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Transport Division

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Acronyms

CFA	Confirmatory Factor Analysis
DID	Differences-in-Differences
LAC	Latin America and the Caribbean
LATAM	Latin America
OLOGIT	Ordered Logit Model
SEM	Structural Equation Model
TNC	Transportation Network Company
USA	United States of America

Contents

Disrupting personal (in)security? The role of ride-hailing service features, commute strategies, and gender in Mexico City

Lynn Scholl[1], Daniel Oviedo[2], Orlando Sabogal-Cardona[2]

Abstract

This paper sheds light on the personal security dimension of ride-hailing from a gender perspective. We explore how features of Transportation Network Companies (TNCs) services affect riders' perceptions of security when commuting in ride-hailing services, and how general perceptions of fear of crime shape the way people value such features. Moreover, we analyze the strategies women and men are using to enhance their own security in ride-hailing and factors influencing these strategies. We conducted a survey of users of the TNC DiDi in Mexico City. The statistical methods used are Structural Equation Models (SEM) and Ordered Logit Models (OLOGIT). Results show that women are more likely to value the information made available by ride-hailing applications (e.g., knowing your location or knowing driver information) and the presence of a panic button. The value given to information also increases if a person feels insecure in the streets, in a public transit station or in public transit. People who perceive higher insecurity in the streets have increased positive perceptions of the possibility of travelling without transfers. We also find that women are 64.4% less likely to share ride-hailing trips (pooling) and 2.14 times more likely to share details of their trips through their cellphones.

JEL classifications: J16, N76, 032
Keywords: Ride-hailing, Public Transportation, Structural Equation Models, Transportation Network Companies

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1. Introduction

Violence against women is an important challenge to safe mobility in developing countries, having negative implications for women's equal access to public spaces, jobs, and other essential opportunities. With approximately three in four women having experienced some sort of violence or harassment in transportation systems in the region, the International Labor Organization (ILO) has declared that a lack of access to safe transportation is one of the greatest challenges to labor force participation faced by women (ILO, 2017).

Ride-hailing has risen rapidly across the globe as a popular alternative for mobility due to its ability to meet on-demand, door-to-door transport needs such as leisure and care-related trips. Most initial research on ride-hailing (Button, 2020; Tirachini, 2020) has come from the United States of America (USA) (Dias et al., 2017; Rayle et al., 2016; Schaller Consulting, 2017), Canada (Young et al., 2020) and other developed countries (González et al., 2018; Hensher, 2017), and more recently developing countries (Acheampong et al., 2020; Lesteven and Samadzad, 2021; Sabogal-Cardona et al., 2021; Tirachini and del Río, 2019; Vanderschuren and Baufeldt, 2018). While recent work has found that women in the Latin American region tend to be more likely to use ride-hailing (Sabogal-Cardona et al., 2021) and are more likely to cite security concerns in public transport as a factor influencing their mode choice, there is little evidence on how the use of Transportation Network Companies (TNC) has contributed to women's security perceptions and experiences and the surrounding implications for mobility and policy responses.

Ride-hailing arguably plays a different role in urban mobility than that in countries of the Global North. Cities in developing countries suffer from high levels of poverty and inequality, and citizen insecurity. Moreover, transit systems are often characterized by overcrowding and high levels of informality and gender-based violence (Gómez-Lobo, 2020). Perceptions of insecurity in public spaces and transit may be interacting with specific characteristics of ride-hailing (Sabogal-Cardona et al., 2021) and producing gendered mobility patterns relevant to policy making. For example, information on real time location and the ability to share details of a trip with other people could increase perceptions of security, and enable trips in times, contexts, and spaces previously considered as high risk in other modes.

Nevertheless, the role of perceptions of personal security and fear of crime in mode choice is an understudied topic in the literature (Acheampong, 2021; Acheampong et al., 2020). Past work exploring the connection between security and ride-hailing (Acheampong, 2021; Dills and Mulholland, 2018; Jing et al., 2021; Ma et al., 2019; Weber, 2019) has often used aggregated data (Dills and Mulholland, 2018; Weber, 2019), has not considered gender or the details in ride-hailing usage, or controlled for fear of crime in public spaces or transit systems (for example, a user could make a trip late at night because considers that walking on the streets or using transit is insecure).

Using Mexico City as a case study, in collaboration with DiDi (operating in Mexico) we disseminated a survey to over 2,000 of DiDi customers, to examine how gender influences valorations of ride-hailing service features when considering personal security, and factors influencing those valorations. We also study what strategies female commuters use, in comparison to men, to feel more secure when using ride-hailing services and test the role that fear of crime plays in turning to ride-hailing as a reliable transport alternative.

Our results suggest that women place higher value on information capabilities of ride-hailing applications (like knowing location and pick-up time) and to the presence of panic buttons within the mobile application. Larger positive perceptions related to information provided by ride-hailing applications are, in turn, influenced by security concerns experienced in public spaces (fear of crime). Security concerns in public spaces also increases the value given to travel with no transfers, and gender also plays a key role in influencing the strategies, mainly those related to travelling with unknown people (pooling) and on sharing trip details with someone else.

The findings related to gender reflect structural inequalities among men and women in Mexico City's transport system and to the need to improve security for the mobility of women. App-based mobility, and technology in a more general sense, seems to be one avenue to achieve security goals in the context of an insecure environment. Yet, given that ride-hailing has been found to be used primarily by upper income or higher educated groups (Alemi et al., 2019; Dias et al., 2017), the accessibility of this option for a large share of trips for lower income groups may be limited. Nevertheless, given that the technologies that improve security in ride-hailing can be applied in other modes (microtransit, pooled ride-hailing, among others), it opens the door for consideration of applications of these technologies in other modes to achieve more widespread security benefits.

This paper is organized as follows. After this introduction we move to the literature review on ride-hailing and crime. Then we present the methods section that presents a contextualization of our case study and describes the demographic details of the sample. In the methods section we also show how latent variables are created and explain the modelling strategy. In the results section we firstly present results from the Structural Equation Models (SEM) and then results from the Ordered Logit Models (OLOGIT). We included a discussion section to present the policy implications of the results and finish the article with the main conclusions.

2. Literature review

Research on ride-hailing has placed attention on many issues such as the determinants of adoption (Alemi et al., 2019, 2018; Dias et al., 2017; Oviedo et al., 2021), impact on congestion (Tirachini and Gomez-Lobo, 2019), and substitution or complementarity with public transit (Habib, 2019; Hall et al., 2018). With works coming now from developed and developing countries, there is some interest in the relationship between ride-hailing and crime. Research on this area can be clustered on two main strands: (i) on the overall impact that the introduction of ride-hailing services has caused on different crime-related indicators but focusing exclusively on the USA and without analyzing perceptions of users or specific impacts on travel behavior; or (ii) on the perceptions of users but in a very qualitative way or without shedding light on strategies dwellers are using when travelling in ride-hailing.

A study in the USA (Dills and Mulholland, 2018) using county data from 2007 to 2015 found through Differences-in-Differences (DID) models that entrance of Uber is related to reductions in arrests for assault and disorderly conduct and to a rise in vehicle thefts (that could be explained due to more vehicles on the streets). The study also highlights that there were no changes in the probability of being a victim of robbery and assault, and a weak association with decline on arrests rates during the first three years that Uber is operating.

Another study in the USA (Weber, 2019), based on 60 months of data in 18 urban areas and considering reported crimes, shows in a Poisson DID model that the entrance of Uber is associated with a 5% decline in personal crimes. Furthermore, there were no significant associations with assaults, crimes against property, crimes against society, or any other crime. In Philadelphia, a study on the accessibility of Uber (Shokoohyar et al., 2020) found in a spatial econometric model that Uber is probably an easy way to get out of zone with high crime rates given the improved accessibility of Uber in those areas. A study focused on sexual assault (Park et al., 2020) used a DID model and an instrumental variables IV linear probability model with data from 2005 to 2017 at the city level to show that ride-hailing reduced rapes in areas with low public transit provision and that is deterring sexual crime on areas of alcohol consumption on weekend nights.

In 2018 two cases of rape and homicide on DiDi rides in China were reported (Jing et al., 2021; Ma et al., 2019). These crimes received extensive media coverage and affected the image of DiDi, prompting the company to adopt additional security measures within their services. A study after the incidents (Ma et al., 2019) investigated how perceptions of risks were associated with the likelihood of customers abandoning the service. With a sample size of 443 respondents and a second-generation multivariate model, authors find that trust in the drivers affects the trust in the service and attitudes towards the platform, that ultimately affects the intention of customers to keep using the service. Another study in China (Jing et al., 2021) focused on perceptions influencing plans to keep using DiDi in view of the new measures after the two crimes. Results show that perceived security, security risk, and government credibility were important predictors to client retention.

A recent study in the cities of Accra and Kumasi in Ghana (Acheampong, 2021) with 548 qualitative non-probabilistic surveys identified the following seven factors affecting passengers' perceptions of safety and security when using ride-hailing: identification of the (driver and vehicle), trip trackability and traceability, fear of exposure to malicious and criminal actions by drivers or other passengers, privacy (lone travel), (dis)trust in app security features, emergency use, and driver behavior. A study in Bogotá (Oviedo et al., 2021) using Latent Class Analysis (LCA) shows that the perception of whether ride-hailing operation is legal or not as well as perception of crime have an effect on the decision users make on using or not the service. One of the few studies of ride-hailing in Mexico City (Sabogal-Cardona et al., 2021) using data from the 2017 Transport Household Survey calls the attention into the gendered dimensions of ride-hailing. The study shows that women are 34.9% more likely to adopt ride-hailing services than men, and that if there is a person above 65 years old in the household then women prefer ride-hailing over any other transport alternative (with private car being the only exception).

2.1 Background

The Latin American and Caribbean region (LAC) is characterized by high levels of poverty and income inequality. In 2020, 34% of the population, an estimated 209 million people were in poverty and 12.5% in extreme poverty (ECLAC, 2021). With more than 80 percent of the population living in cities, the region suffers from low quality and a lack of universal coverage of transport infrastructure services, particularly in lower income areas. Rapid motorization and urbanization have led to high levels of sprawl and congestion, and long travel times of up to two to three hours per day, and to lower levels of access and mobility. Mexico City has undergone explosive urbanization in the past four decades. With its population nearly doubling between 1980 to 2019, from 13 to 22 million, sprawling urban growth patterns have contributed to long commuting times and dependency on private vehicles (Guerra et al., 2018). Roughly 37% of the total daily trips in the city are made by public transport, most of which, 25.5% of the total, are made using small informal operators (OECD, 2019).

Personal security and fear of crime are salient considerations affecting daily mobility in the city, with crime and sexual harassment disproportionately affecting women. A 2014 study that included three Latin American cities revealed that on average more than 60% of women had suffered sexual harassment in public transportation in Mexico City, Bogotá, and Lima (Thomson Reuters Foundation 2014). Each day, approximately ten women are killed in Mexico, making it the country with the second highest levels of feminicides in the Latin American region (ONU Mujeres, 2020) and its transport system is considered one of the most dangerous in the world for women. An estimated 90% of women report having experienced some sort of sexual violence while using public transportation in the city. In some stations nearly 50% of women received obscene words when using public transport, and, in one station, 6.7% have been photographed without consent according to a recent study (Soto Villagrán, 2019). This restricted access to safe transport heavily circumscribes women's travel and hinders their full participation in the labor market of developing countries (International Labour Organization, 2017; Bautista-Hernández, 2020; Dunckel Graglia, 2016; Tirachini et al., 2020). As a response, sexual harassment against women has spurred the implementation of innovative programs like the 'pink transportation program' (Dunckel-Graglia, 2013), a public transport service exclusive for women, that also offers support to victims, and has been expanded to cabs in the city.

Ride-hailing began operating in Mexico City in 2013 with Cabify, being the first company to arrive in the city, followed by Uber in and Lyft in 2014. DiDi has recently implemented new measures to enhance security of their users in Mexico City. For example, users can now use the app to record audio during the trip and the platform can monitor trips to detect anomalies and generate alerts. Moreover, the program "DiDi woman" was launched in 2020 and is expected to improve security by enabling women drivers to take only women passengers.

3. Data and methods

3.1 Data collection

Data for the study was derived from a collaboration with the ride-hailing company DiDi's Mexico office. In November 2020 we designed and disseminated a survey among DiDi users in Mexico City. The questionnaire was developed in collaboration with DiDi Mexico's policy analysis and research team who provided guidance question wording based upon local context. The sampling strategy stratified users by frequency and areas of use, based on historical DiDi data before February 2020 (pre-pandemic). Users were grouped into three categories: (i) low frequency, those who make less than three trips per month; (ii) medium frequency passengers who make between three and eight trips per month; and (iii) high frequency passengers who make more than nine trips per month. With the aim of increasing the geographic coverage of the sample, we distinguished between northern and southern drop off areas of the city. A pilot of the survey was conducted in September 2020, and based upon the respondents, the survey was revised to improve question wording and the accuracy. The final version of the survey was sent in october 2020 to passengers through a pop-up message in the app. Six different cohorts of passengers were randomly selected. Users were offered a 40% discount for their next ride as an incentive to answering the survey. We received a total of 2,122 answers to the survey.

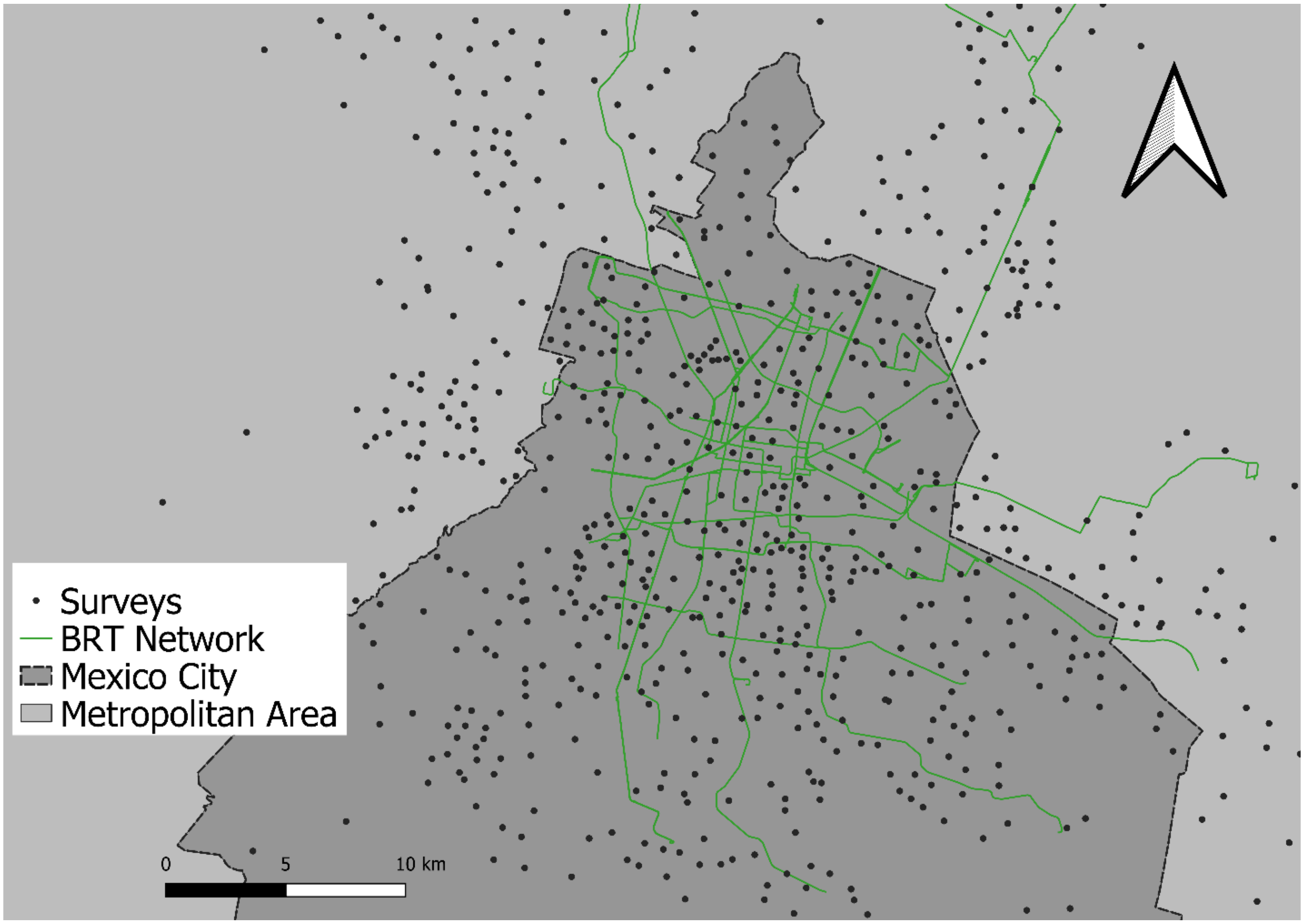

Figure 1. Sample distribution in Mexico City

Source: own elaboration

3.2 Sample description

After removing surveys with missing values in any of the key variables, the final number or useful surveys for the analysis was 1,869. In Figure 1 we present the distribution of the sample in the city at the zip code centroid level (that was asked in the survey), and in Table 1 we present the demographic characteristics of the survey. Most of the users in the sample are between 20 and 40 years old, with only 0.48% above 60 years of age, with more males (50.51%) than females (42.80%). The gender balance of the sample diverges slightly from published 2010 census data for Mexico City (INEGI, n.d.) where 47.83% were males and 52.17% were females. Only 8.45% of respondents declared having a disability. Most of the people in the survey are working (65.60%) or working and studying (17.87%). Lastly, most people live least than 10 minutes (33.49%), or between 10 and 20 minutes (28.79%) walking distance from a transit station.

Table 1. Characteristics of the sample. Source: own elaboration

Age (years) / Total Sample	1869	100.000%
< 18	27	1.445%
19 to 20	155	8.293%
21 to 25	358	19.155%
26 to 30	425	22.739%
31 to 35	337	18.031%
36 to 40	224	11.985%
41 to 45	147	7.865%
46 to 49	81	4.334%
50 to 55	65	3.478%
56 to 60	41	2.194%
>60	9	0.482%
Gender		0.000%
Male	944	50.508%
Female	800	42.804%
Other / No answer	125	6.688%
Disability		0.000%
Yes	158	8.454%
No	1711	91.546%
Occupation		0.000%
Work	1226	65.597%
Work and study	334	17.871%
Study	111	5.939%
Unemployed	113	6.046%
Other	85	4.548%
Distance to station		0.000%
Do not know	78	4.173%
<10	626	33.494%
10 to 20	538	28.785%
20 to 30	236	12.627%
More than 30 minutes	391	20.920%

Source: This study

3.3 Methods of analysis

We use two approaches to understand how the features of ride-hailing interact with perceptions of security. First, we fit a SEM, which combines Confirmatory Factor Analysis (CFA) and path analysis, where the level of importance of ride-hailing features are used as outcomes. And secondly, we move to an OLOGIT where frequency of use of certain strategies are used as outcome variables. All statistical analysis were conducted using the R programming language and specific libraries: lavaan for the SEM (Rosseel, 2012); ordinal, MASS and Brant for the ordered logits; and the Tidyverse for data processing (Wickham, 2014, 2011; Wickham et al., 2019).

Structural Equation Modelling (SEM)

In the SEM we use as outcome variables the variables presented at the beginning of Table 2 and that were asked in the following way: “thinking about your personal security and being one not important at all and five very important, how would you rate the following ride-hailing features for your security?” Characteristics included specific features available in the mobile applications provided by TNC and used by commuters to request and monitor trips. These characteristics are not frequently found or used in other transportation modes.

The variables, *having access to your real-time location* (in other words, knowing your location*), Having access to driver's rating, having access to the driver information (*name, picture, comments from other users, trips performed*), having access to the vehicle information, knowing the time the vehicle will pick you up,* and *knowing the time the vehicle will take you to your destination* are used as indicators for the latent variable *perceived information features of ride-hailing*, that reflects benefits from the detailed information ride-hailing platforms are constantly providing and that recent research have found as instrumental to ride-hailing (Acheampong, 2021). In addition to the perceived *information features of ride-hailing* variable, the model also includes other three outcome variables: *travel with no transfers, payment options, and panic button* (see Table 2). The measurement part of the model (Table 2) includes other latent variable in addition to *perceived information features of ride-hailing*. These latent variables are included as regressor of the outcomes. The latent variable *trust in ride-hailing* is intended to capture a preliminary inclination towards embracing ride-hailing (Ma et al., 2019) that could affect the value of features analyzed. In this latent variable the indicator *trust in being safe from COVID-19* was included.

The latent variable *security concerns in public space* is used to capture the overall perceptions of insecurity and fear of crime people experience. This latent variable encompasses a wider definition of public space that considers standard built environment infrastructure such as streets, parks, and plazas, but that also considers public transport stations and sees the use of public transport as another expression of public space (for example, when people is riding on the bus or the metro). The *security concerns in public space* latent variable is composed by four indicator variables plus other two latent variables and can be interpreted as a measure of fear of crime. The four indicators (see Table 2) capture degree of fear or worry at night and day on the streets and on open public spaces. The two latent variables are: *(i) security concerns on public transit; and (ii) security concerns in public transit stations*. The rationale for including *security concerns in public space* is that people with higher fear of crime are expected to be more likely to use ride-hailing and commute safer. The questions to assess fear of crime (Currie et al., 2021; Delbosc and Currie, 2012) are asked in terms of worrisome following Jackson (Jackson, 2005) who recommends to ask respondents to reflect on the frequency of worry avoiding the effect of transitory emotions.

Table 2. Outcome variables, Latent variables, and indicator variables

	Indicators' scale	Latent interpretation	Mean	SD
Outcome variables				
Perceived information features of ride-hailing				
Having access to your real-time location	Thinking about your personal security, how would you rate the following ride-hailing features for your security? 1 (not important) at 5 (very important)	Higher values are associated to a better rating if information features on ride-hailing	4.839	0.523
Having access to driver's rating			4.606	0.709
Having access to the vehicle information			4.866	0.443
Having access to the driver information			4.873	0.442
Knowing the time the vehicle will pick you up			4.862	0.440
Knowing the time the vehicle will take you to your destination			4.831	0.493
Travel with no transfers		---	4.467	0.965
Payment options		---	4.719	0.699
Panic button		---	4.839	0.496
Measurement model (latent variables and indicators)				
Trust in ride-hailing				
Trust in ride-hailing drivers	How much do you trust on? 1 (no trust) to 5 (much trust)	Higher values are associated to increase Trust in ride-hailing	3.819	0.900
Trust in the driving abilities of ride-hailing			3.910	0.928
Trust in the quality of ride-hailing vehicles			3.911	0.984
Trust in being safe from COVID-19			4.109	1.050
Security concern in public transit (fear of crime)				
How often do you worry about your safety in Jitneys, mini-vans, or combis?	How often do you worry about your safety? 1 (nothing) to 5 (much)	Higher values are associated to feeling in danger (more fear)	4.324	1.168
How often do you worry about your safety in metro or metrobus?			4.294	1.204
How often do you worry about your safety in metro or metrobus during night?			4.300	1.227
How often do you worry about your safety in metro or metrobus in the zone where you live?			4.305	1.167
Security concern in public transit stations (fear of crime)				
How often do you worry about your safety in a transit station during day?	How often do you worry about your safety? 1 (nothing) to 5 (much)	Higher values are associated to feeling in danger (more fear)	4.112	1.230
How often do you worry about your safety in a train station during night?			4.231	1.208
How often do you worry about your safety in a jitney/minivan/combi station during day?			4.124	1.237
How often do you worry about your safety in a jitney/minivan/combi station during night?			4.232	1.212
Perceived safety features of ride-hailing				
Safety against robbery	How do you rate the following characteristics of ride-hailing services? 1 (very bad) to 5 (very good)	Higher values are associated to a better rating of safety features	3.460	0.956
Safety against accidents			3.382	0.899
Safety against verbal violence and/or verbal sexual harassment			3.397	0.958
Safety against physical violence and/or physical sexual harassment			3.410	0.950
Security concerns in public space (fear of crime)				
How often do you worry about your personal security in the streets during day?	How often do you worry about your safety? 1 (nothing) to 5 (much)	Higher values are associated to feeling in danger (more fear)	4.065	1.259
How often do you worry about your personal security in the streets during night?			4.065	1.213
How often do you worry about your personal security in public (open) space during day?			4.035	1.252
How often do you worry about your safety in public (open) space during night?			4.187	1.209
Others				
Trust in the geographic coverage of ride-hailing (that it can pick and drop everywhere)?	How much do you trust on? 1 (no trust) to 5 (much trust)	Higher values are associated to better perceived flexibility	4.172	0.898
Trust that you will find a service regardless of the time?			4.217	0.958
Trust in being protected from COVID-19 when travelling in metro or metrobus?	How much do you trust on? 1 (no trust) to 5 (much trust)	Higher values are associated to feeling safe against COVID-19	2.237	1.359
Trust in being protected from COVID-19 when travelling in other public transit mode?			2.255	1.348

Source: This study

We control for age, gender, distance to the nearest transit station, car and motorbike ownership, and disabilities**.** To control for the effect COVID-19 could have had on travel behavior in public transportation at the time of the survey, during the pandemic before vaccination were available, the variable *trust in being protected from COVID-19 when travelling in metro or metrobus* is used to model the four outcome variables. Metro and metrobus are the most important mass transit systems in Mexico City. As shown in Table 2, *trust in being protected from COVID-19 when travelling in other public transit mode* was also asked in the survey. Given that correlation between trust in being protected from COVID-19 in metro and metrobus and trust in being protected from COVID-19 are above 0.90 we decided to use only one of the variables.

In Figure 2 we present a path diagram of the model. It is important to note that the four regressions for the four outcomes have similar but ultimately different specifications. For the *perceived information features of ride-hailing* and *payment options* the distance to transit is not included. For *panic button* we are not controlling for distance to station and for any of the COVID-19 effects*. Travel with no transfers* has all variables in Figure 2.

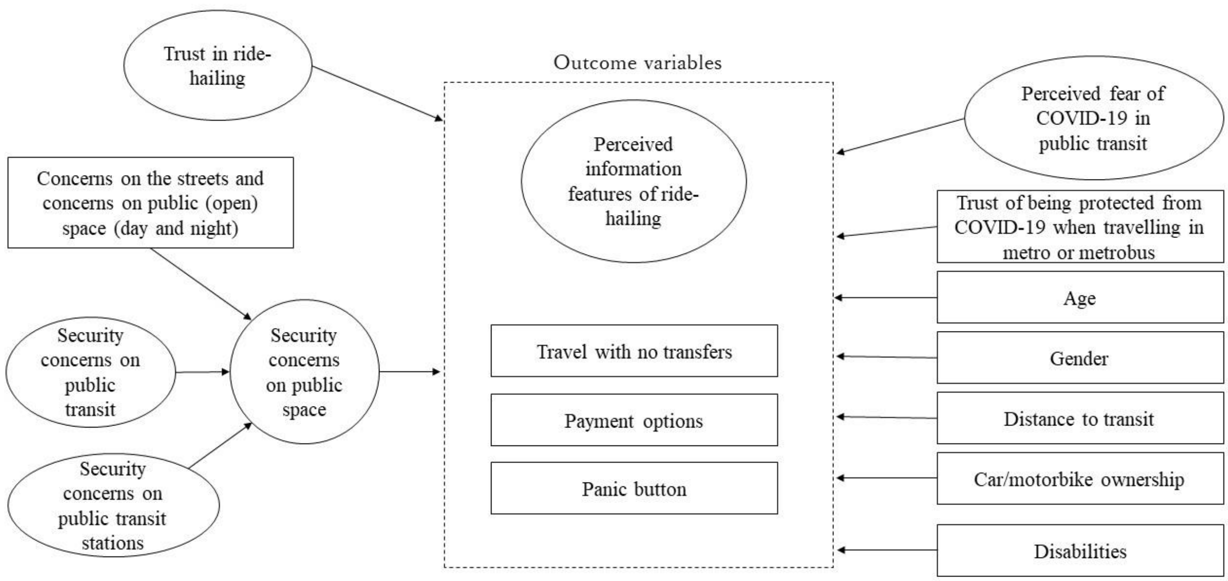

Figure 2 Path diagram of the SEM
Source: This study

Ordered Logit Model (OLOGIT)

Next, we move to the OLOGIT, an extension of a logistic models that allows modeling variables with more than two ordered categories. OLOGIT models are strongly based on the cumulative probability assumption that should be tested through a Brant test. As in the logistic model, in the OLOGIT case the parameters are in the scale of log-odds ratio and can be changed to an odds ratio scale after exponentiating them.

We use OLOGIT models to model the frequency of use of personal security strategies, where the wording in the survey read *"thinking about your personal security, with which frequency do you use the following strategies when travelling in ride-hailing services?".* The set of possible answers were ordered and included: *infrequent, somewhat frequent, frequent*, and *very frequent*.

In Figure 3 we present the frequency distribution of each one of the strategies studied. The OLOGIT models are regressed onto a set of demographic variables. Factor scores of the latent variables in the CFA are used.

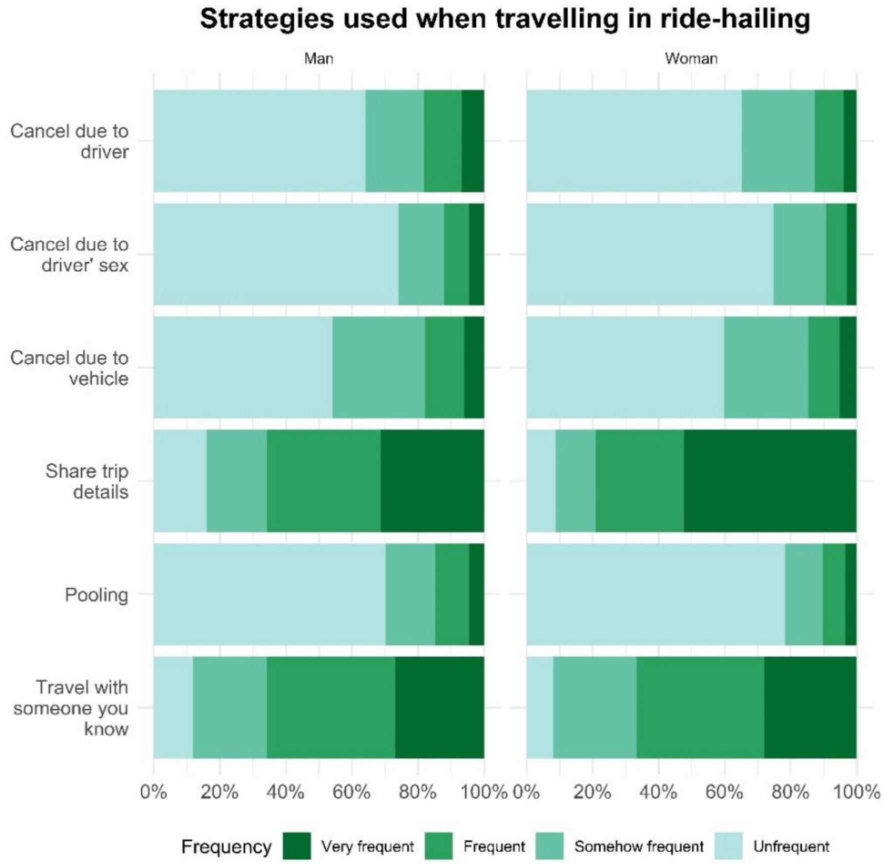

Figure 3 Frequency of use of strategies available in ride-hailing to feel safer
Source: This study

4. Results

In the following sections the results for the SEM and OLOGIT models are presented. First, we discuss the value respondents place on various features of ride-hailing services in relation to personal security. Then, we present the results of the models predicting the role of risk and personal security perceptions play in predicting the likelihood of employing a range of strategies during ride-hailing trips.

4.1 Importance of features for personal security

The measurement part of the SEM shows good goodness of fit measures there within the thresholds recommended by theory; the Comparative Fit Index (CFI) is 0.939, the Tucker-Lewis Index (TLI) is 0.931, the Root Mean Square Error of Approximation (RMSEA) is 0.074 (90% confidence interval between 0.072 and 0.076), and the Standardized Root Mean Square Residual (SRMR) is 0.031. Moreover, all factor loadings are statistically significant and the standardized factor loadings are above 0.559 (with only one exception, see Annex). We also conducted an analysis of invariance by gender (taking the category other/prefer not to say) and results show that the model holds at all levels of invariance.

Results for the regression part of SEM are presented in Table 3 in the form regression coefficients (Est.) and standardized regression coefficients (SC). The standardized regressions coefficients are interpreted as the effect one standard deviation increase on the independent variable will have on the outcome. Based on recent literature on ride-hailing and transportation using SEM, we refer to standardized estimates below 0.1 as a low effect, to standardized estimates between 0.1 and 0.2 as moderate, and to values above 0.2 as strong or important effects. Moreover, to analyze results we focus only on estimates with p values below 0.05 (5%) and refer to them as significant.

The variable *trust in ride-hailing* is significant on all outcomes showing a strong positive effect (0.271) on the perceived information features of ride-hailing and a moderate effect on the others (0.144, 0.173, and 0.137). This is consistent with a recent work on China (Ma et al., 2019) and suggests that trust built around mobility platforms influence how users react to features in the platform.

Moving to the *security concerns in public space* latent variable related to fear of crime, the model find that higher levels of security are associated with higher levels of positive valorations of the features available in ride-hailing. The estimates are significant for all the outcome variables. For *perceived information features of ride-hailing* the standardized estimate is 0.182, for *travel with no transfers* is 0.062, for payment options it is 0.106, and for *panic button* it is 0.144. An interpretation is that people who in their daily life experience more concern regarding their personal security are giving more value to these characteristics of ride-hailing, and that these the features serve as mechanisms to improve their personal security. Additionally, an increased fear of crime might be associated with people perceiving ride-hailing as a safer mobility alternative.

Perceived trust in being protected from COVID-19 when travelling in metro or metrobus is only significant for the perceived information features of ride-hailing, though with a low and negative effect (-0.073). Even though many previous studies recognize that age is one of the key determinants of ride-hailing adoption, our results show no major association between age and valuation of available features. Only for travel with no transfers the model shows statistically significant and positive, but modest, associations for the age cohorts between 41- to 50-years-old (0.067 standardized coefficient) and 51- to 60-year-old (0.052 standardized coefficient). Part of these results could be due to the sample was already on ride-hailing adopters (DiDi users).

In terms of gender, being a female (with male as the reference category) has a moderate positive effect on the overall valorations of features of ride-hailing (0.131) and on the panic button (0.125), and a low estimate on the payment options (0.074). No significant coefficient is estimated for travel without transfers. The interpretation is that being female is mediating the way ride-hailing characteristics are perceived and that the panic button is probably enhancing perceptions of security among women, whilst the electronic payment allows women to travel without cash and without interacting with the driver. We tested complementary specifications of the model interacting gender with the latent variables and with other indicator variables. Estimates were not statistically significant.

Distance to the nearest transit stations has no association with travel not involving transfers. Having a car is only significant (with a low standardized effect of -0.057) on payment options. Having a motorbike or any kind of disability is not insignificant across all the studied outcomes. As a complementarity analysis beyond the estimates presented in Table 3 and taking advantage of the results in the analysis of invariance, we calculated mean values of the latent variables by gender. The mean values show only slight differences for TNC trust with man having a higher mean (0.037) than women (-0.039).

Table 3. Perceived importance of personal security features in ride-hailing services: SEM Model Results

	Perceived information features of ride-hailing			Travel with no transfers			Payment options			Panic button		
	Est.	SE	SC	Est.	SE	SC	Est.	SE	SC	Est.	SE	SC
Trust in ride-hailing	0.128***	0.014	0.271	0.219***	0.038	0.144	0.191***	0.028	0.173	0.107***	0.019	0.137
Security concerns in public space	0.056***	0.008	0.182	0.062***	0.023	0.062	0.076***	0.016	0.106	0.073***	0.012	0.144
Trust in being protected from COVID-19 when travelling in metro or metrobus	-0.016**	0.004	-0.073	0.019	0.016	0.027	-0.001	0.011	-0.001	---	---	---
Age (year old)												
<18	-0.092	0.065	-0.037	-0.242	0.187	-0.030	0.065	0.134	0.011	-0.089	0.095	-0.021
From 19 to 30	-0.006	0.017	-0.011	-0.053	0.051	-0.028	0.084**	0.036	0.060	0.000	0.026	0.000
From 31 to 40	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
From 41 to 50	0.028	0.026	0.030	0.196***	0.074	0.067	0.100*	0.054	0.047	0.070*	0.038	0.046
From 51 to 60	-0.001	0.035	-0.001	0.215**	0.101	0.052	0.045	0.073	0.015	-0.009	0.051	-0.004
Gender												
Male	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Female	0.079***	0.016	0.131	0.014	0.046	0.007	0.104***	0.033	0.074	0.125***	0.024	0.125
Other/prefer not to say	0.073**	0.031	0.061	0.156*	0.091	0.040	0.097	0.065	0.035	0.108**	0.046	0.055
Distance to the nearest stations (minutes)												
Do not know	---	---	---	0.138	0.11	0.029	---	---	---	---	---	---
< =10	---	---	---	0.054	0.053	0.026	---	---	---	---	---	---
11 to 20	---	---	---	ref	ref	ref	---	---	---	---	---	---
21 to 30	---	---	---	-0.061	0.070	-0.021	---	---	---	---	---	---
>30	---	---	---	-0.018	0.060	-0.007	---	---	---	---	---	---
Has a car?												
No	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Yes	-0.019	0.019	-0.026	-0.075	0.056	-0.031	-0.098**	0.040	-0.057	-0.021	0.028	-0.017
Has a motorbike?												
No	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Yes	-0.010	0.031	-0.008	0.082	0.091	0.021	0.108*	0.065	0.037	0.014	0.046	0.007
Disabilities												
No	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Yes	-0.001	0.027	-0.001	-0.016	0.079	-0.005	-0.002	0.057	-0.001	-0.015	0.040	-0.008

Estimates are presented in the column Est.
SE stands for standard errors
SC stands for standardized coefficient.
Statistical significance as follows: *** p<0.01, ** p<0.05, * p<0.1

4.2 Strategies used when travelling in ride-hailing

Results for the OLOGIT are presented in Table 4 with the original estimates, significance level, error, and estimates in the odds ratio scale. The trust in ride-hailing variable is having an important effect on the variables *travel with someone you know* (estimate of 0.479), *travel with unknown people* (estimate of 0.562), and *cancel service due to assigned vehicle* (estimate of 0.303). This is validating recent research proposing trust in ride-hailing platforms and drivers as determinants in riders keeping to use the service (Ma et al., 2019). For the first two cases the interpretation is that higher trust facilitates people travelling with a companion, and for the former, that people with more trust are probably clients with more attention to the vehicle they will be riding.

Estimates for the perceived information features of ride-hailing are key explanatory variables. It is not-significant only for the strategies *cancel service due to assigned vehicle* and *canceling service due to driver*; all other estimates are significant. Nevertheless, there are positive estimates for the strategy of *traveling with someone you know* (0.542) and *share details of your trip* (0.977), and negative estimates for *travel with unknown people* (-0.692) and *cancel service due to driver's sex* (-0.656). These results are consistent. It is expected that people who have more positive perceptions about the relevance of information available in ride-hailing use the information when commuting and that the access to information is used to evaluate vehicles and drivers.

Security concerns in public space are associated with only two strategies. For *travel with unknown people (pooling*) the model finds a negative effect (-0.139) meaning that if people are report more fear of crime, then it they are less likely to share ride-hailing trips. This could be related to fear of other, unknown, passengers. For the strategy *share details of your trips* the estimate is positive (0.121) which implies that people with higher levels of fear of crime are taking most advantage of this strategy. Both results were expected.

Gender (being a female) is one of the most important variables in the presented models (using male as the reference category), arguing in favor of the idea that ride-hailing is providing mobility alternatives that are filling specific needs of women. In this case, the need to move safer. Being female reduces by 64.4% the likelihood of choosing to travel with unknown people (-0.440 estimate). Interestingly, being female increases, by 2.14 times (original log-odds estimate of 0.760), the probability of sharing details of their trips. Therefore, it seems that women are taking advantage of this technological capability in ride-hailing to exercise a strategy not available in other modes. Contrary to what we were expecting, gender is not significant for travelling with someone you know and for cancelling services due to driver or due to driver's sex. The estimate for being a female is negative for the variable cancel service due to vehicle (-0.228) and we think this is probably reflecting that, for men, the brand and model of the vehicle is a more important factor.

Having a car increases by 25.1% the likelihood of sharing trip details, by 28.9% the likelihood of canceling due to the vehicle, and by 33.6% the likelihood of cancel due to driver. These results suggest that car owners probably feel more insecurity when commuting by ride-hailing and rely on the available strategies.

Table 4. Strategies used when travelling in ride-hailing: OLOGIT model results

	Travel with someone you know (family or friends)		Travel with strangers (pooling)		Share details of your trips		Cancel service due to assigned vehicle	Cancel service due to driver' sex		Cancel service due to driver	
	Est.	SE	Est.	SE	Est.	SE	Est.	Est.	SE	Est.	SE
Trust in ride-hailing	0.479***	0.115	0.562***	0.152	-0.154	0.113	0.303**	---	---	---	---
Perceived information features of ride-hailing	0.542***	0.171	-0.692***	0.195	0.977***	0.174	-0.279	-0.656***	0.189	-0.175	0.180
Security concerns in public space	0.028	0.046	-0.139**	0.060	0.121***	0.047	-0.008	-0.001	0.058	-0.028	0.052
Trust of being protected from COVID-19 when travelling in metro or metrobus	0.042	0.033	0.424***	0.042	---	---		---	---	---	---
Trust on the geographic coverage of ride-hailing (that it can pick up and drop off everywhere)	0.021	0.071	-0.138	0.093	-0.071	0.074	-0.163**	-0.031	0.077	-0.160**	0.069
Trust that you will find a service regardless of the time	-0.107	0.060	-0.217***	0.080	0.157**	0.062	-0.088	-0.042	0.071	-0.082	0.064
Assessment of price of ride-hailing	-0.031	0.053	0.049	0.069	---	---	0.033	0.011	0.066	0.026	0.060
Assessment of travel time in ride-hailing	---	---	-0.1276*	0.075	---	---	-0.219***	-0.215***	0.071	-0.183***	0.065
Age (year old)											
<18	0.949***	0.357	0.78064*	0.458	0.490	0.382	0.965**	1.102***	0.400	0.900**	0.368
From 19 to 30	0.137	0.098	0.519***	0.130	0.35***	0.100	0.304***	0.464***	0.126	0.260**	0.111
From 31 to 40	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
From 41 to 50	0.069	0.145	-0.37***	0.214	-0.107	0.146	-0.053	-0.146	0.201	-0.163	0.171
From 51 to 60	-0.563***	0.201	-0.129	0.290	-0.053	0.200	0.026	-0.099	0.267	-0.264	0.237
Gender											
Man	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Woman	0.084	0.090	-0.440***	0.118	0.76***	0.093	-0.228**	-0.115	0.114	-0.153	0.102
Other/prefer not to say	0.280	0.176	-0.840***	0.273	0.421**	0.180	-0.287	-0.030	0.219	-0.211	0.204
Distance to the nearest stations (minutes)											
Do not know	-0.292	0.220	-0.594*	0.327	-0.481**	0.224	-0.192	-0.124	0.297	-0.253	0.266
< =10	-0.317***	0.109	-0.023	0.140	0.030	0.111	0.129	-0.028	0.139	-0.065	0.122
11 to 20	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
21 to 30	-0.336**	0.144	-0.144	0.187	-0.218	0.145	-0.046	0.196	0.177	-0.124	0.164
>30	-0.246**	0.122	-0.072	0.156	-0.207*	0.125	0.015	0.224	0.150	-0.028	0.137
Has a car?											
No	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Yes	0.075	0.109	-0.016	0.142	0.224**	0.110	0.254**	0.134	0.134	0.290**	0.120
Has a motorbike?											
No	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Yes	-0.147	0.170	0.232	0.220	0.008	0.174	0.124	0.086	0.212	-0.155	0.203
Disabilities											
No	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Yes	-0.206	0.153	0.251	0.188	0.055	0.157	-0.180	-0.131	0.196	-0.021	0.175

Estimates are presented in the column Est. SE stands for standard errors
Statistical significance as follows: *** p<0.01, ** p<0.05, * p<0.1.

5. Conclusions

Our findings highlight conceptual and empirical considerations for the analysis of both the unique features of ride-hailing services and the behavior of their users expressed through the frequency of use of different strategies to improve personal security. Results add nuances to our understanding of ride-hailing services by exploring and finding evidence of: (i) the influence of subjective perceptions of (in)security in different settings of urban contexts (i.e., on the street and public transit) and the association with valuing features offered by TNCs and engaging in certain strategies to improve personal security; (ii) how technology in ride-hailing and mainly the access to information are valued by users and serve as mechanisms to facilitate safe transportation; and (iii) strategies (like sharing details of the trips) appear to be helping women to fill mobility gaps.

The study hypothesized that in cities with high levels of crime, insecurity, and gender violence such as Mexico City, variables related to security become effective explanatory factors for the perceptions of service features and frequency of use of certain strategies. In the same vein, the research posited that perceptions of (in)security and trust in urban transport services can explain the definition of specific travel strategies, suggesting significant trade-offs between travel behavior and personal security.

The paper demonstrates the need for partnerships and collaborations, particularly with the private sector in urban mobility markets, in the design, targeting, and delivery of research instruments such as the survey informing the above analysis. It is also relevant to highlight the role of perception questions in travel behavior research, as they have provided the basis for the analysis in this paper. The authors recognize that there may be limitations associated with the analysis of the user base of a single service platform. However, previous research in the local context and existing databases produced by public authorities and other research do not suggest that there are significant differences between users in our sample and ride-hailing users of other platforms (Puche, 2019).

The results suggest that gender and perceptions of personal security explain the value users attach to various features of the service, many of which are often framed by service providers as ways of improving security while riding. Such findings can not only inform decisions by TNCs providing on-demand services in similar contexts but can also inform policies seeking to improve standards for security on shared mobility services. Women engage in more complex trade-offs and decision-making processes related to their travel choices than men do in contexts marked by insecurity and gender violence in public space and public transit. This highlights the need for future research that can not only inform decisions by ride-hailing companies to help them improve their services for women, but shape public policies aimed at improving safe mobility for women.

Future research can build on the analysis in this paper to further disentangle and understand the complexities of travel choices, attitudes and preferences of women and men in cities such as Mexico, as well as extend the methodology presented in this paper to other cities in LAC and the global south. The paper also contributes to the development of partnerships to produce knowledge and the transparent sharing of information by private actors in the ride-hailing market that can inform decision-making in the urban mobility policy sphere. A challenge related to the strengthening of such partnerships is identifying and leveraging the incentives from the private sector to share information and collaborate with research, development, and public organizations in the co-production of knowledge. These incentives need to be explored further. However, lessons from our research show an interest from private operators to contribute to this co-production of knowledge, improve and adapt their services to local conditions, address challenges for mobility that can allow them to access new market segments, and explore avenues for integration with other transport modes, all of which can be informed by research like the one presented in this paper.

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7. Author contributions

The authors confirm contribution to the paper as follows: study conception and design: Lynn Scholl, Daniel Oviedo, and Orlando Sabogal-Cardona; data collection: Lynn Scholl; analysis and interpretation of results: Daniel Oviedo and Orlando Sabogal-Cardona; draft manuscript preparation: Daniel Oviedo and Orlando Sabogal-Cardona. All authors reviewed the results and approved the final version of the manuscript.

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ANNEX

	Est.	SE	SC	R2
Perceived information features of ride-hailing				
Having access to your real-time location	1		0.309	0.360
Having access to driver's rate	1.276	0.071	0.559	0.313
Having access to the vehicle information	0.979	0.050	0.682	0.466
Having access to the driver information	0.995	0.050	0.694	0.482
Knowing the time the vehicle will pick you up	0.941	0.048	0.660	0.435
Knowing the time the vehicle will take you to your destination	0.950	0.052	0.595	0.354
Trust in ride-hailing				
Trust in ride-hailing drivers	1		0.634	0.496
Trust in the driving abilities of ride-hailing	1.218	0.041	0.832	0.692
Trust in the quality of ride-haling vehicles	1.165	0.042	0.751	0.564
Trust in being safe from COVID-19	1.061	0.043	0.642	0.412
Security concern in public transit (fear of crime)				
How often do you worry about your safety in Jitneys, min-vans, or combis	1		1.074	0.846
How often do you worry about your safety in metro or metrobus	1.042	0.014	0.929	0.864
How often do you worry about your safety in metro or metrobus during night	1.085	0.014	0.95	0.902
How often do you worry about your safety in metro or metrobus in the zone where you live	0.93	0.017	0.855	0.732
Security concern in public transit stations (fear of crime)				
How often do you worry about your safety in a transit station during day	1		1.096	0.789
How often do you worry about your safety in a train station during night	1.056	0.015	0.959	0.919
How often do you worry about your safety on a jitney/minivan/combi station during day	1.027	0.017	0.908	0.825
How often do you worry about your safety on a jitney/minivan/combi station during night	1.058	0.015	0.957	0.916
Security concerns in public space (fear of crime)				
Security concern in public transit (fear of crime)	1		0.91	0.827
Security concern on public transit stations (fear of crime)	1.097	0.022	0.977	0.955
How often do you worry about your personal security in the streets during day	1.021	0.024	0.794	0.631
How often do you worry about your personal security in the streets during night	1.122	0.021	0.904	0.818
How often do you worry about your personal security in public (open) space during day	1.043	0.024	0.809	0.655
How often do you worry about your safety in public (open) space during night	1.150	0.020	0.930	0.864

Estimates are presented in the column Est.
SE stands for standard errors
SC stands for standardized coefficient
R2: Communality
All factor loading are significant at the p<0.05 value