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Why do passengers use pooled-rides services? Social effects and implications for policy making

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ABSTRACT

App-based pooled–ride services transform how passengers plan and execute their trips. Even though there is extensive research on the travel behavior and user characteristics of some shared-mobility services, such as ride-hailing, bike-sharing, and scooter-sharing, the user characteristics of pooled-rides platforms have not received as much attention. This paper thoroughly analyzes the travel behavior effects and user characteristics of a new pooled–ride service, the Jetty platform in Mexico, based on a large-scale user survey (N = 2484). The service provides pooled–rides in different-sized vehicles, such as cars, vans, and buses. We characterize the top reasons to choose the pooled–rides service and the activities performed by users while traveling, using Logit and Hybrid choice models, and we perform sentiment analysis to extract patterns from the users' open opinions about the service. Our findings confirm common shared-mobility user attributes while identifying characteristics unique to pooled rides. First, women are more likely to use pooled–rides, as they find a greater sense of security in this shared-mobility platform. Second, pooled–ride services replace complex multi-modal trips, increasing users' convenience and job accessibility by reducing door-to-door travel time. Third, regarding the use of time while traveling, passengers more commonly use their smartphones or try to sleep while traveling, a finding possibly related to the increased comfort and security perceived in Jetty vehicles relative to the usual public transport alternatives in the city. Regarding research methods, choice modeling, and sentiment analysis are complementary tools to uncover different dimensions of travel behavior effects and quality attributes of a new shared mobility mode. From a policy perspective, we conclude that the analyzed pooled-rides platform is a step towards improving the quality of service for people who do not want (or cannot) travel by car and that having a more inclusive pooled-rides service requires the provision of subsidies to low-income travelers.

1. Introduction

Urban areas are under increasing pressure due to rapid population growth and urbanization, with projections indicating that two-thirds of the global population will reside in cities by 2050,[1] Expansion of infrastructure and changes in land-use policies are commonly required to cope with the growing increase in travel demand generated by the urban population growth; however, infrastructure and land-use projects require substantial investments and long-term plans, which sometimes, for many reasons, are hard to materialize (Sabir and Torre, 2023; Ma et al., 2020). Likewise, demand management measures that might control travel demand, such as congestion charges, car-free days, and odd-even plate restriction measures, do not always yield optimal results (Toan et al., 2023; Farda and Balijepalli, 2018). Emerging mobility solutions supported by the latest advancement in information and communication technologies (ICT) present an opportunity for sustainable, efficient solutions for the increased travel demand (Li, 2020). An example of the emerging solution is shared mobility services, which allow passengers to access various transportation modes, such as bicycles, e-scooters, and cars, for short periods as required, and the payment is based on the actual use per minute or kilometer (Shaheen et al., 2016). The attractiveness and popularity of shared mobility are reflected by its exponential demand growth for the different shared

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[1] https://www.worldbank.org/en/topic/transport/overview accessed 05/07/2024.

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services (Shi et al., 2021). One famous example is the on-demand ride-hailing company Uber. This ride-hailing giant has expanded its operations globally to over 10,500 cities in 70 countries by the end of 2023 since its first ride in 2010 (Uber, 2024).

Shared mobility offers several potential benefits for the urban environment. It can improve the efficiency of transportation systems and help reduce traffic-related externalities, such as air and noise pollution, energy consumption, and traffic congestion. It could also help reduce the demand on the infrastructure (Yi and Yan, 2020; Becker et al., 2020). On the other hand, car-based services in which rides are not shared, like ride-hailing, are less sustainable as they likely increase motorized traffic and congestion in cities, under several conditions (Moody et al., 2021a; Duran-Rodas et al., 2020; Tirachini et al., 2020; Tirachini, 2019).

Shared mobility services can be categorized into two main groups. Users can access the vehicle directly in the first group, such as carsharing and shared micromobility. In the second group, passengers share the ride with other passengers under different schemes that aim to reduce travel costs while enjoying the convenience of on-demand services (Morris et al., 2019). Several services are under the umbrella of the second group, such as Ridepooling (pooled-rides) in different-sized vehicles (carpooling, vanpooling), Alternative Transit Services (ATS), and Courier Network Services (Abouelela, 2024). Several business models within the shared economy encompass shared mobility. The two main models that dominate the shared mobility sector are the Consumer-to-Consumer (C2C), also known as the Peer-to-Peer (P2P) model, where individual providers allow others to use their underutilized vehicles. An example of this model is Blablacar, which facilitates carpooling (Lembcke et al., 2020). The second model is the Business-to-Consumer (B2C) model, where a company owns the assets and offers users access through membership and usage-based fees. Examples of B2C shared mobility services include Lime scooters, oBike, Zipcar, Car2go, DriveNow, Uber, DiDi, and Lyft (Liu and Kim, 2022; Jochem et al., 2020).

Pooled–rides could efficiently solve several traffic externalities if a high vehicle occupancy rate is maintained during the trips (Tirachini and Gomez-Lobo, 2020; Tirachini et al., 2020). Pooled-ride services have been recently introduced in many urban areas, and their influences on short- and long-term travel decisions are not fully comprehended (Young et al., 2020). Important characteristics such as factors influencing the demand, the replaced travel modes, frequency of use, and interaction with the different elements of the urban environment, such as transport supply, land use, and accessibility to PT, in addition to trip's characteristics, are still ambiguous (Soza-Parra et al., 2024; Zhu and Mo, 2022).

This research is motivated by the need for a deeper understanding of the user and trip characteristics of the growing pooled-ride services. We developed a survey that investigated the users' characteristics, general travel behavior, and service use behavior, such as the reasons behind using the service and activities during the trip. We also analyzed an extensive trip dataset performed by the survey respondents. The collected datasets contained user-level information and actual use data that is not widely available, and it helped us to gain deeper insights regarding the actual use behavior. Our study is not based on hypothetical scenarios; many previous studies were based on stated preference (SP) surveys. Also, a significant part of the earlier studies was concentrated in North America and Europe, except a limited number of studies discussed the subject in Asia and South America, which largely depended on aggregated data sources due to the ethical and legal issues mobility companies face surrounding public sharing of consumer data (Liu et al., 2019; Shaheen et al., 2017b).

Therefore, the unique study setup of this research, based on the collected data, the survey, and trip data obtained from a commercial (for profit), third-party, organized pooled-rides service in Mexico City, one of the world's most populated cities (United Nations Department of Economic and Social Affairs, Population Division, 2018), with one of the highest motorization rates in developing countries, where for each newborn baby, two cars are added to the city roads (Jirón, 2013). We contribute to the current literature by answering the following three research questions:

- (RQ1) What are the pooled-rides trip characteristics?
- (RQ2) What are pooled-rides users' characteristics and travel behavior, and their impact on why they use and choose the service?
- (RQ3) What are the policy implications of the identified effects of the pooled-rides service?

The research questions' answers contribute to the existing shared mobility literature with an in-depth understanding of the characteristics of pooled-rides on various fronts: (a) user's travel patterns are examined, focusing on aspects of trip characteristics, reason for use, and onboard activities, (b) operators data is analyzed to understand the particularities of the service.

The rest of this article is organized as follows: Section 3 is the literature review section, and Section 4 describes the data collection process, the research methodology, and the study setup. Sections 4 and 5 show the data analysis and modeling results, respectively, while Section 6 summarizes the research discussion and limitations; Section 7 concludes the research findings.

2. Literature review

2.1. Taxonomy and definition

Shared mobility has changed the urban transportation landscape by providing quick access, on a need-to-travel basis, to several transport options, where users can pay for their exact use per ride, minute, or kilometer (Shaheen and Cohen, 2018). One of the problems around research efforts on shared mobility is the need for standard definitions of the services (Castellanos et al., 2022), which has not been a simple task. Standardizing definitions of shared mobility is essential for reducing discrepancies in terminology, which might contribute to public misperception regarding the different services. A standard terminology helps public agencies clarify policies on insurance, taxation, rights-of-way, parking, and operation zoning. Also, the standardization process aligns public and private sector definitions to support service development and public–private partnerships. The guiding principles for this standardization emphasize providing descriptive, functional, and industry-consistent definitions that are clear and useful across various disciplines. They also avoid ambiguity, ensuring no competitive advantage to any shared mobility provider (SAE International, 2018).

Therefore, this section describes the different services and how we would categorize them. Shared mobility can be classified into two groups of services; in the first group, users have access to the vehicle directly, such as the case of carsharing and shared micromobility (bike-sharing, shared e-scooter, and moped scooter); in the second group, users share their rides based on different schemes, or their willingness to pool the rides. The latter group of services includes the following services: (i) Ridesharing (pooled–ride) in different-sized vehicles (e.g., carpooling, vanpooling) (ii) Ride–hailing, On-Demand Ride Services, Transportation Network Companies (TNC), ride–sourcing, and in special cases ride–splitting (iii) Alternative Transit Services (ATS) (iv) Courier Network Services.[2]

These services can potentially reduce traffic externalities, especially if they do not replace sustainable modes such as active mobility and public transportation. Reducing traffic externalities would materialize

[2] CNS offers for-hire delivery services in exchange for payment, utilizing an online platform (such as a website or mobile app) to link couriers, who use their own vehicles, bicycles, or scooters, with goods for delivery; e.g., packages, and food (SAE International, 2018).

by substituting and combining low occupancy motorized trips (e.g., solo private car trips) in higher capacity vehicles that fully or near fully utilize their full capacity, ultimately reducing the number of vehicles on the road, and subsequently reducing motorized traffic and its externalities (Tirachini et al., 2020; Tirachini and Gomez-Lobo, 2020).

The service analyzed in this research, Jetty, which is a commercial pooled-rides service, has common attributes with three shared services, namely: (iv) ridesharing (pooled–ride), (v) ride–hailing, and (vi) ATS. Therefore, we explore the definition of these services to better understand these mobility alternatives and later compare them with the Jetty service. Fig. 1 summarizes the pooled-rides ecosystem based on the obligation to pool, matching method, and vehicle size.

- Ridesharing or pooled–ride is a mode of transportation where users with matching or partially matching itineraries and schedules share a vehicle and the emanated cost of the trip (Shaheen, 2018). Ridesharing includes carpooling (e.g., BlaBlaCar) and vanpooling; their subgroups are categorized by vehicle size. Vanpooling is a group of seven to fifteen passengers traveling together (not using a bus) (Shaheen et al., 2019). At the same time, carpooling takes place in a passenger private vehicle when two users, including the driver, travel together in an ad-hoc fashion. It can also be categorized based on the relation between the users of the services: (I) acquaintance-based services, such as coworkers or family members (Fampool); (II) organization-based services where users join the service through digital platforms; (III) Ad-hoc ridesharing (slugging), for example, when drivers pick up share riders to gain access to the highway's High Occupancy Vehicle lanes (HOV) (Shaheen et al., 2015; LeBlanc, 2021)
- Ride–hailing is the service where users use a mobile application to connect through the platform with the nearest available driver, who uses his private car to transport the users to their destination on an individual basis (Shared and Digital Mobility Committee, 2018; Shaheen and Cohen, 2018; Shaheen et al., 2015). Ride–hailing companies provide pooled options in some cities, where passengers with matching or partially matching routes can split the ride cost, cheaper than the average individual hailed trip, as compensation for the detours and delays. These rides are commonly defined as ridesplitting such as the case of UberPool (Young et al., 2020)
- Alternative transit services (ATS) and Demand Responsive Transport (DRT) run lateral to public transport. These two formats encircle extensive types of modes, such as paratransit, shuttles, microtransit, vans, dollar vans, jitneys, and small buses (Shaheen and Cohen, 2018; Cohen and Shaheen, 2018; Mourad et al., 2019). ATS differ from PT as they are costlier to the provider, generally, due to the low demand volume of travelers per trip, as these services usually try to address the spatial and/or temporal gaps in PT coverage (Shared and Digital Mobility Committee, 2018; Cohen and Shaheen, 2018; Shaheen et al., 2015).

2.2. Potential and challenges of pooled-rides

The importance of pooled-rides schemes lies in their ability to drive the transportation system in a more sustainable direction, and in developing countries with poor PT infrastructure, it could be a sustainable mode to complement PT by extending its spatial and temporal access (Abutaleb et al., 2020). Pooled-rides have the potential to reduce GHG emissions, reduce energy consumption, reduce VKT, increase accessibility, especially for carfree households, improve curb management by reducing the parking demand, and save time and money for users (Alonso-González et al., 2020; Ayaz et al., 2021; Delhomme and Gheorghiu, 2016). This potential is coupled with a modal convenience and comfort that is usually superior to traditional forms of public transportation at a lower cost than taxi services (Karaenke et al., 2023). Moreover, pooled-rides services are also being piloted as a first/last mile solution connecting passengers to transit stations, especially in low-demand areas where transit operation cost is high (Wang and Shen, 2024), e.g., the Via partnership with the Puget Sound region, Washington to increase the accessibility of vulnerable groups (people with mobility challenges, unbanked population, and people with no access to smartphone) to transit (Gifford et al., 2021), or Via as a first/last mile connector to the LA Metro (Miller et al., 2021).

While there is an expected positive potential of pooled-rides to encourage more sustainable mobility patterns, several of the service aspects do not have a decisive direction; for example, the service impact on vehicle-kilometers traveled (VKT) is not always clear, Tirachini et al. (2020) found that pooled-rides reduce VKT only if the occupancy rate of the vehicle in use is high and a large portion of users did not shift from public transport; otherwise VKT could increase.

On the other hand, pooled-rides face several challenges, as with the rest of shared mobility services, namely the need for smartphone and online banking options to use the service excludes users who do not have access to both means from accessing the service and therefore creates an inequitable use problem (Abouelela, 2024). Another issue is the users' willingness to pool and the materialization of the pooled trips; even if they opted to pool their rides, this is not always possible. Several factors might impact the user's decision to pool a ride, such as their concerns regarding their safety and privacy, the reliability of the travel time due to the expected detouring, the longer waiting time, and the value of the pooling incentive compared to the original non-pooling trip price (Su et al., 2023). Therefore, there is a need to understand the factors impacting these service uses to plan them accordingly and attract users without jeopardizing the service's impact on sustainability.

2.3. User characteristics

One of the most decisive factors motivating using pooled-rides is the user's sociodemographic characteristics. The most common shared mobility users profile could be young men, single, highly educated, high income-level, full-time employees, and living near downtown areas (Mouratidis, 2022; Ahmed et al., 2021). However, similarities and discrepancies between the general shared mobility user profile and the pooled–ride user profile could be identified. Older adults prefer to avoid pooled-rides, as they do not prefer to travel with strangers, and it might be difficult for them to use the apps (Alyavina et al., 2020; Neoh et al., 2018). Shaheen et al. (2017c) found that carpoolers in France are less likely to have a high income or live in a single-person household; also, Bulteau et al. (2019) confirmed the same observation in Paris, France. Lazarus et al. (2021) observed similar behavior for shared ride users in Los Angeles, Sacramento, San Diego, and the San Francisco Bay Area; USA. On the contrary, several other studies on pooled–ride users were found to have higher income in comparison to the rest of the population, for example, microtransit users in Washington D.C., Miami, Minneapolis, and Seattle (Rossetti et al., 2023), group travel ride-hailing in Minneapolis–St. Paul (Dean, 2024), and carpool users in France (Gheorghiu and Delhomme, 2018). Education level also played a role in some studies, such as the case of Ride–splitting (Express Pool) in Hangzhou, China, Wang et al. (2019), pooled–ride-hailing in Austin (Kang et al., 2021) and shared ride–hailing in California (Malik et al., 2021), where users were more likely to be highly educated compared to the rest of the population. On the other hand, education was not always significant, and even people with lower education were more likely to adopt pooled-rides (Julagasigorn et al., 2021).

Another factor with conflicting results is gender, where women, single or married, and married men do not prefer to share their rides (Chen et al., 2022; Ayaz et al., 2021). In other cases, women were three times more likely than men to adopt carpooling for long-distance trips (Monchambert, 2020). Various reasons might have caused the high adoption of carpooling by women, such as but not limited to unpaid care responsibility for kids and house chores and the easiness of transporting children in pooled-rides services (Gheorghiu and

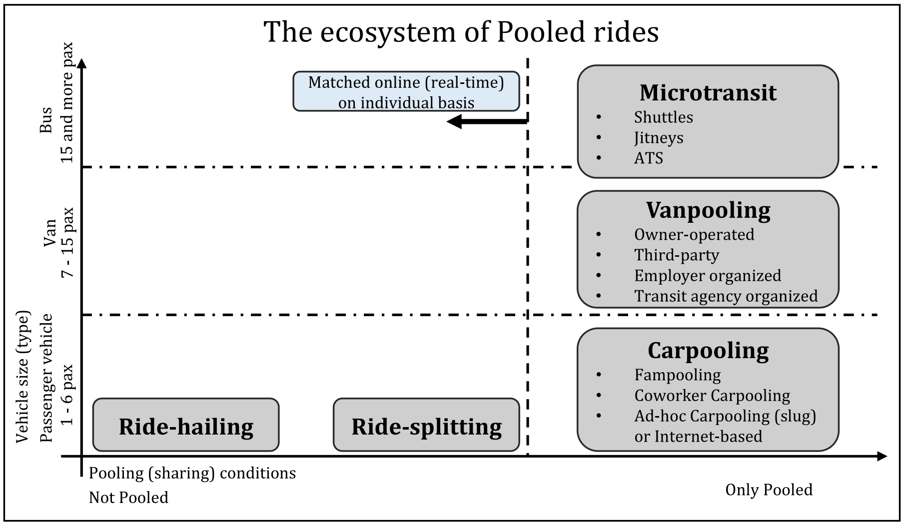

Fig. 1. Pooled–ride services ecosystem, own elaboration.

Delhomme, 2018; Neoh et al., 2018). However, these differences in conclusions could be due to the different sample characteristics in terms of education and income level (Si et al., 2023). Understanding the role of gender in pooled–ride adoption is vital as substantial behavior differences were identified, such as the fact that men are more rational in their choices for pooled-rides focusing on functional values, e.g., cost and time-saving; at the same time, women are more likely to value their enjoyment and emotional incentives (Chen et al., 2022).

The seemingly conflicting effects identified by the different sociodemographic characteristics of users highlight the need to further understand the role of sociodemographic attributes in pooled–ride use. Table 1 shows a summary of some selected studies regarding the user's profiles for the different types of pooled–rides, in addition to the sample size, geographical location, and the type of survey. As can be observed, a significant part of the summarized studies are based on stated preference (SP) surveys and not based on actual use data or revealed preference.

It is essential to highlight that other important factors related to the users, such as psychological factors in terms of personality traits and attitudes, impact the general use of shared mobility (Abouelela et al., 2024), and specifically shared rides (Abutaleb et al., 2021), but they are not the focus of this research.

2.4. User travel behavior

User general travel behavior is essential in deciding the shift and adoption of shared mobility services, specifically pooled-rides. Two main factors related to the general travel behavior that have been observed to impact the adoption of pooled-rides are car ownership and PT use. An example is carpool users, who were found to be less likely to be frequent PT users for several reasons, including high car ownership rates coupled with an increased preference to drive (Monchambert, 2020; Bulteau et al., 2019; Javid et al., 2017). In specific cases, such as in Hangzhou, China, most carpoolers were frequent PT users who shifted a proportion of their trips to carpooling (Wang et al., 2019). On the other hand, for pooled-rides (pooled–ride–hailing and microtransit), most users were frequent PT users (Rossetti et al., 2023; Dean, 2024; Gehrke et al., 2021; Moody et al., 2021b).

Car ownership was also a significant variable in the adoption of the pooled–rides, where 75% of the carpooling users have at least one car in Hangzhou, China (Wang et al., 2019), and 55% of the users own a car in Lahore City, Pakistan (Javid et al., 2017). A high car ownership rate was also observed in carpooling surveys in several cities from the USA, Germany and France (Park et al., 2018; Gheorghiu and Delhomme, 2018; Rossetti et al., 2023; Gödde et al., 2023; Kostorz et al., 2021), whereas other studies from Seattle and Boston the users were mainly from a car-free or car-lite households (Wang and Shen, 2024; Gehrke et al., 2021). We believe that the observed travel behavior is related to the pooled service setup, e.g., in the case of carpooling, there is a percentage of the users are using the service as drivers; therefore, they have high car ownership rates, and also they use cars instead of PT for regular travel. Also, the sampling strategy plays a role. An example is the case of Transit Incorporating Mobility on Demand (TIMOD), where the service was designed for people with mobility challenges to connect them to the metro line; therefore, their car ownership rate is low (Wang and Shen, 2024).

2.5. Reasons to use pooled-rides

Schaefers (2013) grouped the main reasons to use shared mobility into four main groups: (I) financial, in terms of money-saving; (II) convenience; in terms of ease of use; (III) lifestyle, in terms of the pleasure of using private vehicles; and finally (IV) sustainability, in terms of environmental concerns. Similarly, several reasons were associated with pooled–ride use, such as but not limited to time and cost savings and the increased convenience compared to PT use (Morris et al., 2019). For example, in California, it was found that ride-splitting would save between $1.57 to $ 2.13 per mile compared to a solo TNC trip; and in Guangzhou, China (Wang et al., 2022) found that the monetary saving from using shared rides could be up to $8500 per year. Time-saving was one of the main reasons to use pooled–rides; as compared to PT, the travel time is usually shorter, and shared rides have the option to use high occupancy vehicle lanes (HOV), which also saves more time (Ahmed et al., 2021; Julagasigorn et al., 2021; Ayaz et al., 2021). Observing sustainability goals was also identified, where students identified reducing energy consumption as a significant reason to share their rides (Lee et al., 2020).

Other reasons were also evident in different studies, e.g., the service is offered by the employer, carpooling in Paris, France, and the associated perceived value of service use (Bulteau et al., 2019), also the perceived social and environmental benefits for carpooling in Lahore City, Pakistan (Javid et al., 2017), and the increased sense of security in Merida, Toluca de Lerdo, and Aguascalientes in Mexico (Moody et al., 2021b).

Table 1
On-demand pooled-rides user characteristics, summary of selected studies.

Reference	Service type	Gender	Age	Martial status	Income	Occupation	Education	Car ownership	Sample size	Area	Survey type
Bulteau et al. (2019)	Carpooling	Man	16–49		Individual monthly low income (<1K Euro)				2002	Paris, France	RP
Wang et al. (2019)	Carpooling, and Ridesplitting (Express Pool)		Young	Married		Employed	Highly educated	High car ownership rate	607	Hangzhou, China	RP/SP
Javid et al. (2017)	Carpooling			Single		Employed		High car ownership rate	354	Lahore City, Pakistan	SP
Moody et al. (2021b)	pooled–ride–hailing	man	18–45			Employed			1322	Three Mexican cities: Merida, Toluca de Lerdo, and Aguascalientes.	RP
Lazarus et al. (2021)	Shared ride		Between 18 to 29 years and 70 years or older		Low income (annual income less than $35K)			High car ownership rate	2434	Los Angeles, Sacramento, San Diego, and the San Francisco Bay Area; USA	SP
Gehrke et al. (2021)	pooled–ride–hailing		Young		Low income	Employed		car-free or car-lite household	944	Boston, USA	RP
Kumar et al. (2022)	Ride-sharing	Man				Employed			630	Delhi-National Capital Region (NCR)	
Kang et al. (2021)	pooled–ride–hailing	Man	Between 18–24			Employed	Highly educated		953	Austin, TX	RP/SP
Rossetti et al. (2023)	Microtransit	Man	young		Annual income more than $35K	Employed	Graduate degree	High car ownership rate	2315	Washington D.C., Miami, Minneapolis, Seattle, USA	SP
Dean (2024)	Group Travel Ride-Hailing		18–54		Annual income more than $50K	Employed		High car ownership rate	845	Minneapolis and St.Paul, MN, USA	RP
Kostorz et al. (2021)	Ridepooling		18–49		Monthly income more than 2K Euro	Employed		High car ownership rate	12 000	Hamburg, Germany	RP
Gödde et al. (2023)	Ride-pooling		Between 16–39 years		Monthly income less than 3K Euro per month			High car ownership rate	1814	Berlin and Munich, Germany	RP
Park et al. (2018)	Carpooling			Married, with children				High car ownership rate	1843	Ohio, USA	RP
Gheorghiu and Delhomme (2018)	Carpool		Young		High income			High car ownership rate	634	France	RP
Monchambert (2020)	Carpool	Man	Young		High income	Employed		High car ownership rate	1700	France	SP
Malik et al. (2021)	Shared ride–hailing		Millennials and younger		Annual income $50K and more	Employed	More than Bachelor's		3767	California, USA	
Wang and Shen (2024)	Transit Incorporating Mobility on Demand (TIMOD)	Man	Less than 25 years old					Low car ownership rate	1272	Seattle, USA	RP

When age, income, and other factors were modeled as continuous variables, we state in the table younger, higher income with no specific value defined as in the case of categorical variables, where exact age and income group are identified.

2.6. Trip purpose and demand characteristics

Trip purpose is also one of the key factors in pooled–ride use; several primary purposes were education (trips to the university) and shopping in Lahore City, Pakistan (Javid et al., 2017), going to work in Hangzhou, China (Wang et al., 2019), or access the PT as in the case of Seattle, USA (Wang and Shen, 2024); however, the most common identified trip purpose was leisure and leisure-related activities, in Mexico, New Delhi, Hamburg, Berlin, and Munich, and France (Zwick and Axhausen, 2022; Moody et al., 2021b; Kumar et al., 2022; Kostorz et al., 2021; Gödde et al., 2023; Gheorghiu and Delhomme, 2018)

It is also important to highlight that the most performed trip purpose might differ for the same service concerning the different population groups. Wang et al. (2019) examined the trip purpose for the various age groups for carpooling and ridesplitting services to find that for carpooling, both age groups used it to go to work as a primary reason, but for ride-splitting, the young population used it primary for entertainment purposes, while the old population used it for going to work. Another example is provided by Lavieri and Bhat (2019), who found that young women who had cars in their households were likelier to opt for pooled–rides for commuting, and highly educated individuals were less likely to use them for leisure trips.

Demand information for pooled–rides is not widely available, except for a limited number of studies; e.g., for ride-pooling services in Munich and Berlin, where the primary trip purpose was recreational activities, for more than one-half of the users, demand was uni-distributed demand with one peak (9% of the total daily demand) around the mid-night in both cities, especially during the weekend (Gödde et al., 2023). Similar patterns with different peak hours (8% of the total daily demand) between 18 and 23 h were identified for pooled-rides in Hamburg and Hanover (Zwick and Axhausen, 2022)

2.7. Research gaps

The previous literature review reveals gaps in the current ride–pooling literature that should be bridged. A significant portion of the studies is built around stated preference surveys, which suffer from several biases and differ from the actual use (Fifer et al., 2014). Previous studies have examined the pooled-rides user sociodemographic characteristics; however, they did not construct a solid profile for the users, refer to Table 1. Also, some aspects of service usage, such as activities performed during the trips and the trip's characteristics in terms of distance, duration, and vehicle occupancy, were not widely identified. Analyzing what people do while traveling and the time they use in shared vehicles may provide insights into the comfort and safety levels they perceive. Finally, while most of the pooled–ride studies were built on survey data or trip data, and not both, there is a need to match survey data with actual trip data for a deeper understanding of the service use.

3. Data sources, and study–setup

3.1. Data sources

We used three primary sources of information in this research: user survey, trip details for the survey respondents, and vehicle occupancy information for one month.

A three-part user survey was designed to address the research questions. The first part investigated the details of the users' latest trip using the service (purpose, access mode, access time, egress mode, and egress time; times here are reported user time), modes replaced by the service, and the expected trip duration in replaced modes. The second part of the survey investigated the users' general travel behavior, such as habitual mode choice, activities during the service rides, and reasons to use the service, and the last part of the survey was designed to explore the sociodemographic characteristics of the respondents. Finally, an optional open-ended question was provided to the users so they could add comments regarding the service in general. We designed the survey to connect the user's characteristics, such as sociodemographic and general travel behavior, to their service use to further understand pooled–ride use. The survey was implemented in Spanish using the open-source software *Limesurvey*.[3]

The survey was distributed randomly by the service company through the user's registered emails and the service mobile phone app for the users who performed at least one trip six months before May 2019. The company offered 200 MXN as a credit to be used for rides to 25 randomly selected participants who completed the survey as an incentive to increase the response rate. Responses were collected between the 30th of May to the 11th of June 2019, resulting in a sample of 3050 responses. The collected data were checked, incomplete answers and duplicate entries were removed, and the final sample size was 2484. The service organizer (Jetty) had no access to the collected data.

In addition, the survey dataset was combined with participants' trip details for the last seven months before the survey launching date (dates spanning from November 2018 to June 2019.), including the following variables: (i) user ID (ii) trip ID (iii) route ID (iv) pick-up and drop-off coordinates (v) trip distance (vi) number of booked tickets (vii) trip fare (viii) type of used vehicles (ix) vehicle capacity (x) departure and arrival times (xi) total trip route length. Finally, the service organizer also shared the service demand information for May 2019 to assess the occupancy of the different vehicles. This database contained the demand volume per vehicle type, the number of passengers in each vehicle type, and the various vehicles' capacities.

3.2. Study–setup

3.2.1. Study area

Mexico City (Ciudad de México; CDMX) is the capital city of Mexico, and it is a part of the Valley of Mexico Metropolitan Area (Zona Metropolitana del Valle de México; ZMVM). ZMVM is the most populated area in Central and North America and the world's fifth-largest metropolitan area with a total population of 21.58 million inhabitants; the population of CDMX is around 9 million inhabitants (United Nations Department of Economic and Social Affairs, Population Division, 2018; Mejía-Dorantes and Soto Villagrán, 2020-01). According to the Tomtom global traffic index (tomtom.com), CDMX is the most congested city in Mexico, the second most crowded city in North America, and the world's 13th most crowded city, and the most crowded mega city in 2023.

Half of CDMX's daily trips are performed by public transportation (PT) (INEGI, 2017), with two-thirds of the PT trips performed using collective services (combi and microbus). Collective services are a loosely regulated, not-subsidized paratransit in which passengers make three out of four PT trips in ZMVM (INEGI, 2017). The formal CDMX PT network consists of Metro (subway), electric light rail, trolleybuses, electric bus services network (RTP), Bus Rapid Transit (BRT, Metrobus), suburban trains, and a cable car. CDMX's PT network is well-connected in the central part of the city, but to a lesser extent, it is connected to the suburban areas, especially in the north. PT users face several daily challenges, with safety being the primary concern as 90% of PT users feel unsafe while using transit services (Mejía-Dorantes and Soto Villagrán, 2020-01; Rivadeneyra et al., 2015). Sexual harassment and petty crimes are frequent, and gender-based violence is a growing problem for both users and operators, as 23% of women reported avoiding PT use for safety reasons (Mejía-Dorantes and Soto Villagrán, 2020-01). Rivadeneyra et al. (2015) surveyed PT women passengers to investigate the sexual harassment incidents; the study disclosed that collective services (Combi and Microbus) are the most dangerous modes with 44% of the incidents occurring on board, followed by metro (26%), BRT (14%), and trolleys (6%). The metro system is considered the least safe in Central and South America and the second least safe in the world's largest fifteen cities (Mejía-Dorantes and Soto Villagrán, 2020-01). Other problems also exist as the fleet of PT vehicles is outdated, with several issues affecting the travel time and causing persistent delays and overcrowding (Sheinbaum, 2018). Shared mobility is evident in CDMX, such as TNC, E-scooters, and bike-sharing (Eisenmeier, 2019). Although TNCs are considered well-established in CDMX, their high price compared to other services limits their use. According to the 2017 CDMX travel (origin–destination) survey, the percentage of average daily trips performed using TNC compared to other paratransit services is 1.4% (INEGI, 2017).

3.2.2. Service description

Jetty[4] is an application-based pooled-rides service (company) that runs within the vicinity of CDMX. The app allows users to book a seat, share a ride in different-sized vehicles (three-seat taxis to 45-seat buses), and get information regarding the cost of different-sized vehicles. Users' requests are matched to the nearest available routes and vehicles, providing alternatives. Once the user chooses a trip and pickup location and pays for the trip, the ticket is issued and sent, followed by live updates of the time and location of the vehicles; the matching process is not done online (real–time), as users are matched to pre-scheduled routes. The service does not own the vehicles but cooperates with collective-services operators to provide vehicles. Jetty's routes are concentrated in locations with sparse PT services northwest of the city, directly connecting to the job centers and shopping centers in the Santa Fe business area and Polanco districts (Tirachini et al., 2020). In our sample, average Jetty fares were between 43 and 69 Mexican Pesos (MXN), whereas fares for paratransit, Metro, Metrobus, and Ecobus are between 5 and 7 Mexican Pesos (1 USD = 19 MXN, 1 Euro = 21 MXN). For ride-hailing, the price depends on trip distance and duration; considering the Uber pricing formula, a trip of 25 km (average Jetty trip length) costs around 200 MXN. In other words, the Jetty is one order of magnitude more expensive than usual public transport modes, but it is significantly cheaper than traveling by ride-hailing

Jetty service can be matched to more than one category of the shared mobility taxonomy. If the service is classified based on the used vehicle size, it could come under carpooling and vanpooling. If classified based on the operation scheme, Jetty can be considered ATS as it operates on a fixed geographic and temporal schedule with a finite number of stations on a fixed route. The company business model can be described as users paying the service organizer's service fees, which keeps marginal revenue (20%) and pays the rest to the vehicle owner, who pays the driver's salary. Driver's wages are fixed salaries and not a commission from the revenues of regular collective services (Dewey, 2019). Although ride–hailing companies provide some pooled services in some cities, commonly defined as ride-splitting such as UberPool, Uber Express Pool, Lyft Line, UberX Share, and Lyft Shared (Hansen and Sener, 2023; Young et al., 2020), these services are not comparable to Jetty as shared ride–hailing, also known as ridesplitting, depends on the dynamic matching of the users' with drivers on a real-time basis, which is different from the Jetty operational model.

[3] limesurvey.org.

[4] jetty.mx, last accessed 04/12/2024.

Table 2
Survey sample sociodemographic summary statistics (Tirachini et al., 2020).

Variable		Survey sample	CDMX population
	Levels	No (Pct%)	Level
Age			
	Between 18 and 25	376 (15.1%)	28,2% Between 6 and 24 year
	Between 26 and 35	1143 (46.0%)	54.3% Between 25 and 59 years
	More than 36	938 (37.9%)	17.5% 60 years and more
	Missing	27 (1.0%)	
Gender			
	Woman	1212 (48.8%)	Ratio of Man:Woman 1:1.11
	Man	1262 (50.8%)	
	Other	10 (0.4%)	
Household size			
	1	122 (4.9%)	Average Household Size, 3.2 unit
	2	556 (22.4%)	
	3	582 (23.4%)	
	4 and more	1125 (45.3%)	
	Missing	99 (4.0%)	
Personal net monthly income, Pesos (MXN)			
	Less than 10,000	320 (12.9%)	Average Net Monthly Income 10,000MXN
	10,000–20,000	878 (35.4%)	
	20,000–30,000	484 (19.5%)	
	More than 30,000	400 (16.1%)	
	Missing	402 (16.2%)	
Driving license			
	Yes	1901 (76.5%)	
	No	583 (23.5%)	
Cars in household			
	0	520 (20.9%)	44% Household with at least one car
	1	1130 (45.5%)	
	2 and more	834 (33.6%)	
Education level			
	Masters or Doctorate	378 (15.2%)	High Education 32.1%
	Bachelor or professional degree	1813 (73.0%)	Upper Secondary 26.6%
	Technical career	134 (5.4%)	Basic Schooling 38.9%
	High School or Baccalaureate	126 (5.0%)	No specific degree 0.3%
	Other	13 (0.5%)	Illiterate 1.5%
	Missing	20 (0.8%)	
Employment status			
	Full time job	2127 (85.6%)	95.5% Economically Active
	Part time job	99 (4.0%)	
	Other	258 (10.4%)	
	N = 2484 (100%)		CDMX Population = 8,811,266 (INEGI, 2015)

4. Data analysis

In this section, we analyzed the users' survey, exploring users' profiles and trips database for the same users who responded to the survey.

4.1. User survey

4.1.1. Users' profile and travel patterns

Table 2 shows the survey sample sociodemographic statistics summary and their comparison with the CDMX population. The sample is somewhat representative of the average population of CDMX in terms of age, gender ratio, and household size distribution. On the other hand, the sample is skewed towards higher income groups, higher education levels, and higher car ownership rates. Only 32.1% of the CDMX population has completed higher education compared to the 88% of the sample, with at least a bachelor's degree. Moreover, the average net monthly income per person in CDMX is 10,000 MXN,[5] while in the survey sample, the average net monthly income is around 20,000 MXN. Also, 80% of the survey sample reported at least having one car per household with an average of 1.25 cars per household; this car ownership rate is almost 2.5 times the city average of 0.53 cars per household (INEGI, 2015; Información estadística para el futuro académico y laboral en México, 2020). The differences between the service users and the average city demographics align with the location of the Jetty service, as the spatial coverage of the platform aligns with the location of middle-income and high-income households in the city, which concentrate in the area and the municipalities north and west of Mixco City,[6] Our sample's bias towards high income also aligns with the general profile of shared mobility service users being more affluent and educated than the average population in other parts of the world. It is to be noted that a significant amount of the users are women. However, their average income is statistically significantly different and lower than men (\$960 ± 540, and \$1217 ± 676, respectively, and p-value < 0.0001).

Respondents ranked their use frequency for the modes available in CDMX on a five-point-ordered Likert scale ranging from never to more than four times per week for different modes of transport, Fig. 2. The least used modes are shared scooters, bike-sharing, and suburban trains. This low usage rate could be attributed to the recent introduction of shared scooters to the city (at the time of the survey) and the limited geographical cover for the suburban train as it runs only in the north of CDMX. The most frequently used modes are e-hailing, metro, car as a passenger, and walking. This mode selection distribution aligns with the most used modes to replace the latest pooled trip, discussed in detail in the following sections (Section 4.1.2). Pooled-ride (Jetty) users are

[5] During the survey deployment period, one US Dollar = 19 Mexican pesos (MXN) in July 2019, source: xe.com.

[6] https://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0185-62862022000200006 last accessed 27/12/2024.

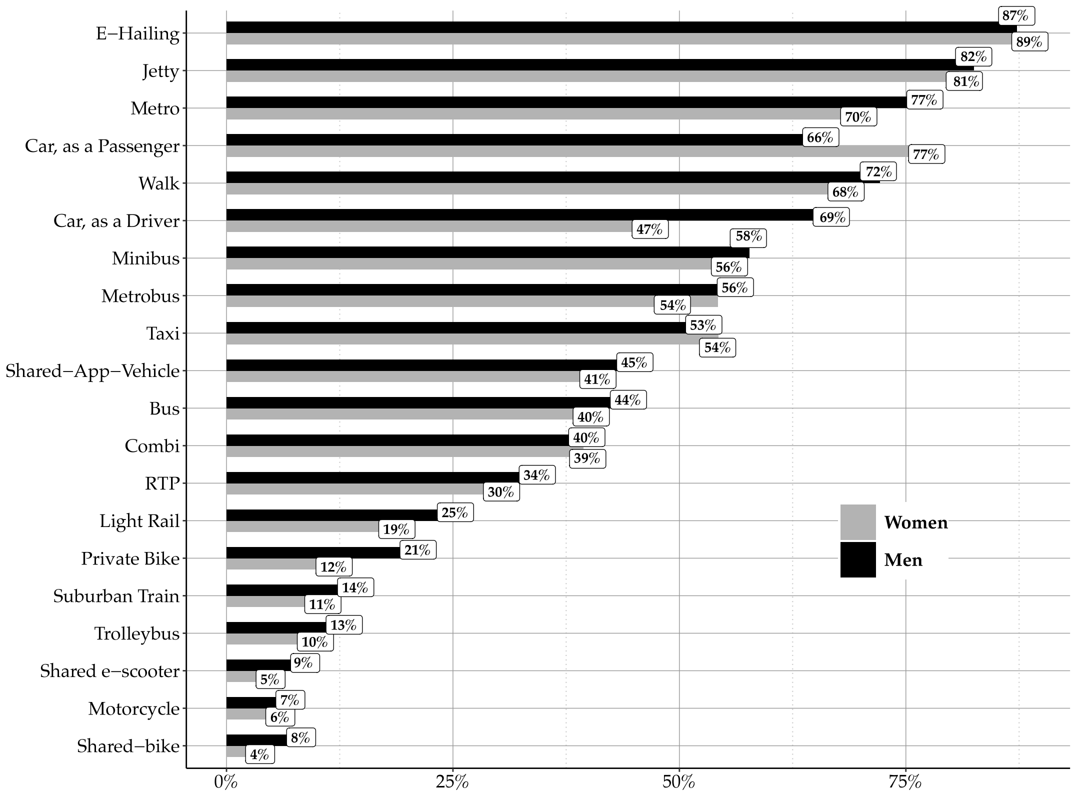

Fig. 2. Modes use frequency, E-hailing includes ride–sourcing.

regular users of e-hailing and ride–sourcing; 35% of users use e-hailing and ride–sourcing at least once a week compared to 16% using a taxi at the same rate. This travel behavior might indicate that the service users are frequent e-hailing users, or in other words, they are more able to adopt shared mobility services, supported by their higher income and education than the average population. However, this use pattern might be due to the advantages e-hailing provides for the users compared to taxis in terms of ease of payment and fare transparency (Tirachini and del Río, 2019).

The use of the different modes per gender is balanced; for most PT modes and the walking, Fig. 2. Some of the observed significant differences in travel behavior are evident for cars as drivers, where men are more frequent drivers than women, and cars as passengers, where women are more frequent users than men. This difference in use patterns for these modes could be because men have a 37% higher driving license ownership rate compared to women; however, the car ownership rate per gender per household is almost equal (1.19 car/household per woman household, and 1.22 car/household per man household).

4.1.2. Trip characteristics

Users reported their last trip purpose, with the most common response being work trips (95%). The reported purpose suggests that the primary factor influencing the recorded trip patterns is the need to commute to work, which is directed mainly toward job centers near downtown. The spatial pattern of trips – from residential areas with limited public transport coverage to central job hubs – appears to result from this work commute demand. Also, it was reflected by the trip use database, where we identified the latest for each user, which was the most recent trip before the survey completion time (extracted from the user's survey), and we compared the origin–destination (OD) coordinates of all other trips performed by the same user. The last trip represented at least 50% or more of the performed trips, and for 22% of the users, their latest trip matched all their previous trips. This finding conforms with the specified trip purposes, as home-work trips are generally fixed-route trips.

4.2. Service databases

The second and third sources of information we analyzed were the service trip database and the demand and occupancy data for the different vehicle types for May 2019. The trip database contained individual trip details for the survey participants for the seven months before the survey launching date; 96,317 trips were performed by 2196 users from the total survey respondents.

The first item to analyze was the individual trips use frequency; on average, users made (6.3 ± 8.3) trips per month, and when disaggregated per gender the difference in use was statistically different ($t = 2.96$, df $= 2160$, p-value $= 0.003$), between women (6.88 ± 8.57), and men (5.82 ± 8.08), showing that women are more frequent passengers compared to men. However, they are getting paid less on average, as observed in the user profile analysis. Also, comparing the general user travel behavior, Fig. 2, with shared rides use frequency reveals that users are commuting using the service more than any other mode, which could be a strong indication for the service convenience considering that users have high car ownership rate compared to the average population, the safety provided by the service, or it could also be attributed to the primary purpose of using the service for work commuting.

The service travel demand follows a bimodal distribution with two peaks: the morning peak hour is at 6:00 a.m., and the evening peak is between 17:00 and 19:00; the morning demand is almost double the evening demand. This service demand distribution follows CDMX temporal traffic demand (INEGI, 2017). There is a significant difference between the percentage of morning and evening trips, with the number of morning trips almost double following a similar distribution to CDMX traffic patterns (INEGI, 2017). The increasing demand for the service in the mornings could be due to the saving in travel time, which the people value more, as people value the time before reaching the workplace more than the time after leaving work due to the time constraints (Paleti et al., 2015); Fig. 3 shows trips temporal distribution.

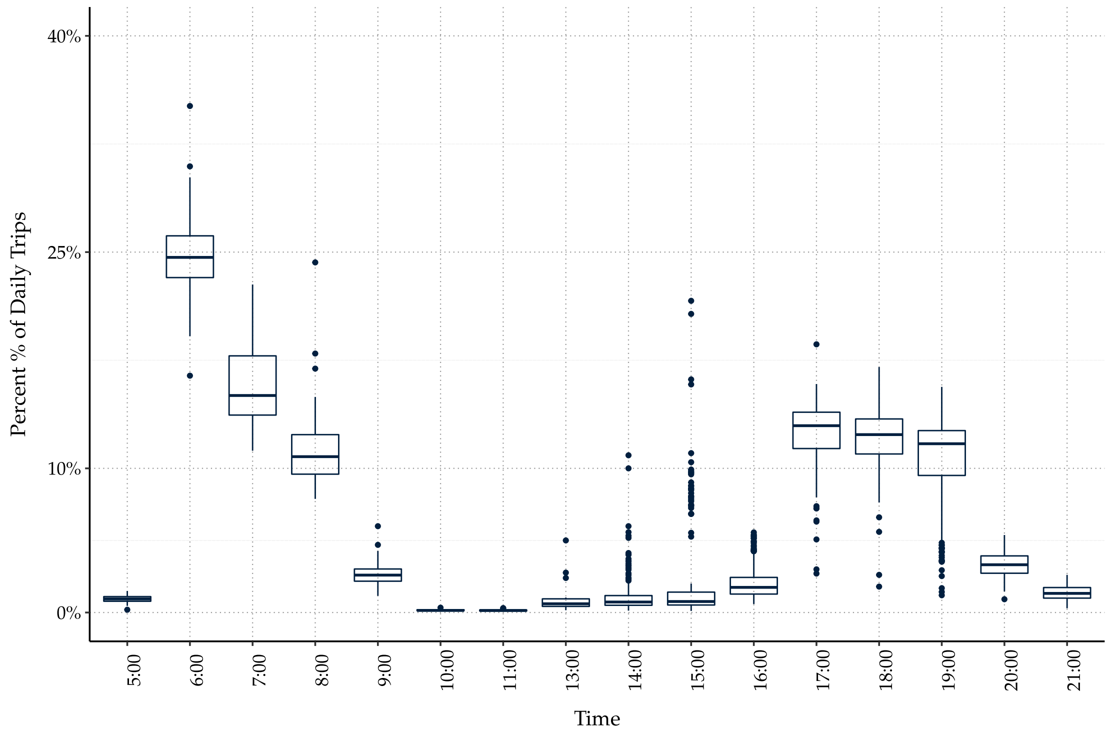

Fig. 3. Jetty trips departure time distribution.

Finally, we analyzed the trip characteristics, where the trip distance is (25.1 ± 6.35 km), which is four times the length of the average ride-hailing trip (6 km) in Santiago, Chile (Tirachini and del Río, 2019), and (4.9 km) in San Francisco, California (Shaheen et al., 2016). Every trip is part of a route, and the average route distance is (27.8 ± 7.97 km). Three-quarters of the trips utilize at least 90% of the total route length, indicating the routes' directness and potential in time and transfer saving. The average trip duration is (46.06 ± 11.27 min), and 75% of the trips are performed in under 49 min (see Table 3).

The service offers trips in four-vehicle sizes: (i) taxi, with a capacity for three passengers; (ii) caddy, which is a six-seat minivan; (iii) van, whose capacity varies from 13 to 19 seats; (iv) bus where capacity varies from 30–45 seats. Two-thirds of the trips are made on buses because buses are cheaper than other vehicles. It is worth mentioning that Jetty starts new route operations in small-sized vehicles, increasing the vehicle sizes according to the demand increase. The percentage of each user's trips in a specific vehicle type was calculated to investigate further the individual use pattern and the preference for the different Jetty vehicle types. Interestingly, almost 82% of users use only one kind of vehicle for their trips, 30% of those users use only vans, and the other 52% use buses.

The received demand and occupancy data for May 2019 show that for buses, on average, 40% of the vehicle's capacity is utilized, and the rate increases in other vehicles to 60% of its capacity. During May, the daily demand is stable for all vehicle types, with a slight rise in the middle of the weekdays and a slight decrease on Fridays .

Table 3
Jetty trips characteristic summary statistics.

Variables (Unit)	Mean	SD	Min.	1stQ.	Median	3rdQ.	Max.
Trip Distance, (km)	24.92	6.10	4.85	23.91	24.23	26.65	52.37
Route Distance, (km)	27.80	7.97	6.50	24.20	26.50	26.60	55.12
(Trip Dist./Route Dist.) (%)	91.56	11.6	17.33	91.08	93.69	100.00	100.00
Duration, (Minutes)	46.06	11.27	9.00	44.00	45.00	49.00	97.00
Occupancy, (Passenger)	33.79	13.77	3.00	17.00	42.00	45.00	45.00

Routes represent the service line from its starting point to its endpoint, while trips represent individual journey distance each passenger covers in the vehicle from the pick up to the drop off point.

Table 4
Exploratory factor analysis results summary.

Mode	Factor 1	Factor 2
Minibus	0.68	
Metro	0.63	
RTP	0.59	
Combi	0.57	
Bus	0.52	
Light Rail	0.49	
Shared–bike		0.84
Shared e-scooter		0.76
Private Bike		0.55
Model diagnostics	**PT frequent users**	**MM frequent users**
Factor loadings	2.06	1.69
Proportion variance	0.23	0.19
Kaiser-Meyer-Olkin factor adequacy: MSA= 0.75		

5. Modeling

5.1. Exploratory factor analysis

We applied Exploratory Factor Analysis (EFA) on the user's mode use frequency to understand their general travel behavior (Fig. 2), and we used a scree test to define the number of factors. As per Table 4, two main factors were estimated. The two factors can be described as frequent PT and micromobility users. Variables were kept when their loading on one factor was greater than 0.40, with no double loading on two factors simultaneously (Ledesma et al., 2021), and the two factors explain 42% of the data variability. We further used these results to understand the impacts of general travel behavior, in this case, on the two major groups of frequent PT and micromobility users' service use by integrating them into the different models discussed in the next section.

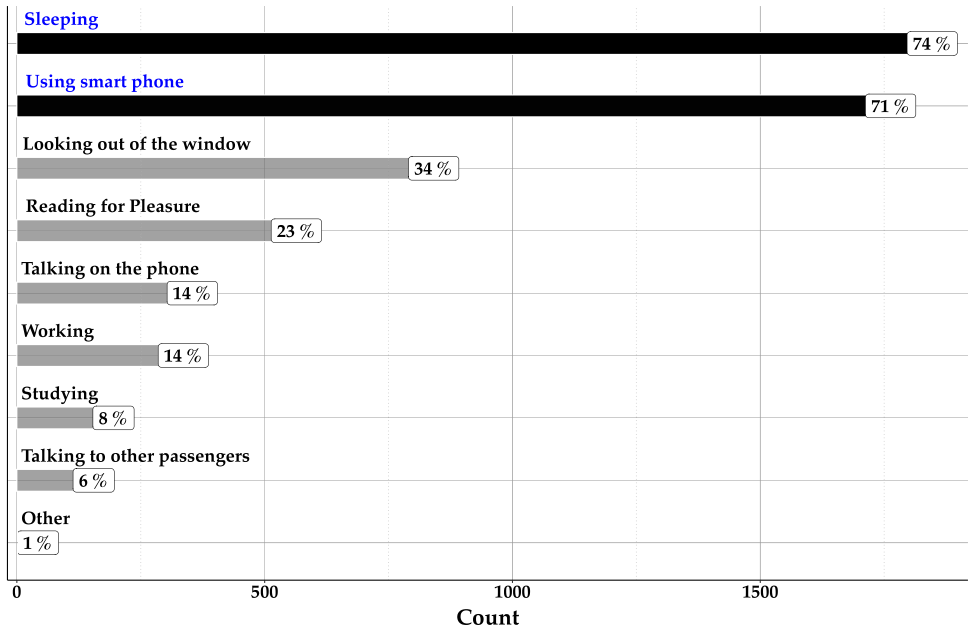

Fig. 4. Users' activities during Jetty trips.

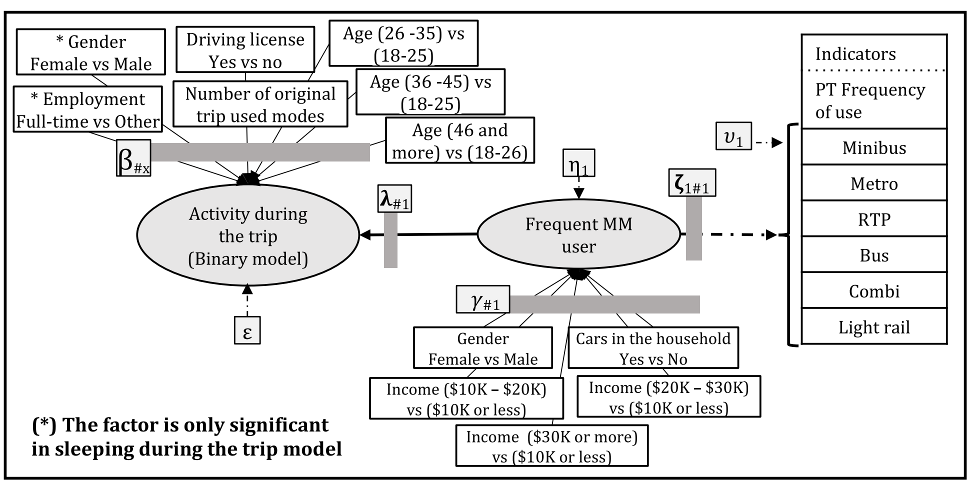

Fig. 5. Activity during the Jetty trip binary ICLV models path diagram.

5.2. Activities during trips

Users were asked to specify up to three activities they do during their travel, and the most chosen activities were sleeping, using the smartphone, and looking out of the window. Fig. 4 shows the summary of the disaggregated users' activities, which reflect some critical aspects of the service. First, the feeling of safety, where users could sleep without any concerns of harassment or theft, which is not the general case of regular public transportation CDMX, as discussed by several sources (Magaloni, 2019; Mujeres, 2018). Second, there is the possibility of multi-tasking in terms of using the mobile phone, reading, working, or studying, all activities requiring reasonable comfort to be developed within shared vehicles. Finally, socializing with other passengers received the lowest score of all surveyed activities. The activities were coded as binary variables based on the usage, and the Phi coefficient of correlation for binary variables (Ekström, 2011) was calculated for the variables to investigate if there is any correlation between pairs of different variables. The estimated phi coefficient was less than 0.1 between all variables, indicating no association between choosing any of the activities. To further investigate the impact of users' demographic and travel behavior on their activities during the service, we modeled the reasons that were chosen by 50% or more of the users: sleeping during the trip and using a smartphone were the two top activities selected from by 74% and 71% of the users respectively, Fig. 5. Table 5 shows the estimated binary ICLV models for sleeping during the trip and using smartphones. Both dependent variables in the two models were coded as binary variables equal to one if the user indicates the activity and zero otherwise.

In both models, the user's age and the availability of a driver's license play the same significant role; older passengers and passengers with a driving license are less likely to sleep or use their smartphone during the trip than young users and users without a driving license. At the same time, the more modes used in the original trip that Jetty replaced, the increased the probability of using a mobile phone or sleeping during the trip, reflecting the convenience of using the service considering their original trip.

Only for sleeping during the trip women were more likely to sleep during the trip, which is mainly attributed to the safety of the service in comparison to PT, in addition to the full-time workers, which could also be due to the trip time use. The latent variable of frequent PT users

Table 5
Activity during the Jetty trip binary ICLV models result.

	Sleeping during the trip			Using smartphone		
	β	S.E.	P-value	β	S.E	P-value
Interceptor	0.85	0.25	0.00	0.70	0.20	0.00
Gender Woman vs. Man	0.37	0.11	0.00			
Employment status Full-time vs. other	0.41	0.15	0.01			
Age (26–35) vs. (18–25)	−0.24	0.16	0.14	−0.18	0.15	0.22
Age (36–45) vs. (18–25)	−0.56	0.17	0.00	−0.46	0.16	0.00
Age (46 and more) vs. (18–25)	−0.81	0.20	0.00	−0.76	0.19	0.00
Availability of driving license Yes vs. No	−0.23	0.14	0.10	−0.15	0.12	0.10
No of modes in the original trip	0.19	0.06	0.00	0.22	0.06	0.00
LV: Frequent PT user (λ)	0.12	0.06	0.05	−0.16	0.06	0.00
$\rho^2_{Adjusted}$ = 0.051 AIC = 31228.68 BIC =31476.68				$\rho^2_{Adjusted}$ = 0.0496 AIC = 31566.56 BIC = 31803.46		
Structural model						
	γ	S.E.	P-value	γ	S.E.	P-value
Gender Woman vs. Man	−0.36	0.06	0.00	−0.35	0.06	0.00
Income \$10K–\$20K vs. \$10K or less	−0.43	0.08	0.00	−0.43	0.08	0.00
Income \$20K –\$30K vs. \$10K or less	−0.78	0.09	0.00	−0.79	0.09	0.00
Income more than \$30K vs. \$10K or less	−1.26	0.10	0.00	−1.26	0.10	0.00
Availability of cars in household Yes vs. No	−0.55	0.07	0.00	−0.55	0.07	0.00
Measurement model frequency of PT use						
	ζ	S.E.	P-value	ζ	S.E.	P-value
Frequency of minibus use	1.43	0.09	0.00	1.42	0.09	0.00
Frequency of metro use	1.16	0.07	0.00	1.16	0.08	0.00
Frequency of RTP use	1.26	0.09	0.00	1.26	0.09	0.00
Frequency of bus use	0.93	0.07	0.00	0.93	0.07	0.00
Frequency of Combi use	1.17	0.08	0.00	1.16	0.08	0.00
Frequency of light rail use	0.95	0.08	0.00	0.95	0.08	0.00

plays a different role in both models. At the same time, it increases the probability of sleeping during the trip, mainly for safety reasons, and it reduces the probability of using a smartphone. There is no clear interpretation for the latter relationship between a more considerable smartphone use while traveling by Jetty among non-frequent public transport users; more research would be required to fully understand this effect.

The structure model part in both models plays the same role as women are less likely to use PT compared to men, and the higher the income and the availability of a driver's license reduces the probability of being a frequent user of PT.

5.3. Reasons to use pooled-rides

Users were asked to specify up to six reasons to use the service, Fig. 6. The top four reasons to use Jetty are booking the seat, security against theft, travel time saving, and travel time reliability chosen by at least 50% of users. These reasons represent service-related attributes and reflect the problems of PT in a crowded city like CDMX. The gender distribution for the different reasons is balanced except for two: (i) security against harassment. Women reported this reason six times more than men, which reflects the increasing gender-based violence problem in public transportation in CDMX (Rivadeneyra et al., 2015; Mejía-Dorantes and Soto Villagrán, 2020-01). (ii) The second difference is avoiding parking problems; men were twice as likely as women to report this reason. The underreporting is because men use cars as drivers more than women, and men have higher driving license ownership rates, as shown in Fig. 2 and Table 2.

We modeled the factors impacting the reasons for using Jetty for the reasons indicated by more than 50% of users, i.e., the top four factors. The latent variable (frequent public transport user) was not significant in any of the models except for the trip duration reason, reference to Tables 6, 7, and Fig. 7.

First, regarding gender, women are more likely to use the service because they can book a seat in advance, which is not possible in PT, and also to improve security against theft. Age impacts the use of Jerry because of security against theft, where the older the user, the more likely to use the service for its perceived personal security; on the other hand, the older the user, the less likely they use the service for the saving in travel time. The higher the education level, the more likely the user is to choose Jetty for its security against theft, and the less likely they will use it to book a seat. Income also plays a significant role, as the higher the income, the less likely to use the service for its travel time reliability, which might be because the higher income groups might prefer the use of a car in general, as the availability of driving license reduce the likelihood of the use of the Jetty service. Access by walking reduces the likelihood of using the service for its security against theft, which is also understandable as users might not feel safe walking in the city in general. The only factor that was significant in all the models with the same direction of the effect is the number of original modes (trip stages) replaced because the larger the number of modes replaced (i.e., the more complex the original trip replaced by Jetty was), the more likely that the users chose Jetty for all four reasons.

For the latent variable, Table 7, the latent variable frequent PT user increase the probability to use the service for its saving in travel time, which is logic comparing the service directness of Jetty services against the original, generally more complicated PT trip replaced by Jetty. The structural model shows that men are more likely to use PT than women, and higher-income people are less likely to use PT, in addition to households with cars available to them.

5.4. Users comments analysis

An open-ended, optional question was provided to the users to comment on the service; 864 users answered this question in Spanish, and we used Google translation (translate.google.com) to convert the responses to English, and the translation was verified manually. Text and sentimental analysis were performed to understand user service perception.

Sentiment analysis is widely adopted to investigate people's opinions in text data. Several techniques are used to perform sentiment analysis. Two of the most commonly used techniques are machine learning algorithms and lexicon-based analysis or word lists analysis (Li et al., 2019). We used lexicon-based methods to perform the

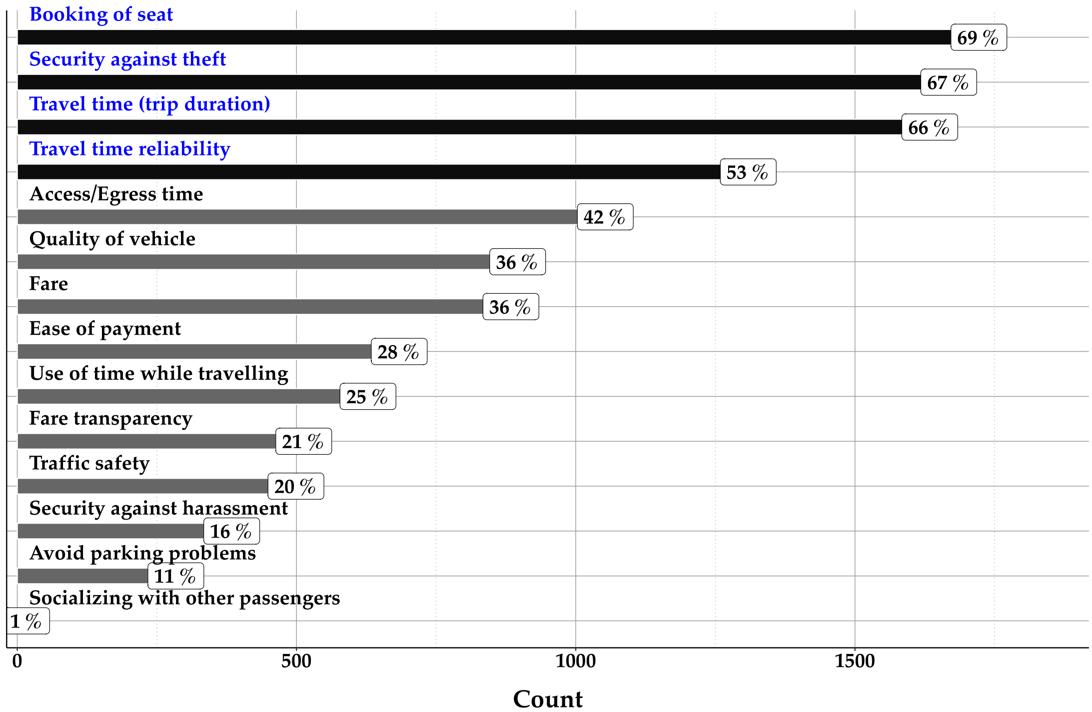

Fig. 6. Users' reasons to use Jetty.

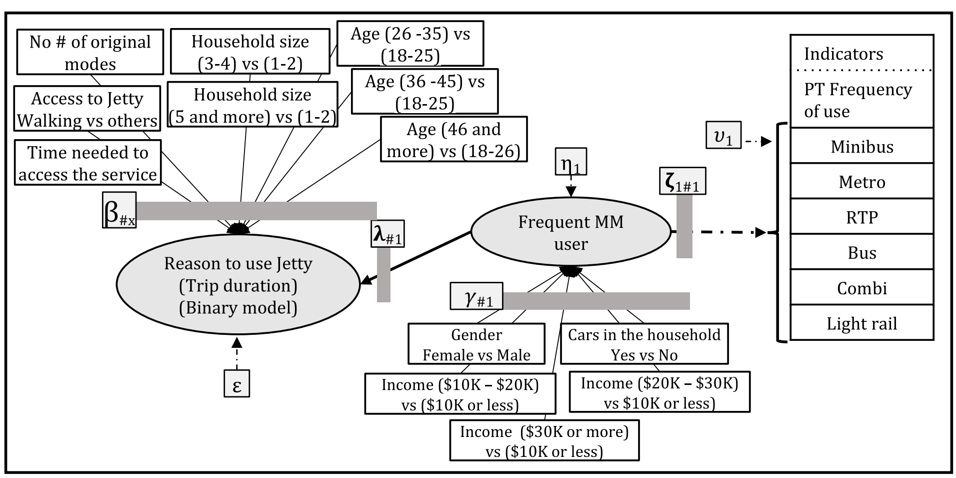

Fig. 7. Path diagram for the reason to use Jetty trip duration (saving in travel time).

sentiment analysis mainly because they are (i) simple to use and (ii) their predicted results are proven accurate when tested on several data sets (Ribeiro et al., 2016). The application of Sentiment analysis in transportation is growing; for example, Twitter[7] feeds were used to investigate transit riders' satisfaction and to evaluate and assess transit network performance (Liu et al., 2019; Haghighi et al., 2018; Collins et al., 2013), also user's impressions regarding ridesharing use (Pratt et al., 2019).

Firstly, we investigated how the words in the responses are linked, i.e., what words are generally mentioned in consecutive order, forming so-called Ngrams, which are combinations of a set of co-occurring two words. We used the tidytext package (Silge and Robinson, 2016) under the statistical software R (R Core Team, 2024) for the Ngrams creation, and their reparation was counted. Only word relations repeated more than two times were kept. Fig. 8 shows a network graph for the correlated words created; the edges-links color was weighted by the frequency of the word correlation counts. Word relations revealed some interesting insights, where positive assessments outweigh the negative ones, as the most related word pair is "excellent service", and the word "service" is connected to "convenience". The word "excellent" is connected to "alternative" and "choice". Other word pairs that indicated the service characteristics were (safe-reliable), and the request to expand the routes, where the two words "expand" and "routes" are associated in multiple comments. Complaints were also noticed where the words "uncomfortable seats" and "bad experience" were associated. It is to be highlighted that the results of this analysis are aligned with the results of the estimated models with a deeper level of information due to the nature of the question. The convenience of the service is reflected in many of the answers, where these levels of convenience were not investigated directly in the survey, such as the drivers being friendly to the users.

Finn Årup Nielsen (AFINN) word list (Nielsen, 2011) was used for sentimental analysis. The list assigns each word a score that ranges

[7] x.com.

Table 6
Reasons to use Jetty binary models.

	Booking of seat			Security against theft			Reliability		
	β	S.E.	*p*-value	β	S.E.	p-value	β	S.E.	p-value
(Intercept)	0.77	0.20	0.00	−0.19	0.23	0.41	0.35	0.19	0.07
Gender Woman vs. Man	0.17	0.09	0.06	0.30	0.09	0.00			
Age (26 −35) vs. (18-25)				0.18	0.13	0.15			
Age (36 −45) vs. (18-26)				0.34	0.14	0.02			
Age (46 and more) vs. (18-27)				0.42	0.17	0.01			
Education (Bachelor or professional degree) vs. (other)	−0.31	0.15	0.03	0.27	0.14	0.06			
Education (Masters or PhD) vs. (Other)	−0.32	0.18	0.07	−0.03	0.17	0.85			
Employment status (Full-time) vs. (Other)	0.23	0.12	0.06				−0.21	0.13	0.10
Income ($10K–$20K) vs. ($10K or less)							−0.23	0.14	0.10
Income ($20K –$30K) vs. ($10K or less)							−0.45	0.15	0.00
Income (more than $30K) vs. ($10K or less)							−0.35	0.16	0.02
Availability of driving license (Yes vs. No)				−0.03	0.11	0.80			
Access mode (Walking vs. Others)				−0.27	0.09	0.00	−0.20	0.09	0.04
Main trip number of modes	0.10	0.05	0.04	0.18	0.05	0.00	0.13	0.05	0.01
	$\rho^2_{Adjusted} = 0.0485$ AIC = 3044.92 BIC = 3079.78			$\rho^2_{Adjusted} = 0.0496$ AIC = 3049.35 BIC = 3113.10			$\rho^2_{Adjusted} = 0.0486$ AIC = 2844.54 BIC = 2883.92		

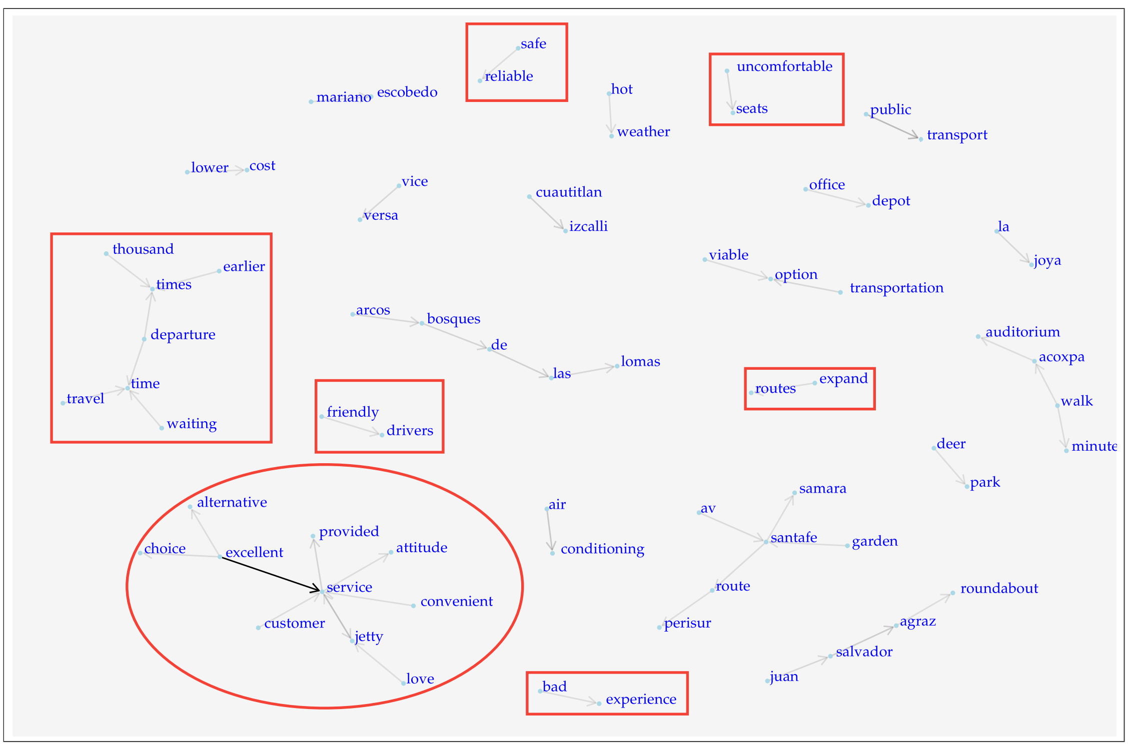

Fig. 8. Associated words; the arrow directions show the order of the words and the darker the arrow, the stronger the relationship between the two words; they are repeated more frequently compared to other words (*own illustration*).

between (−5 and 5)[8]; names and articles do not have scores, words with no score were removed, and the sum of scores per user was calculated. The average score was (2.87 ± 7.26). When calculated by gender, it was statistically different (t = 2.7747, df = 862, p-value = 0.006) between women (3.51 ± 7.61) and men (2.14 ± 6.77), showing women's higher evaluation of the service; Table 8 shows the general score distribution per gender, most used vehicle types, (buses and vans), where bus users, in general, have higher scores than van users, which could be due to several factors, such as the higher bus occupancy, the cheaper trip cost, and extra personal space. In general, van trip costs are more expensive than bus trips, and 60% of van capacity is utilized on average compared to 40% of the utilized bus capacity, which gives bus users more personal space. Moreover, women who use buses have almost double the positive scores compared to men, which could be because buses have more personal space than vans.

6. Discussion and study limitation

6.1. Discussion

The sample analysis illustrated that respondents are full-time employees, highly educated, with medium to high-income levels, and have

[8] Some examples for the scoring are the words best and bliss with a score = 3, and the words awful and bad with a score = −3. An example of a negative response: "The biggest issue with your app is the unclear interface and broken flows, making it frustrating to use. However, the service is very good once you are in the car". An example of a positive response: "I use Jetty because my company covers the cost of the service. Jetty Care includes timely billing, and the service operates on the block where I live. The drivers are always attentive and provide excellent service. Given the cost, convenience, and comfort of traveling between home and work, I plan to continue using the service, even if the company withdraws its support".

Table 7
ICLV binary model for the reason to use Jetty trip duration (saving in travel time).

	β	Std.err.	Rob.p-val(0)
Interceptor	0.77	0.22	0.00
Age (26–35) vs. (18-25)	−0.11	0.14	0.42
Age (36–45) vs. (18-25)	−0.29	0.15	0.06
Age (46 and more) vs. (18-26)	−0.28	0.18	0.12
Household size (3–4) vs. (1-2)	−0.01	0.11	0.93
Household size (5 and more) vs. (1-2)	0.27	0.14	0.05
Access mode (Walking vs. Other)	−0.21	0.10	0.04
Access to Jetty duration	−0.01	0.00	0.00
No of modes in the original trip	0.20	0.06	0.00
LV: Frequent PT user (λ)	0.16	0.05	0.00
$\rho^2_{Adjusted} = 0.0496$			
AIC = 31 654.99			
BIC = 31 908.73			
Structural model			
	γ	S.E.	P-value
Gender Man vs. Women	0.35	0.06	0.00
Income $10K–$20K vs. $10K or less	−0.43	0.08	0.00
Income $20K –$30K vs. $10K or less	−0.79	0.09	0.00
Income more than $30K vs. $10K or less	−1.27	0.10	0.00
Availability of cars in household Yes vs. No	−0.55	0.07	0.00
Measurement model, frequency of PT use			
	ζ	S.E.	P-value
Frequency of minibus use	1.43	0.09	0.00
Frequency of metro use	1.15	0.07	0.00
Frequency of RTP use	1.26	0.09	0.00
Frequency of bus use	0.93	0.07	0.00
Frequency of Combi use	1.17	0.08	0.00
Frequency of light rail use	0.95	0.08	0.00

Table 8
Overall and per user most frequently used vehicle type sentiment Score summary.

Users' Group	Overall	Van (Mean ± Std.Dev)	Bus (Mean ± Std.Dev)
All users	2.87 ± 7.26	3.03 ± 4.62	3.52 ± 3.55
Women	3.51 ± 7.61	3.12 ± 3.21	4.16 ± 4.13
Men	2.14 ± 6.77	2.93 ± 5.89	2.76 ± 2.51

All users with valid responses = 864 (Women = 460 and Men = 404).

high rates of car ownership and driving license availability relative to the average population of CDMX. These socioeconomic attributes follow the general profile of shared mobility users worldwide, as summarized in Section 2. The main difference in Jetty's user profile compared to other shared mobility services is that women are frequent users compared to men, according to the survey, which was also similar to a case study in London, where the majority of ATS service users were women (77%) (Wang et al., 2012). There is insufficient user-level data in the London case to determine the factors behind the high percentage of women users. The operational Jetty scheme shares characteristics with ATS, and it is notable that women tend to favor ATS and services with similar operational schemes more than men. Although the sample used for this study was random, online surveys could suffer from gender-response bias, where women are more likely to respond to surveys than men (Smith, 2008). Therefore, more studies for similar systems are required to verify and generalize this finding.

Women's high presence in Jetty's case could have been motivated by the deteriorated security condition of PT in CDMX and especially the phenomena of gender-based violence (Abouelela et al., 2022; McCasland et al., 2018; Dunckel Graglia, 2016; Rivadeneyra et al., 2015), Dewey (2019) reported that almost 23% of women living in CDMX avoid using PT for personal security reasons. Our survey analysis provides similar insights, as (27%) of women respondents reported using the service for its security against harassment, compared to only (4%) of men. Considering that the average wage of women in the sample is 21% less than that of men, they still pay the same ticket price, highlighting the significant financial burden on women when using the service. The gender wage gap in our sample matches the gender wage gap in Mexico, estimated at around 27% (Cuellar and Moreno, 2022). We believe that women are willing to bear this burden to avoid the higher risk of violence they face in public transportation modes in CDMX.

Pooled-rides users are frequent users of e-hailing and ride-sourcing services, compared to taxis; this travel behavior pattern is different from the general CDMX population, where e-hailing trips represent only 30% of daily hailing trips (INEGI, 2017; Dewey, 2019). This finding could indicate that pooled–ride users are more able to adopt several shared mobility platforms than the average population, which is also supported by their being mostly in the higher income group compared to the rest of the population.

Users' reported activities during trips are equally distributed between genders; sleeping and using smartphones are by far the most reported activities, as chosen by 7 out of 10 users. Fig. 4 shows other activities, such as looking out of the window, reading for pleasure, talking on the phone, or working, which were chosen by between 14% and 34% of users. Sleeping during the trip might be related to the level of safety users feel while using the service; however, it is essential to note that sleeping during the trip could also be attributed to other factors related to the nature of the service, such as but not limited to the comfort level due to the seating design or the low levels of noise and vibration, and the fact that the peak demand is concentrated in the early morning hours. At the same time, riders might not be able to do the same activity while using PT because, in our sample, users travel a long distance to work and, therefore, wake up early to start their day. The distribution of reasons to use pooled–rides by gender are balanced, except for security against harassment, where women were six times more than men, and using pooled–rides to avoid parking problems, where the proportion of men doubled that of women choosing this reason. Men rely more on cars as drivers for their trips, and the pooled-ride platform replaces them compared to women. The deteriorated condition and crowdedness of public transport in CDMX are also reflected in the users' reasons for using the pooled-rides platform. The top four reasons for using the service are booking the seat, security against theft, trip duration, and travel time reliability. These reasons were chosen by at least 50% of the survey respondents. Fare is only selected by 35% of the users, which might be because the trip cost is more expensive than PT but still cheaper than ride–sourcing and taxis, and it is a good value for money for the gained convenience compared to PT.

Responses' sentiment analysis to their open comments on the Jetty service reflects the respondents' impression of the pooled-rides platform, confirming the findings of the quantitative choice models. Respondents indicated that the service is safe, reliable, and convenient (Fig. 8), among the top factors chosen in the question about reasons to choose pooled-rides, or were indirectly implied by the activities they perform during the trip. These virtues are, to a large extent, not present in the city's PT, and pointing them shows why people migrate from low-quality PT to commercially organized pooled-rides that provide a higher quality of service and user comfort at a higher price. Also, a factor that came from the sentiment analysis, not included in the closed questions of the service, was that users requested the expansion of Jetty routes, which indicates users' satisfaction with the service and the low accessibility of PT, especially in the north part of the city (Guerra, 2015). On the other hand, people asked to lower the trip cost, suggesting that Jetty is not affordable to all users, which is evident compared to other PT modes. Therefore, we observe that the sentiment analysis on an open question about the service also provides new insights on topics not covered by usually closed questions analyzed with choice models. We conclude that sentiment analysis and choice modeling are complementary tools to better understand the travel behavior effects and users' perceptions of new shared mobility modes.

Ninety-five percent (95%) of the users specified that their latest trip purpose was commuting to work, which is supported by two observations from the analyzed use database: (i) the trip's geographic routes, where 50% of the users always traveled between the exact origin and destination while using the service platform; (ii) 97% of users booked one ticket on their trips. These observations comply with the fact that work commuting trips are usually solo trips (Lavieri and Bhat, 2019), representing a substantial share of yearly VKT in a city (Convery and Williams, 2019; McGuckin and Srinivasan, 2005). Also, the purpose of the service was to connect residential areas to job centers.

Moreover, respondents reported that 66% of the disaggregated trips replaced by Jetty would have been made in car-based modes (passenger vehicles, ride-hailing, or taxis), which are low-occupancy vehicles. On average, the private passenger car trip occupancy is 1.3 passengers per vehicle for commuting trips in CDMX,[9] whereas Jetty's vehicle occupancy rate is around 40% (between 13 and 18 passengers per vehicle) on average for buses and around 60% (between 7 and 11 passengers per vehicle) for vans. This occupancy rate is mainly due to the nature of the service, which utilizes predefined fixed routes and schedules compared to the other real-time-matching pooled services operated by the TNC companies, such as UberPOOL. Real-time-matching pooled services do not grant the matching with other users (Kang et al., 2021; Conway et al., 2018; Cramer and Krueger, 2016). Using a service with a high occupancy rate for traveling represents an opportunity to reduce VKT; however, this opportunity depends on the replaced modes, the used vehicle size, utilized occupancy, and the modes used to access and egress to the pooled-rides (Tirachini et al., 2020).

Jetty service increases job accessibility by providing a direct connection to job centers in CDMX; the limited accessibility to formal jobs in the north of the city, where service pick-up locations are concentrated, is reduced due to the limited number of jobs offered in that area and the low coverage of the PT network as indicated by the city urban marginalization index.[10] Most respondents belong to the high-income segment of the population, which raises the question of the equitable use of shared mobility platforms for the different population groups, especially low-income groups. As the survey sentiment analysis indicated, some users asked to lower trip fares.

Our findings point to a more extensive policy question: should shared mobility innovations receive subsidies to increase service accessibility to disadvantaged populations and locations with reduced accessibility? The demographics of disadvantaged population groups could include, but are not limited to, racial minorities, lower-income, old population, physically challenged populations, and gender disparities (Bai and Jiao, 2024; McQueen and Clifton, 2022). The results of our analysis identify two of the potentially disadvantaged groups, women and low-income groups. The net monthly income of 13% of the people who responded to the survey is lower than the average of the city residents, as shown in Table 2, and women reported using the service for personal security reasons, despite the increased financial burden of this use, Section 5.3.

A current example of subsidizing shared mobility service is the French government subsidizing carpooling trips to increase its use (Wang and Monchambert, 2024); however, there is no current conclusion on the usefulness of such subsidy scheme for the different population groups or its impacts on the sustainability of the urban environment. The platform analyzed in our research is a high-quality transport service, which, without subsidies, will remain affordable only for a limited group of users. The equity of using app-based mobility services should alert policymakers and city planners, noting that Jetty operates in areas with low PT and job accessibility[10].

Solving the low PT accessibility and the limited job opportunities north of CDMX will require significant infrastructure investment and land use re-planning, which would require a long time to materialize. Shared mobility offers an intermediate solution for such problems; the integration of pooled-rides with other PT services could be hindered by the fact that shared mobility use needs smartphones, bank accounts, and credit cards (Golub et al., 2019), which are not always available, especially for transport-disadvantaged groups. Such structural barriers need to be addressed by the authorities by establishing shared mobility access points for people with no smartphones and subsidizing the service for the groups who experience limited access to daily activities (Shaheen et al., 2017a).

6.2. Study limitations

The survey had some drawbacks in its design discovered during the data processing stage; however, those drawbacks did not affect the quality of the collected data or the final results and conclusions. Avoiding these drawbacks when conducting similar studies is advisable. The survey did not investigate the family status and the number of children in the household, which could be important factors impacting pooled-ride use. The number of children in the household is a significant factor influencing different shared services use as found in other studies (Dias et al., 2017), and it impacts the general user's travel behavior (Chakrabarti and Joh, 2019). In this research, the focus was on work trips, which are usually solo trips.

The specified levels of the sociodemographic attributes in the survey questions differ from the available published levels for CDMX. This mismatch made the comparison between the survey representation of the total population unclear for some attributes like age and income level.

We asked the user to specify up to three activities they perform during their trips; there is a probability that some users have performed more than the three specified activities, leading to underreporting for the other activities. We believe that the chances of underreporting are minimal and would not impact the integrity of the results; however, we highlight this limitation to increase the transparency of our results.

Also, it is to be highlighted that the data was collected from one city and one platform; the generalization of the findings needs to be carefully studied before using it for the decision-making process of other services at other locations.

We acknowledge that incentives to reduce the non-response bias, while useful to boost user participation in transport studies (Arriagada et al., 2023), might introduce potential biases, mainly if they disproportionately attract participants who are more inclined to favor the service. Mixed results have been reported on this matter, Singer et al. (1999) performed a meta-analysis of 13 incentives and data quality studies and found mixed results, as seven studies reported no impact on response quality, and six observed improvements when incentives were offered. Regarding effects on the composition of the samples, in three studies, paying an incentive was useful to increase the representation of specific demographic categories (e.g. low-income citizens), while five studies reported no effect of incentives in sample composition. A follow-up study with a control group would be necessary to assess, for example, if the incentives had any effect on sample composition regarding the positive and negative experiences reported in Fig. 8.

7. Conclusion

Cities face significant challenges due to rapid growth in urbanization, population and travel demand. With limited resources, the gap between travel demand and supply, especially in large cities, widens. Short-term improvement is unlikely without a disturbing solution. Traditional long-term solutions, such as a change in land use

[9] https://www.inegi.org.mx/programas/eod/2017/ INEGI, 2017. Encuesta Origen-Destino en Hogares de la Zona Metropolitana del Valle de Mexico (EOD 2017) (in spanish). Report Instituto Nacional de Estadistica y Geografia (INEGI), last accessed 04/07/2024.

[10] An accessibility index to jobs and essential services, www.conapo.gob.mx/en/CONAPO/Indice_de_marginacion_urbana_2010 last accessed on 5 June, 2024.

and infrastructure extension (e.g., rail networks), need high capital investment that might not always be available; other relatively recent solutions, such as traffic demand management, do not always yield optimum results. Shared mobility presents an opportunity for an immediate solution to partially tackle some of the externalities of a growing travel demand. Specifically, under the scope of this study, pooled-ride services might have positive potential impacts if high occupancy rates are utilized during the rides (compared to trips by ride–sourcing platforms and private cars) and with their ability to attract car users, as shown in our analysis.

The service in question, Jetty, does not offer door-to-door service; it has a fixed schedule, restrictive time supply, and fixed routes. Integrating such service in the broader PT network could increase positive impacts; however, some rules conditioned this integration to produce successful results. These rules can be summarized as (i) planning the service based on the actual spatial and temporal travel demand fulfilling people's needs dynamically, (ii) considering the land use of potential origins and destination locations. (iii) Synchronize the service operations spatially and temporally with other PT services. (iv) Subsidize the service for marginalized groups, in this case, low-income people and women who are, on average, paid less than men and face more challenges regarding their daily travels, e.g., gender-based violence. Otherwise, pooled-ride demand will remain negligible compared to CDMX's total travel demand. Providing high-quality pooled-rides services in a city with poor-quality local public transport is likely a step in the right direction; how such a new form of high-quality shared mobility could genuinely become a form of public transport is a relevant challenge for policy-making and private-public partnerships in the mobility sector.

CRediT authorship contribution statement

Mohamed Abouelela: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Alejandro Tirachini:** Writing – original draft, Methodology, Investigation, Formal analysis, Conceptualization. **Emmanouil Chaniotakis:** Writing – original draft, Validation, Supervision, Methodology, Formal analysis, Conceptualization. **Constantinos Antoniou:** Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data can be made available on request for reasonable purposes.

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