit the travel capacity of socially disadvantaged groups. Most cities in LAC are characterized by high socio-economic spatial segregation or concentration of social groups (determined by income, ethnicity, and status, among others) in specific areas of a city or metropolitan region (Thibert and Osorio, 2014). Spatial mismatch between where people live and where they work poses a range of geographical barriers to employment for segregated and economically disadvantaged groups (McLafferty, 2015). In LAC, areas of economic activity tend to be far from where most of the middle and low-income population lives, leading to a spatial mismatch (E. Blumenberg, 2004; Fan, 2012; McLafferty, 2015; Ong & Blumenberg, 1998). Moreover, informal settlements and development of State-provided low-cost housing for the poor where land is still affordable lead most of the urban poor to live in the periphery or less attractive suburban areas (Gilbert, 1981; Thibert & Osorio, 2014; McLafferty, 2015; Tarazona, 2015).

Prohibitive costs in terms of money and time to travel in most cities of the region are one of the main consequences of urban and social structures of LAC cities. Residents of the largest 15 metropolitan areas in the region spent in average 1.1 hours/trip/day, which adds to over 118 million hours per day at the beginning of the decade (Montoya, Dirección de Análisis y Programación and CAF., 2011). Today, in many cities across the region, travel by public transport can imply spending between 1.5 and 2 times the average travel times in private vehicles (Vecchio, Tiznado-Aitken and Hurtubia, 2020). By being farther from the city center, socially disadvantaged citizens -who use public transport the most- experience long travel times, longer distances, congestion, and often low local coverage of public transport that requires long walking times (Hidalgo and Huizenga, 2013; Benevenuto and Caulfield, 2019; Vecchio, Tiznado-Aitken and Hurtubia, 2020). Economic expenditure can also be disproportionately high. People in large cities such as Bogotá spend in total 82 million US$ per day in transport, of which 78% are spent in the use of private vehicles. Average expenditure per trip in public transport is 0.7 US$, while in private vehicles this average is 4 US$ (UNCRD-IDB, 2011). This cost can become a heavy burden for low-income households. Disadvantaged populations can spend up to 25% of their income, while car users tend to spend on average below 10% (Bocarejo & Oviedo, 2012; Falavigna & Hernandez, 2016; Yañez-Pagans et al., 2019).

Car use tends to be associated with conditions of transport advantage and to be accessible mostly to higher-income groups and those in socially advantaged circumstances. Car and motorcycle ownership rates in Latin America is highly correlated with income and population distribution (Acevedo, 2013). With rising middle classes and transition from low to middle-income levels, there is an expected increase in both automobiles and motorcycles in cities of the region. Nonetheless, motorization rates in LAC are still low compared to industrialized countries. The number of cars per 1,000 inhabitants varies from 55 in Ecuador to 185 vehicles in Mexico (UNCRD-IDB, 2011). Countries in the lowest range of motorization rates such as Peru and Bolivia are between 51 and 56 cars per 1,000 inhabitants, while the same figures in Venezuela, Chile and Argentina are between 135 and 165 cars/1,000 inhabitants. Motorcycles, which have a much lower income threshold for purchasing and daily operation, have experienced rapid growth in the region (Gómez & Acevedo, 2013). In Uruguay, the number of motorcycles per 1,000 inhabitants reaches 141 vehicles, while in Brazil and Colombia, this figure is 81 and 68, respectively (Hidalgo and Huizenga, 2013). These figures are expected to increase in the coming years as a result of economic growth and a reduction in the price of vehicles being distributed. For example, the number of motorcycles in Brazil increased by 38% annually between 2000 and 2010 while in Colombia and Mexico growth rates have been between 14.7% and 16.4% per year, respectively. On average, cars have increased by about 6% annually in the region (Hidalgo & Huizenga, 2013; UNCRD-IDB, 2011).

The unequal distribution of travel resources and costs, in combination with the urban and functional structures of cities in the region, suggests a marked divide along the lines of social and transport advantage/disadvantage. Such a divide has as consequences inequalities in access and social inclusion across the urban population in LAC. Ride-hailing may contribute to conditions of advantage or disadvantage by enabling added benefits in terms of costs, convenience, or comfort to its users, while affecting negatively non-users already at a disadvantage given its contribution to congestion and pollution.

3. Data and methods

This research builds on data from a survey collected between October and November 2018 with the participation of 1,390 residents of Bogotá, Colombia. The survey consisted of 29 questions in four sections. The first section included sociodemographic information about the individual such as age, gender, vehicle ownership, household socioeconomic strata (SES), education level, occupation, and neighborhood of residence. SES is a standard proxy used in Colombia to household income, which categorizes households into six categories, where the lower the stratum, the lower the income (Cantillo-García, Guzman and Arellana, 2019). Information about the most recent trip was collected, including the start time of the trip, purpose, travel time and cost, mode of transport and vehicle occupation, among other relevant travel features. Additionally, we collected perception information about the reasons for selecting their current modes, their potential reasons to shift to ride-hailing and their overall perception of ride-hailing services using a Likert scale ranging from 1 (strong disagreement) to 5 (strong agreement). The sampling frame does not intend to be representative of the whole city of Bogotá. However, the size of the dataset is large and diverse enough to reach relevant conclusions about the make-up of ride-hailing demand at the time of data collection. Building on the information available from the Household Travel Survey of the city for 2015, the team identified the areas with higher demand for ride-hailing services and traditional taxis, seeking to understand the patterns of areas where a larger share of the population used the type of services app-based ridesourcing can provide. The survey was administered as an interception survey. This means a higher proportion of middle and middle-high income users in the sample, with lower rats of response in low-income neighbourhoods, particularly those in the periphery.

The sample was cleaned to remove respondents with short (i.e., least than 5 minutes) and high (i.e., more than 2 hours) response times in the web-based responses. We also removed surveys with more than 70% of unanswered questions. After data cleaning, the sample was filtered based on the following criteria: 1) Trips in the last month within the city in any of the conventional public transport, taxis, private vehicle, or ride-hailing and with a trip frequency of at least three times per week. 2) Trips which last at least 15 minutes. The final sample selected for analysis was 1,390 respondents. Data analysis

Survey data was analyzed through two complementary approaches. First, we applied exploratory data analysis to the full sample to understand aggregated travel patterns, characteristics, and perceptions. Such findings allow us to reflect on trends associated with the use of specific modes and overall travel behavior. Second, we used a Latent Class Analysis (LCA) to identify sub-population groups that allow disentangling heterogeneity in conditions of advantage and disadvantage and to separate users and non-users of ride-hailing based on more than their mode choice. Based on the formulation of the LCA, we seek to test the hypothesis that specific conditions of (dis)advantage are strongly associated with both travel behavior and perceptions of ride-hailing in relation to other modes of transport[1].

LCA is a form of statistical analysis applied regularly in social sciences to sort individuals into unobserved clusters with similar characteristics or behavioral patterns (Denson and Ing, 2014;

[1] See code for LCA used in this paper in Appendix 1 of this document

Porcu and Giambona, 2016). LCA extends the notion of latent constructs from unobserved variables to unobserved groups to identify clusters that show marked differences with each other while remaining as homogenous within each cluster as possible. LCA builds on categorical indicators (measurable variable) to estimate a categorical latent construct. The research has selected LCA as a preferred option for the study despite other clustering methods such as the k-means method being available. Although methods such as the latter have been used in previous research in transport and in the local context (Rosas-Satizábal, Guzman and Oviedo, 2020), LCA has the advantage of allowing the researchers to differentiate statistically unique groups from a sample, while methods such as k-means builds on more input from researchers, and requires higher familiarity with the sample. As ride-hailing is a relatively new form of transport services in the local context, the latent component of LCA will serve to inform a more reliable estimation of the composition of the clusters. LCA has been deployed in the study of transportation and urban issues (González *et al.*, 2018; Lee *et al.*, 2020), and it is most useful when researchers do not know the number of clusters in the data. In such cases, LCA analysis is run for several target numbers of categories, seeking to maximize goodness of fit and interpretability. LCA's goodness of fit can be assessed through the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). A model with lower values in these two metrics is preferred.

The LCA specification for this study considers SES, age, gender, education level, vehicle ownership, driver license availability and usual transport mode as individual characteristics that have been used in the literature as proxies of both social and transport disadvantage. Indicators in our model include responses to perception questions related to preferred features of transport modes that can also be related to conditions of advantage and disadvantage such as time savings, lack of alternative options, safety from crime, other aspects of safety such as traffic accidents, payment methods, and overall attitude towards ride-hailing. All data processing and plots were performed in the R programming language (Wickham *et al.*, 2019), and the LCA was run with the poLCA package (Kennedy, 2013).

4. Findings

4.1. Descriptive analysis

Users in the sample reflect a population that travels frequently, predominantly in an economically active age group, with a larger proportion of men and mostly middle-SES. The sample reflects more mobile populations in the local context, understood as those that use a motorized mode of transport at least three times per week. Table 1 summarizes the main characteristics of the sample. As shown, over 70% of respondents travel by public transport, and over 95% is educated above High-school level. Moreover, most people in the sample are employed or attending school as their primary activity and have income above the minimum wage for Colombia in 2018 ($781.242) with over 85% of the population reporting income above COP 2.5M.

Table 1 Descriptive statistics

	A subsample (for LCA)	
	People in Survey	Percentage
SES		
High (SES 5 and 6)	133	9.57%
Medium (SES 3 and 4)	892	64.17%
Low (SES 1 and 2)	365	26.26%

Gender		
Male	806	57.99%
Female	574	41.29%
Prefer not to say	10	0.72%
Age		
0 - 15	4	0.29%
15 -20	143	10.29%
20 - 30	538	38.71%
30 - 40	361	25.97%
40 - 50	191	13.74%
50 - 60	110	7.91%
More than 60	43	3.09%
Education level		
No education	3	0.22%
Primary school	18	1.29%
Middle school	30	2.16%
High school	301	21.65%
Technical	281	20.22%
University	567	40.79%
Postgraduate	190	13.67%
Transport Mode		
Public Transport	1001	72.01%
Car	177	12.73%
Taxi	75	5.40%
Ride hailing	137	9.86%
Driving License		
Yes	669	48%
No	721	52%
Reduced mobility		

Yes	15	1%
No	1375	99%
Work situation		
Employee or self-employed	1099	79%
Student	204	15%
Homemaker	17	1%
Retired	39	3%
Unemployed	14	1%
Other	17	1%
Reported household monthly income		
$0 to $2,500,000*	193	14%
$2,500,001 to $5,000,000	807	58%
$5,000,000 to $7,500,000	204	15%
$7,500,000 to $10,000,000	101	7%
$10,000,001 to $12,500,000	65	5%
$12,500,001 to $15,000,000	20	1%
$15,000,001 to $20,000,000	0	0%
More than $20,000,000	0	0%

*Income data is expressed in COP: 1 USD = $3,300 COP

Survey participants were asked to report the features of their most recent trip. For such a trip, 75% of respondents report having travelled in the morning (between 5 and 10 a.m.) which was consistent with the most frequent reason for traveling. For most participants, their reported trip was made for work (79%), and these trips were reported as frequent or very frequent (88%). For the afternoon, trips were reported to different destinations between work and home and trip frequency was lower. The data in the sample also shows that 94% of users reported their tips between Monday and Friday.

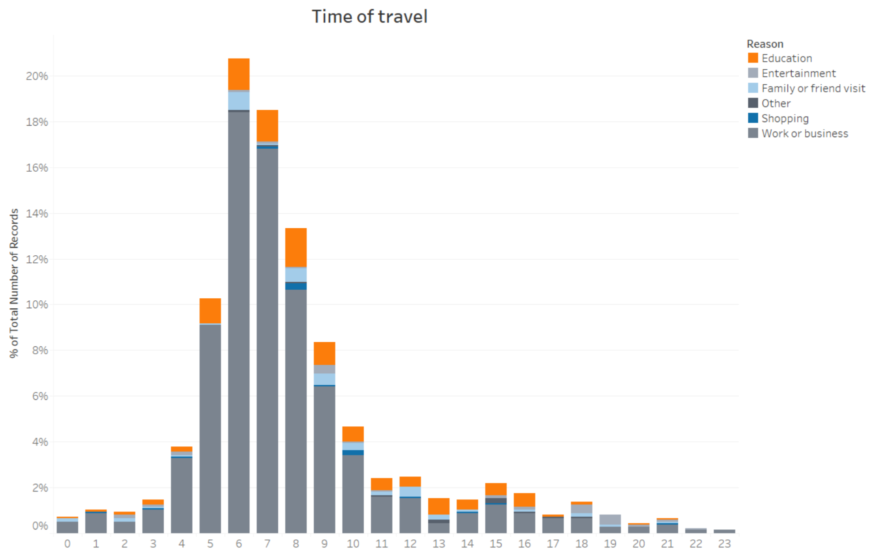


Figure 1 Distribution of time of travel for the most recent trip

Regarding travel time, 52% of respondents reported traveling between 30 and 60 minutes, 23% between 1-2 hours, and 1% for more than 2 hours. When segmented by modes, public transport users reported the longest travel time with an average of 60 minutes, while ride-hailing users reported the less amount of time with an average of 35 minutes (Figure 2).

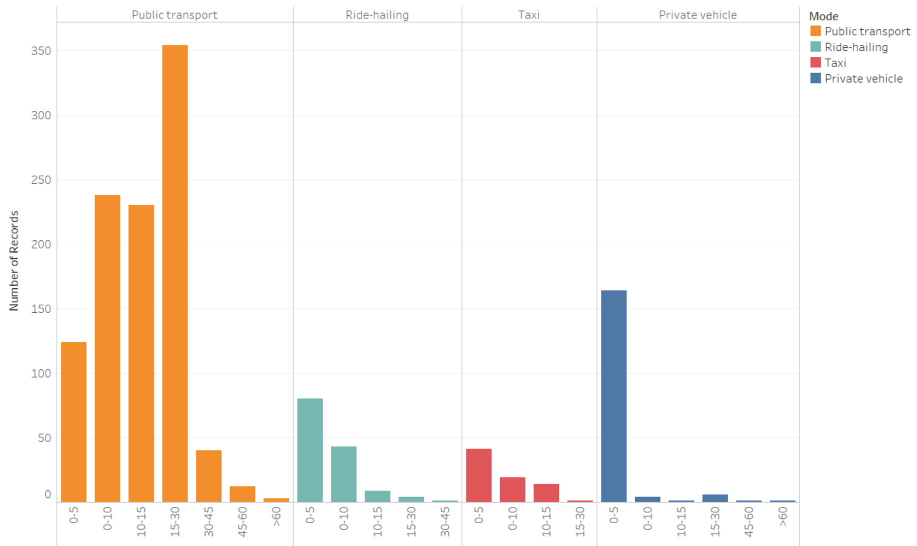


Figure 2 Travel time for the most recent trip

Regarding travel cost, taxi and ride-hailing users report the higher cost. The equivalent for waiting time in the survey for private vehicle corresponds to parking. This travel feature is relevant for ride-hailing as it may make on-demand modes more attractive. As expected, public transport users reported the most considerable waiting time, in some cases, more than 45 minutes. In comparison, most ride-hailing users reported waiting times below 10 minutes, although the same applies to users of conventional taxis (Figure 3).

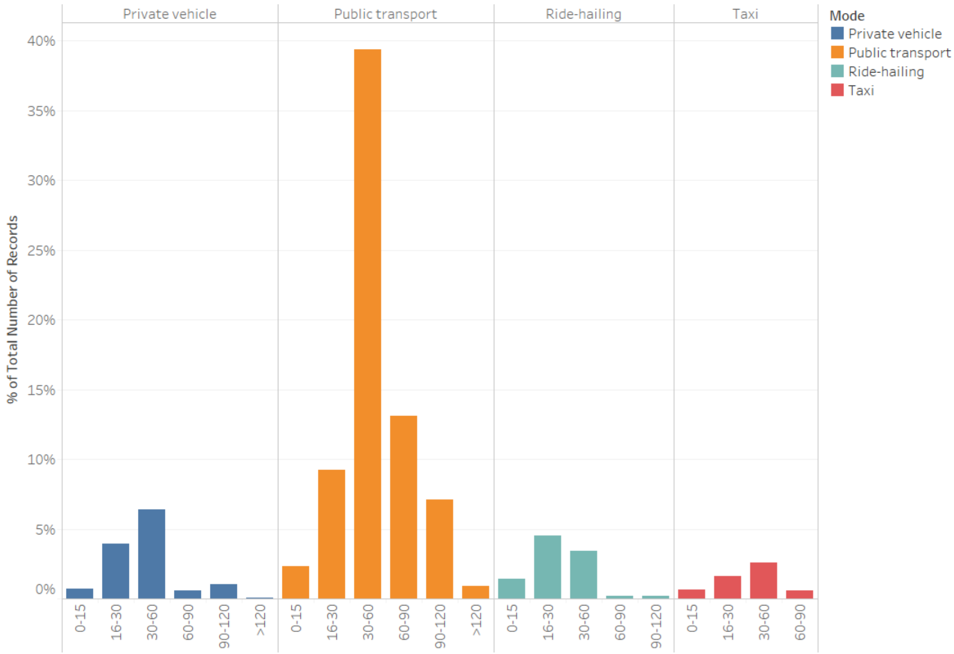


Figure 3 Waiting time for the most recent trip

Respondents were questioned about their reason to choose the mode for the current trip. Figure 4 shows the distribution of respondents by mode that selected each reason presented. This shows some interesting tendencies. On the one hand, 38% of private vehicle users chose “less time” as a reason explaining their mode choice. This was the highest choice rate of this option across all modes. In comparison, 36% of public transport users selected “only choice”. The reasons where taxi and ride-hailing users are the main respondents vary more widely. Ride-hailing users report better system conditions, crime safety, and time savings (Figure 4). For context, it is important to recall that public transit users represent 72% of the sample.

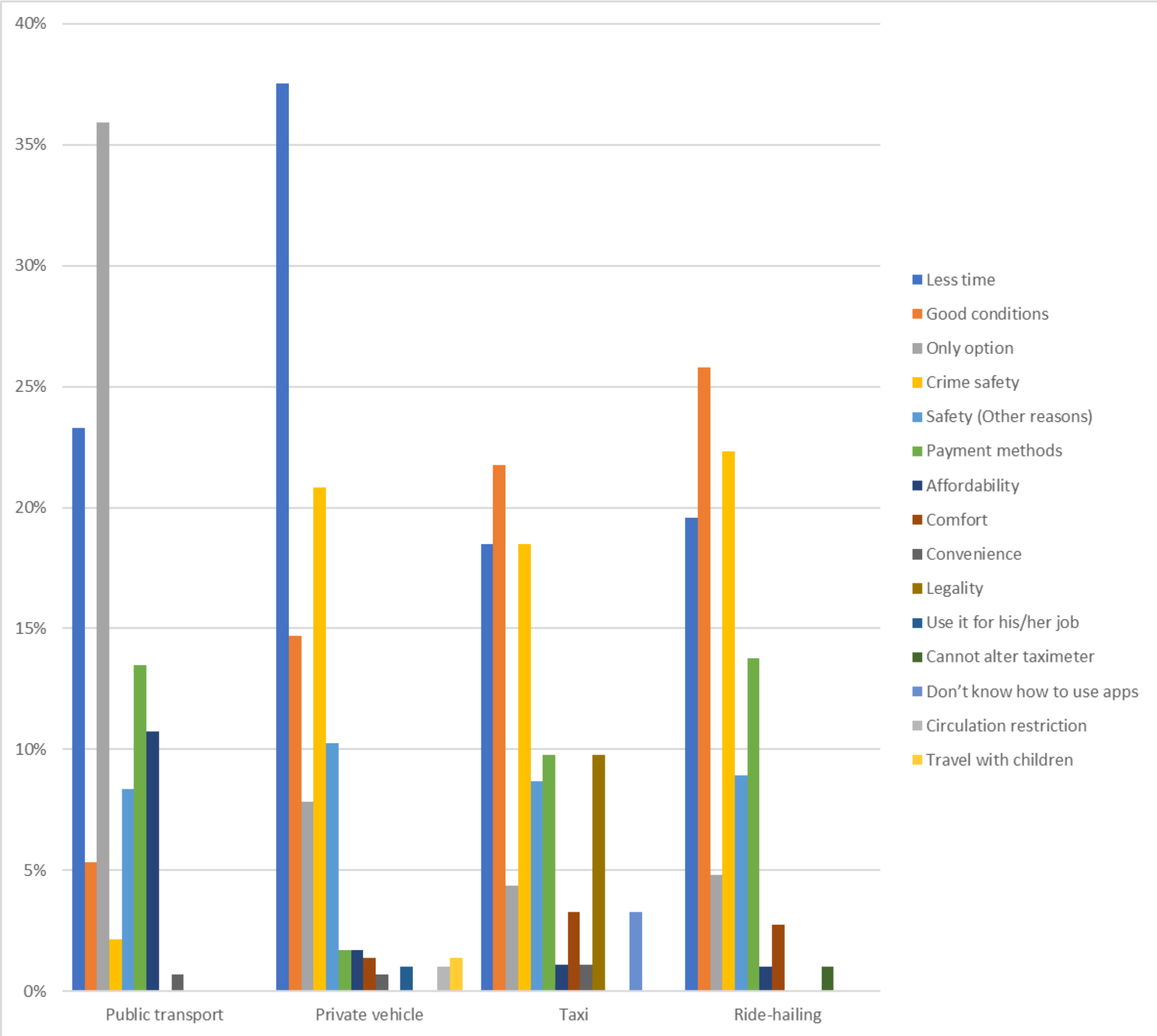


Figure 4 Distribution of respondents for reasons for using the current mode of transport

Reasons provided by respondents for their mode choice reflect slight variation across modes for reasons such as right conditions and crime safety. However, other reasons such as travel time, payment methods, safety (other reasons[2]), the specific mode being the only available option, affordability and convenience have higher variability across modes with a predominance in the sample choosing public transport as their most frequent travel alternative. A striking result is that for some users, there are reasons that apply only to their chosen mode. Reasons such as comfort and the fact that taximeter cannot be altered are highly valued by ride-hailing users. At the same time, legality, and lack of familiarity with apps were only selected by taxi users.

Descriptive findings suggest marked differences in travel experiences and preferences across modes of transport in a relatively similar sample. Such differences suggest unobserved commonalities that may tell us more information about the characteristics of users and non-users of ride-hailing in this group of non-poor, economically active and mobile residents of Bogotá. This motivates the application of an LCA model to determine whether there are groups

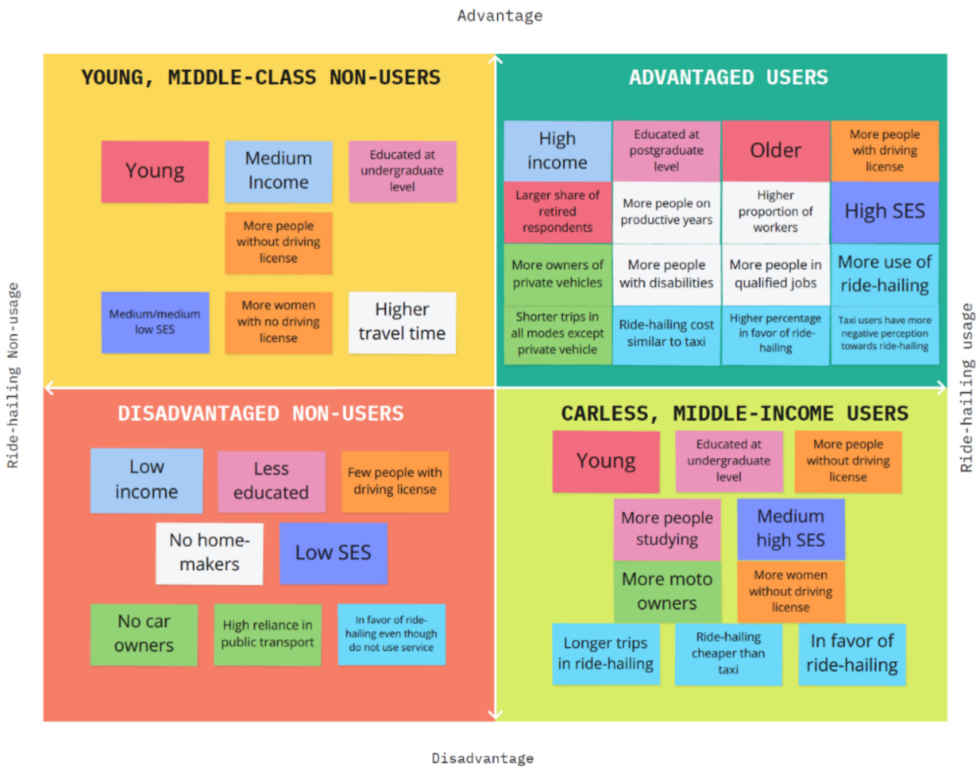
[2] This response refers to issues such as traffic accidents and being stopped by police.

that can be categorized at a specific condition of advantage or disadvantage. Findings from this analysis are shown below.

4.2. Latent Class Analysis: ride-hailing and (dis)advantage

We tested eight iterations of the LCA model, testing between two and ten clusters, and finding optimal values for AIC and BIC, as well as better data interpretability. Characteristics of the sample are categorized under a framework of advantage and disadvantage and presence of ride-hailing users in the cluster. The classes are summarized qualitatively below, finding two

Figure 5 Latent Classes Identified in the LCA Model (4 classes)



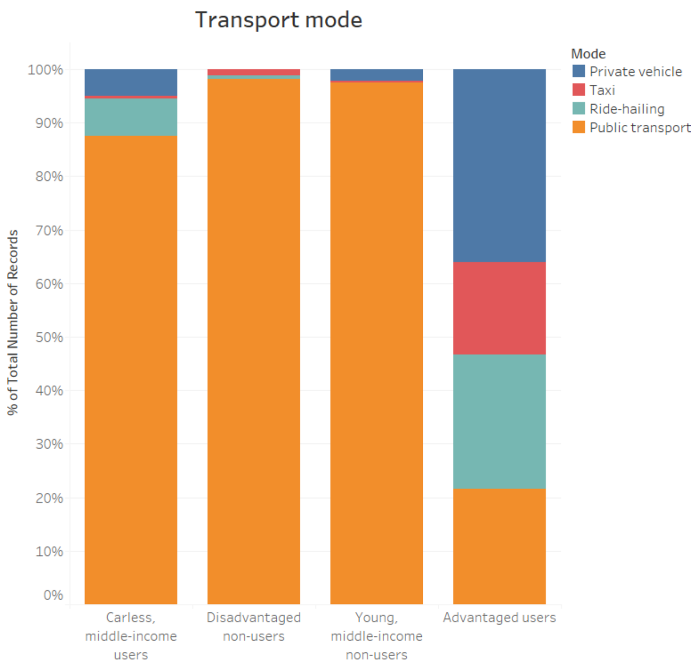
groups of users and two of non-users. Considering the composition of the sample presented in Table 1, it is expected to find fewer people in severe conditions of social disadvantage. However, as shown in Figure 5, this population group is clustered mainly in the groups of non-users of ride-hailing. Figure 5 represents qualitatively the main characteristics of the four clusters identified in quadrants defined by ride-hailing-usage- (dis)advantage and a traffic light color scale representing the severity of the conditions of disadvantage in each group.

In general, Figure 5 shows that groups of users of ride-hailing are overall socially advantaged in terms of income and education. Eighty percent of the individuals in the Advantaged Users group have educational attainment above an undergraduate degree, while this percentage is nearly 50% of the Carless Middle-income Users. Moreover, in both groups, the share of respondents belonging to higher SES -which is a signal of better-off neighborhoods- is 25% in the Advantaged Users Group and 10% in the Carless Middle-income Users. Differences between the two user groups concerning age are larger. Seventy percent of the Advantaged Users group are above 30 years of age and only 7% are above retirement age. Such an age profile signals that these individuals are primarily in age groups in which people tend to be more advanced professionally. By contrast, the group of Carless Middle-income Users of ride-hailing is primarily young, with over 65% of respondents below 30 (20% below the age of 20) and less than 5% between 50 and 60, with 60 being the maximum age of respondents in this cluster. The distribution of sex in the two clusters of ride-hailing users provides further insights on levels of social (dis)advantage. It is perhaps unsurprising that the gender make-up of the Advantaged Users group is primarily male (70%), while the Carless Middle-income Users are distributed evenly. Here it is relevant to clarify that not all people in the Advantaged cluster use ride-hailing. However, this group has the highest percentage of users in the whole sample which places it in the top-right quadrant of Figure 5.

The non-user groups found in the LCA show distinct levels of social disadvantage. Both groups belong primarily to low and middle SES (almost 50-50 distribution in both non-user groups), with more people in SES 1 (a standard proxy to poverty in Colombia) in the disadvantaged group. 70% of the sub-sample in the Young Middle-income Non-users' group is below age 40, with only 10% aged 50 and above. In the Disadvantaged Non-users' group is the second cluster in the concentration of respondents below the age of 20 (8%). However, it has the highest concentration of respondents aged 50 and above across all clusters (20%). Moreover, education levels in the non-user groups are much lower than in the user groups. Roughly 7% of respondents in these groups have low levels of education (below secondary school), and there is a smaller proportion of respondents with education above undergraduate college degrees (below 30% in both groups). Furthermore, all respondents in the Disadvantaged Non-users group reported household incomes below $2.5M, which suggests low purchasing power. Regarding gender, there is a lower proportion of women in the Disadvantaged Non-users cluster, with 60% male respondents in the sub-sample.

Ride-hailing user and non-user groups differ more sharply in terms of their levels of transport (dis)advantage. Such differences are first reflected in the mode choice for reported trips in each of the latent classes (Figure 6). Disadvantaged Non-users and Young Middle-income Non-users rely mostly on public transport (98% and 97% respectively). In comparison, although Carless Middle-income Users primarily use public transport (87%), they also use ride-hailing and private vehicle. Advantaged users have the opportunity of using all modes, with private vehicle, the preferable alternative (36%) followed by ride-hailing (25%) and public transport (22%).

Figure 6 Mode choice of participants by latent class

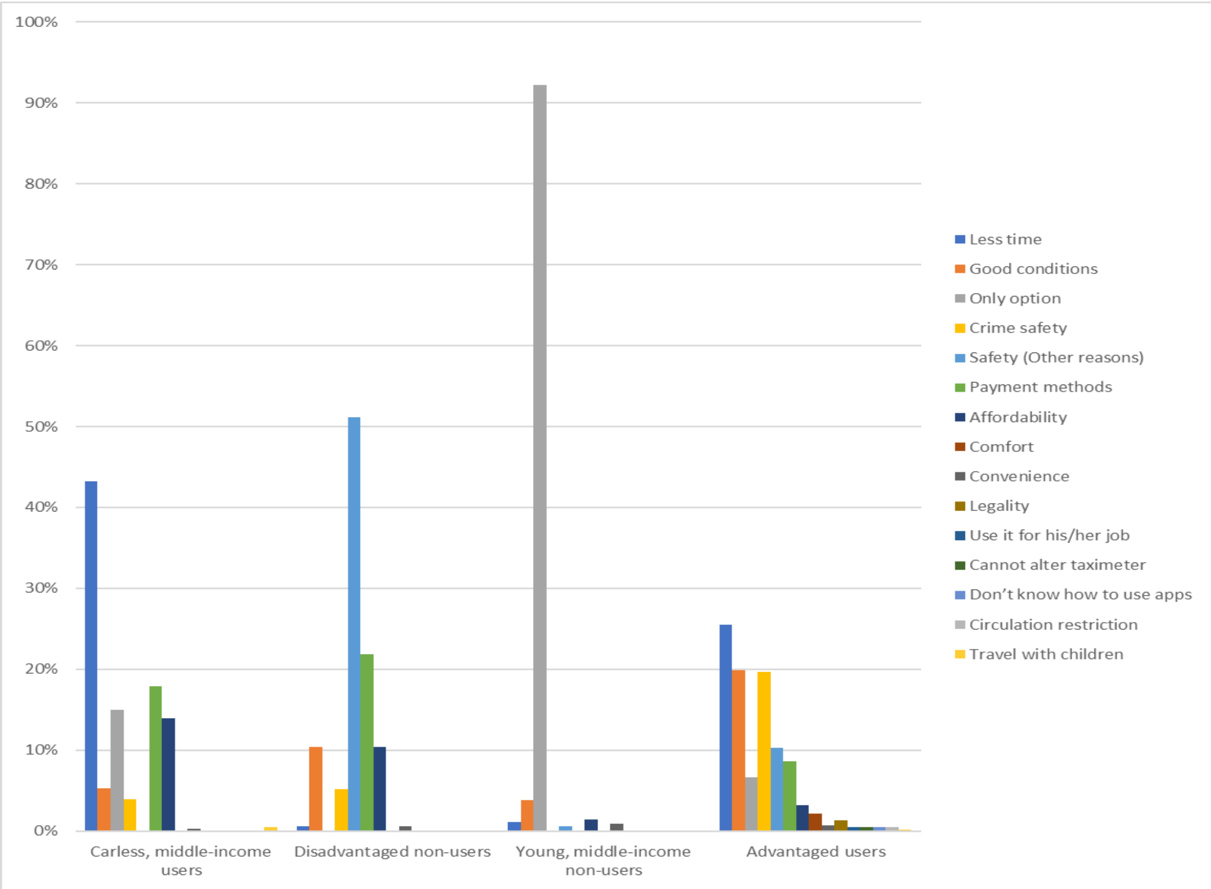


The mode distribution presented in Figure 6 is partly explained by related factors of transport (dis)advantage such as private vehicle ownership and having a driver's license. Such factors have a direct effect on the opportunity people in each cluster must make use of private modes of transport.

While in the Advantaged User group nearly 90% of the sample has access to a private vehicle at home, for the Carless Middle-income group this percentage is below 40%, and most private vehicle owners have a motorcycle rather than a car (80% of vehicle owners in this cluster). This stands in stark contrast with the group of non-users. As summarized in Figure 5, the cluster of Disadvantaged non-users have no car owners, and only 4% have access to a motorcycle at home being those with lower availability of alternatives for urban transport. The Young Middle-income Non-users have a small degree of vehicle ownership, with only 12% of the sample in the cluster having access to at least one car and a higher rate of motorcycle ownership than other clusters with over 15% of motorcycle-owners. When analyzing data on bicycle ownership across clusters, the trends are inverted. Non-user clusters have higher rates of bicycle ownership, with 56% of the sample in the Disadvantaged Non-user group and 51% in the Carless Middle-income Non-Users group. In the ride-hailing user groups, bicycle ownership is below 40%. These findings are complemented by the distribution of driving licenses in the four groups identified. In the Disadvantaged Non-users' group, over 87% of respondents do not have a driving license, while in the Young Middle-Income Non-users, 74% have a driving license. In the ride-hailing user groups, a driving license is available for 60% of the Carless Middle-income Users group and 90% of the Advantaged group have a driving license.

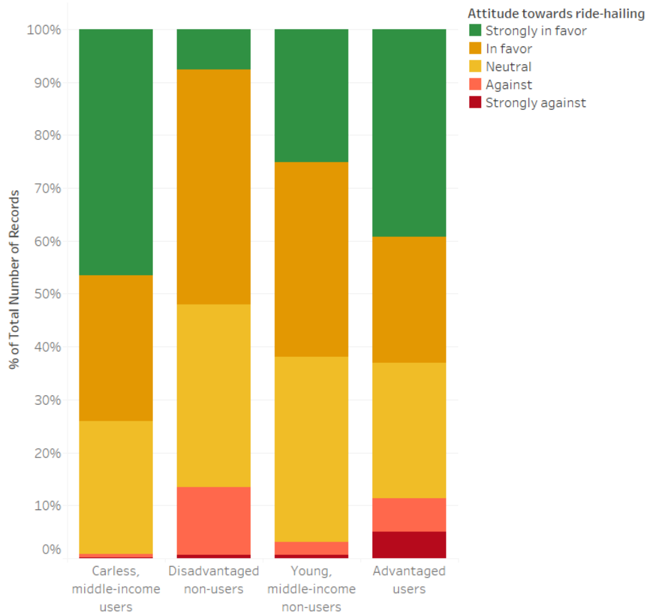
We revisited findings shown in Figure 4 by latent class. The exploration of the reasons behind using the current mode reflects a higher diversity in the reasons for mode choice among the Advantaged group (Figure 7). Advantaged Users' reasons behind their current mode are the good condition of the system, crime safety, comfort, convenience, and the fact taximeter cannot be altered. There is a minority in the Advantaged group that do not use ride-hailing, for whom lack of familiarity with technology (do not know how to use apps) and the legality of their transport alternative are the main reason for not using ride-hailing services. This, despite sharing most characteristics that qualifies them to be part of the Advantaged Users group. For disadvantaged users, on the other corner, the most relevant reason is safety-other reasons. For Carless Middle-income Users, affordability, payment methods and less time are crucial elements to decide their current transport mode while for Young Middle-income Non-users the most essential reasons to choose a transport mode is because it is the respondent's only option.

Figure 7 Reasons behind mode choice of participants by latent class



Respondents in the survey also reported on their general attitude towards ride-hailing. As shown in Figure 8, almost no respondent claimed to be strongly against or against ride-hailing while a substantial percentage of Carless Middle-income users (47%), Young Middle-income Non-users (25%) and Advantaged Users (39%) are strongly in favor of ride-hailing. Even more surprisingly, a high number of users in the Disadvantaged Non-users group show to be in favor of ride-hailing (44%) or at least have a neutral position (34.5%).

Figure 8 Overall attitude towards ride-hailing by latent class



The attitude of most respondents towards ride-hailing is positive, although many are not users of this transport mode. The survey queried respondents regarding the reasons why they would change to or continue using ride-hailing. Findings by latent class reveal further relevant information that supports previous analyses. Time seems to be the most popular answer across groups. However, the distribution by latent class shown in Figure 9 shows that the distribution of priorities changes significantly. For Carless, Middle-income Users and Young, Middle-income Non-users, good conditions of the system, time and crime safety would be fundamental reasons to change to ride-hailing. However, Young Middle-income Non-users seem to be inclined to use ride-hailing only if it was their only option, which serves to reflect on the role of the continued provision of public transit in middle-income neighborhoods. On the Disadvantaged Non-users, the safety-other reason- is the most relevant reason for which they would change to ride-hailing, followed by good conditions in the system and time. Finally, for Advantaged Users, time, good conditions of the system and crime safety would be the main reason to change to or continue using the system. However, in the Advantaged group, some additional and concrete reasons were stated by non-users within the advantaged group: legality of the system (ride-hailing has not been regulated in Colombia and taxi companies have won several lawsuits) and desire to continue using a taxi. These reasons suggest that for users in conditions of social and transport advantage, personal preferences for specific modes and attitudes towards informality and illegality can shape their decisions beyond transport-related motivations.

Figure 9 Reason why respondents would change to/continue using ride-hailing

	Carless, middle-income users	Disadvantaged non-users	Young, middle-income non-users	Advantaged users
Save time	28.2%	18.0%	17.9%	27.6%
Good conditions	33.6%	22.8%	38.8%	23.9%
Only option	2.1%	6.6%	22.8%	4.1%
Crime safety	27.7%	4.2%	18.9%	22.2%
Safety (other reasons)	2.8%	43.7%	0.3%	4.1%
Payment methods	3.3%	3.6%	0.3%	5.3%
Don't need it	0.7%			
Affordability	0.7%			1.6%
Flexibility				0.4%
Legality				4.9%
Less travel and waiting time, comfort, safety	0.2%			
Other	0.7%	1.2%	1.0%	3.3%
Would not change Taxi				2.5%

% of Total 0.2% 43.7%

5. Conclusions

This paper builds on a primary dataset of mobile users and non-users of ride-hailing in Bogotá to construct an analysis of the links between the use of this mode and conditions of social and transport (dis)advantage. The paper is one of the first detailed analyses of this phenomenon in the local context (see (Oviedo, Granada and Perez-Jaramillo, 2020)) and one of few studies in LAC as argued in section 1. The perspective adopted in the paper contributes to current debates in the literature as it provides an alternative interpretation of features of citizens and their mobility not always interrelated. The paper's findings are consistent with previous research in relation to the role of income, age, and occupation in the propensity of using ride-hailing. However, our analysis adds depth to the interpretation of survey data by applying an LCA model that identifies clusters presenting specific combinations of levels of social and transport disadvantage. We find diversity in the type of users of ride-hailing that place higher income and life stage as relevant determinants of the ability to use ride-hailing. Moreover, given the specific urban configuration of cities such as Bogotá around SES, it is also found that SES can be both a condition of social advantage or disadvantage and that higher SES are correlated with higher ride-hailing usage.

The analysis of conditions of transport (dis)advantage complements findings associated with user characteristics that can inform specific policy decisions around urban transport and ride-hailing. On the one hand, the group with the highest level of use of ride-hailing also has higher vehicle ownership rates, travel more frequently and has almost ubiquitous access to private vehicles. This suggest a potential substitution of ride-hailing trips of trips that would otherwise be conducted by private vehicles, which is a relevant finding from a sustainability perspective. This can also be related to the effect of circulation restriction policies such as local "Pico y Placa" (Ramos *et al.*, 2017), which is expected to affect most the Advantaged cluster. Findings from the other user group (Carless Middle-income Users) support an altogether different hypothesis. This group has a lower degree of transport advantage, and socioeconomic conditions that suggest an earlier life stage than most respondents in the Advantaged Users group. Differences in transport and social advantage in the Carless Middle-income User group are reflected first by participants' age and occupation in this sub-sample, and second by lower vehicle ownership, less driving licenses, and more diverse reasons to justify their mode choice. This suggests that for this group ride-hailing can play a role in providing access to better-quality transport services during the transition to car ownership. This is relevant from a policy perspective as the provision of disincentives to the adoption of private motorized mobility can be supported by the availability of alternative services of similar quality. Shorter travel times in this group also signal shorter displacements, which may be linked with combination with other modes such as public transit. This group is a relevant target for actions seeking to incentivize continued use of public transit and exploring potential of ride-hailing for complementing transit coverage.

By comparison, the analysis of the Non-user groups tells a different story about the role of ride-hailing in urban mobility across groups that although can still afford to be frequently mobile, do so largely by public transport. The both groups reflect the middle-low-income groups in Bogotá in employment and education that have no access to private cars and that are increasingly relying on the motorbike for private motorization. These clusters reflect the reality of a large share of residents of Bogotá, according to findings in previous research (Guzman and Bocarejo, 2017; Guzman and Oviedo, 2018), who are captive public transit users. High dependency of public transit in the disadvantaged group is compounded by longer displacements, which makes it more expensive to consider alternatives such as taxi and ride-hailing. In the Young Middle-income Non-users' group, transport disadvantage intersects with life stage. This group not only has a similarly low level of private motorization to the Disadvantaged group; they also have a low level of access to driver's licenses and are the group that are more likely to report their current mode being their only alternative. The overall analysis of characteristics of non-user groups suggests that ride-hailing is not a feasible option under the conditions in which such services were provided at the time of collecting data for this study.

The findings from this analysis support some of the policy recommendations associated with shared mobility proposed by the Transportation Sector Framework of the IDB (Roa *et al.*, 2020). However, these need to be targeted to the diverse types of users and non-users in terms of (dis)advantage. For instance, policies for promoting the physical and fare integration of shared mobility services and public transportation services can help improving the accessibility of carless users and young non-users. There is clear need for regulation to improve equity in shared systems as currently the disadvantaged are those less able to use ride-hailing services. Policies seeking to develop fare alleviations for essential trip purposes and improved coverage in disadvantaged areas have the potential of closing the gaps between disadvantaged and advantaged non-users and users. It is important to seek balance in policy actions targeting the advantaged group. This paper mentioned the effect of circulation restrictions such as the *pico y placa* in place in Bogotá. Such policies have been identified not only to have a limited effect in curbing congestion, but they are likely to lead to an increase in household motorization among wealthier groups (Calatayud *et al.*, 2021). The recently published flagship report on the state of congestion in Latin American cities suggests future avenues to reduce congestion from private vehicles, and the role of shared mobility in replacing trips by frequent car users. In this regard, the paper's findings support the need to support ride-hailing as an alternative to current car trips while setting fare mechanisms that can contribute to strengthen the ability of such systems to address some of the needs of disadvantaged groups currently unable to use it such as the urban mobility tax of Mexico city, but with a targeting mechanism that allows to reduce potential regressive effects (SEMOVI, 2019; Roa *et al.*, 2020; Calatayud *et al.*, 2021).

Despite differences in the characteristics and mobility of users and non-users in the four latent classes, perceptions of ride-hailing are overall positive, with larger differences in the extremes of the advantage/disadvantage spectrum analyzed. For the Advantaged Users who are against ride-hailing this has more to do with the current legal standing of these services than on their service features, with issues such as legality and loyalty to the traditional taxi playing a role in mode choice. This is a unique finding in the local context and in the literature on ride-hailing in the region. Such a finding suggests that for individuals in conditions of advantage and with sufficient available choices, larger societal issues can play a role in their individual travel decisions.

Findings also point toward further research avenues that build on the specific clusters identified in this research. There is little research on the accessibility effects of ride-hailing and its consequences on distributional issues such as social exclusion. The categories identified in this paper can inform research along such lines, allowing for analysis of accessibility by clusters and providing an entry point for in-depth analysis of social outcomes of current travel patterns of different latent classes. Furthermore, the COVID-19 crisis is likely to have changed both the level of (dis)advantage in the city and their travel behavior, which can prompt a similar study under current circumstances that can be compared to the reality captured in this study. Such research can inform policy and practice seeking to achieve a recovery of urban mobility and development after the health emergency and re-define the role ride-hailing services may play in a post-COVID scenario.

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Appendix 1: Modelling code for LCA analysis using R

~~~~
dim(DataModel)

DataModel <- DataModel[complete.cases(DataModel),]

dim(DataModel)

```

# Model

## Equation

```{r}

Equation <- cbind(Modo_Number,

            razonGeneralMenosTiempo, razonGeneralBuenasCondiciones,

            razonGeneralUnicaOpcion, razonGeneralSeguridadNoRoban,

            razonGeneralSeguridadOtrosMotivos, razonGeneralMetodosPago,

            comoSeSiente,

            edad_Cuts_Number, genero_Number, Education_Number, SES_Number, IncomeGroup_Number,

            vehiculoParticular, tieneLicencia_Number) ~ 1

```

```{r}

# Model_Test <- poLCA(Equation, data = DataModel, nclass = 5, na.rm = TRUE)

```

Starts at 3:15 pm

```{r}

Model_2 <- poLCA(Equation, data = DataModel, nclass = 2, nrep = 1000, maxiter = 5000, na.rm = TRUE)

Model_3 <- poLCA(Equation, data = DataModel, nclass = 3, nrep = 1000, maxiter = 5000, na.rm = TRUE)

Model_4 <- poLCA(Equation, data = DataModel, nclass = 4, nrep = 1000, maxiter = 5000, na.rm = TRUE)

Model_5 <- poLCA(Equation, data = DataModel, nclass = 5, nrep = 1000, maxiter = 5000, na.rm = TRUE)

Model_6 <- poLCA(Equation, data = DataModel, nclass = 6, nrep = 1000, maxiter = 5000, na.rm = TRUE)
~~~~

```
Model_7 <- poLCA(Equation, data = DataModel, nclass = 7, nrep = 1000, maxiter = 5000, na.rm = TRUE)

Model_8 <- poLCA(Equation, data = DataModel, nclass = 8, nrep = 1000, maxiter = 5000, na.rm = TRUE)

Model_9 <- poLCA(Equation, data = DataModel, nclass = 9, nrep = 1000, maxiter = 5000, na.rm = TRUE)

#Model_10 <- poLCA(Equation, data = DataModel, nclass = 10, nrep = 1000, maxiter = 5000, na.rm = TRUE)
```

```{r}
Model_2$aic
Model_3$aic
Model_4$aic
Model_5$aic
Model_6$aic
Model_7$aic
Model_8$aic
Model_9$aic
#Model_10$aic
```

```{r}
Model_2$bic
Model_3$bic
Model_4$bic
Model_5$bic
Model_6$bic
Model_7$bic
Model_8$bic
Model_9$bic
#Model_10$bic
```

```{r}
DataModel$Class_2 <- Model_2$predclass
DataModel$Class_3 <- Model_3$predclass
DataModel$Class_4 <- Model_4$predclass
DataModel$Class_5 <- Model_5$predclass
DataModel$Class_6 <- Model_6$predclass
DataModel$Class_7 <- Model_7$predclass
DataModel$Class_8 <- Model_8$predclass
DataModel$Class_9 <- Model_9$predclass
```

```{r}
getwd()
```

```{r}
write_delim(DataModel, "DataModel_Clusters.csv", delim = ";")
```