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Understanding Ride-Sharing Systems in Urban Areas: The Role of Location, Users and Barriers

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Abstract

The design and development of ride-sharing systems have been urged from the need to improve the performance of transport systems in urban areas and promote sustainability. Despite its significant potential, ride-sharing has demonstrated limited uptake so far, because of a set of barriers (technological and legal). This paper aims to provide a better understanding of ride-sharing systems through an extensive review of definitions, ride-sharing systems, legislation and user characteristics. Identified ride-sharing systems are analyzed in terms of their attributes such as operation status and location, distance of service and payment methods to provide an insight into local conditions. The legislative and regulatory framework related to ride-sharing for the EU27 countries and the UK is reviewed to understand potential barriers in ride-sharing implementation. Furthermore, this research identifies user trip purposes related to ride-sharing and defines ride-sharing user types. Four user types are defined to target when deploying ride-sharing services: 1) Household work user, 2) Solo work user, 3) Education user, and 4) Recreation/entertainment user.

Keywords: Ride-sharing; on-demand; User characteristics; User types.

1. Introduction

The design and development of ride-sharing systems have been urged from the need to promote sustainability, multimodality and improve the efficiency of the transport system in urban areas by minimizing negative impacts related to emissions, travelling costs and congestion [17], and by increasing passenger vehicle occupancy and public transit ridership.

The emerging growth of on-demand transport services has also contributed to the creation of terms and names, with differences often not being distinct and often being used for the same purpose. Ride-sharing (also known as lift-sharing in the UK and carpooling in US and various EU countries) has emerged as an effective alternative, after 2005, when mobile technologies enabled matchmaking mechanisms and allowed people to offer and request trips whenever they want, wherever they are, enabling dynamic, on-demand ride-sharing [1].

Improving transportation planning by incorporating ride-sharing services relies on the understanding of different components of ride-sharing services and adjustment to local conditions. Past ride-sharing studies focused mainly on ride-matching algorithms for ridesharing systems and optimization [1, 18], dynamic ridesharing pricing [2, 3], and the economic, social, transport, and environmental benefits of ride-sharing [7, 8, 27]. However, it becomes unlikely that transport planners will be able to make policy decisions on promoting sharing services by relying solely on single studies [25].

This study attempts to map and understand ride-sharing services by disaggregating them in four ride-sharing aspects: 1) The definition of ride-sharing, 2) Who provides ride-sharing services (i.e., companies and providers), 3) Where and how ride-sharing services are provided (i.e., environment), and 4) By whom ride-sharing services are used (i.e., users) by reviewing user characteristics. It should be noted that users in this study are further divided into drivers and travelers (i.e., passengers). Drivers are also referred to literature as Travel Service Providers (TSP). The study approach includes an extensive literature review for all major ride-sharing programmes operated or still operating at global level with the goal of gaining a comprehensive understanding of the ride-sharing and its components. Venues for further research are highlighted through the article.

2. Methodology

This research focuses on a state-of-the-art analysis of ride-sharing systems that will constitute the basis for understanding different components of ride-sharing services, including the systems, legal framework and user characteristics. The methodological approach, which is adopted in the context of the paper, builds on the principles

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of a systematic literature review to achieve its purpose. The methodology focuses on the content of the publications, the research per se, rather than on their metrics. The methodological approach comprises of six parts, as follows:

1.Identification of objectives. Adapting the paper's goal, five main objectives were identified as of high relevance to the understanding of ride-sharing services:1) Definition of a ride-sharing; 2)State-of-the-art analysis of ride-sharing systems; 3) Analysis of the legal framework in EU countries; and 4) Identification of current and potential ride-sharing travelers and drivers.

2. Identification of data sources and databases. The data sources that were used to collect the necessary information and data include: 1) Research projects on sharing-mobility from the EU database CORDIS and other global databases, which are relevant to the goal of the paper; 2) Published papers and reports on the current state of ride-sharing; 3) Ride-sharing services that operated or are still in operation at global level. The latter two have been based on online information, including webpages, social media and personal communication.

3. Selection of publications. A set of predefined criteria was used first to identify publications and then to assign them to the five objectives by developing and using a data template.

4. Development of tools for data collection. For facilitating the data collection process, two templates were developed, one to support the classification of publications per objective and one to support specifically the objective "State-of-the art of ride-sharing systems". The first template aimed to organize the collected information about ride-sharing or related services. Each publication was categorized, based on its content, in one or more of the following groups: 1) Ride-sharing systems – referring to publications that mention specific ride-sharing systems, 2) Barriers – referring to potential barriers that were faced in the implementation of the ride-sharing service, 3) Incentives – referring to the provided incentives for the implementation of the ride-sharing service, and 4) Behavior – referring to the users of ride-sharing services.

5. Analysis. Collected and grouped information is used as input to each of the four objectives.

6. Exploration and synthesis. For each of the five objectives a discussion and synthesis of information is provided.

3. Ride-sharing definition

The literature review focused firstly on the identification of different ride-sharing concepts and definitions as various terms are used to describe similar transport sharing concepts. Keywords related to shared mobility definition included ride-sharing, carpooling, ride-hailing, on-demand mobility. Information was searched through scientific web sites including Science Direct, Web of Science, Google Scholar, Wiley Online Library and Springer as well as the EU portal for European projects, CORDIS and individual project sites. Concurrently, authors and year of publication were also identified to perform a second search based on their names. Car-sharing related publications and projects were excluded from this research to focus exclusively on on-demand transport for passengers. Each publication was recorded according to its title, authors, year of publication and location of the study. Then for each publication, the ride-sharing definition was recorded; a database of all relevant publications was built. Several definitions for different and partially overlapping concepts have emerged, including ride-sharing, ride-selling (commercial, organized by single person), ride-hailing (commercial, organized by companies) and ride-pooling (commercial, organized by public institutions).

A glossary of ride-sharing related terms has also been published in [8]. Thus, a universally accepted definition for "ride-sharing" does not exist; "ride-sharing" is defined in each publication based on its context. Additionally, the term ride-sharing is used either for-profit or non-profit services. Ride-sharing services may be provided to passengers as a single mode to complete their trips or they may complement rail or other public transport modes available in urban and rural areas, with the focus of further incorporating public transport in the multimodal transport chain.

Therefore, within the scope of this paper, "ride-sharing" is divided into for-profit (FP) and non-profit (NP) services. For-profit ride-sharing refers to a joint trip of at least two participants that share a vehicle and require coordination with respect to itineraries, by a service provider that provides ride-matching opportunities and compensates participating drivers. Non-profit ride-sharing refers to the transport of persons in a motor vehicle when such transportation is incidental to the principal purpose of the driver, which is to reach a destination and not to transport persons for any kind of profit [10]. Both ride-sharing services take place via digital means – either via a smartphone application or/and a website browser.

4. Ride-sharing systems and legislation

In total, 80 publications were identified as relevant and 59 ride-sharing systems were recorded at global level. It should be mentioned that the ride-sharing systems analyzed here refer to both for-profit and non-profit ones. The developed template aimed to collect and organize information relative to ride-sharing systems, which is provided on the websites and social media of ride-sharing companies or related services. In total 38 for-profit (FP)

and 29 non-profit (NP) ride-sharing systems have been identified. Eight ride-sharing systems are identified as both, as for these ride-sharing systems the fee that each passenger is charged for the trip lies on the driver's judgement, which is considered as the travel service provider.

The majority of NP ride-sharing systems charge travelers based on the distance traveled, to cover gas and parking expanses. The system recommends a ride fee and travelers decide to accept it or not; from the total fee the system retain a fixed amount to cover the transaction. Although this is the practice, in very few occasions (only 2% of the cases), which refer to long-haul services, drivers may decide what to charge passengers after reviewing the system's recommendation.

In terms of geographical coverage, the majority of the ride-sharing systems were found to operate in EU (34%) or at global level (35%). It should be noted that EU based systems include an Israeli and a Turkish ride-sharing system. US and Asia based systems accounted for 17% and 10% of all systems, respectively. A small share, of only 3.4% of the systems, has been found to operate exclusively in Canada (1.7%) and Latin America (1.7%). Although, these shares refer to the wider area of countries or continents, rarely one system covers the totality of a country as in most cases, systems operate in a specific city or several close-by cities.

Short and long-haul services cover roughly 58% and 12% of all services, respectively, while ride-sharing services that cover both short and long-haul trips account for 30% of all services. Short haul trips here are considered within the same city; long haul include all other trip types. Often, ride-sharing systems that provide only long-haul services provide booking access through a website platform; in these cases, provision of additional services, though mobile applications, are not available.

Several identified systems have ceased operations due to the low demand; some of them have re-opened under different names and follow a different business model. Approximately, 80% of the surveyed ride-sharing systems are currently in operation, whereas 20% have ceased their operation. The vast majority of ride-sharing systems (92%) have started their operation in 2005 or after, while 65% was found to start operations in or after 2010, which might be explained by the rapid development of mobile applications and spread of smart phones.

It is found that an important aspect to address security concerns and improve the overall level of services is users' feedback, as all ride-sharing systems allow travelers to provide "feedback" either through the provided platform, through the application, or both. The feedback system allows travelers to comment and evaluate the seriousness and reliability of drivers and vice versa. In some cases, and to strengthen the feeling of safety, the mobile application employs GPS tracking that may be shared with users' contacts to ensure that travelers are monitored and completed as planned. To further increase the sense of safety, some systems provide women with the option to travel only with other women as co-travelers or even drivers.

The EU transport policy aims to ensure the movement of people and goods throughout the EU by means of integrated networks using all modes of transport (road, rail, water and air). Governed by Title VI of the Treaty on the Functioning of the EU, transport is one of the EU's most strategic common policies [15]. However, within the existing legislation a common directive for shared-mobility is not shared. As the EU regulatory framework does not support yet shared-mobility services with an EU decision, their success may be hindered.

The majority of EU-Members allow at some level the operation of for-profit (FP) ride-sharing systems. However, only 13 out of the 28 have implemented specific regulations in order to specify the context in which ride-sharing systems should operate. One of the main reasons for this situation is that, while making a profit is allowed, several complications arise with laws related to the operation of taxis. In this respect, many countries have chosen until now not to regulate ride-sharing systems, but rather let them operate in a kind of "grey" area. Indeed, wherever FP ride-sharing companies enter the market (e.g., Uber, BlaBlaCar and Taxify), strikes and other obstacles were encountered, which in many cases led to the banning (at least temporary) of these services. However, other cases exist, such as the example of Croatia, where the Court in Zagreb has rejected a motion filed by the government that wanted the court to ban Uber in the country [15].

Several options have been examined to ameliorate this situation, such as including taxi drivers in the ride-sharing platforms (Spain) and obliging FP ride-sharing providers to acquire the same licenses as taxi drivers. In many cases, FP ride-sharing is allowed as long as the private drivers do not invoice more than the real costs of the journey. There are other cases, such as the case of the Czech law, where if a driver pursues such activities regularly in order to make a profit, it will most likely fall within the category of regular taxi services and they will be subjected to the same legislation. Another way to appease taxi drivers – is to allow large for-profit ride-sharing companies to provide only specific services (e.g., Uber black) or to allow them to operate only in specific areas and/or regions. One such case is Bulgaria, where Uber is allowed to operate only in Sofia [15].

Overall, the discussion about ride-sharing is mainly focused on how to allow and promote it without opening up the possibility of misuse of ride-sharing. An example of such misuse could be people claiming they are ride-sharing while they are actually offering taxi services for profit without fulfilling the requirements for taxi services (e.g., Sweden). Despite this situation, governments and users acknowledge the many advantages of ride-sharing for the environment, for the sharing economy, and for the reduction of congestion in large urban areas.

5. Ride-sharing users

Several studies in the literature focus on understanding users' attitude and characteristics towards encouraging them to use ride-sharing services [25]. However, user behavior and travel needs appear to differentiate when using FP and NP ride-sharing systems. Many studies have focused on users of FP ride-sharing systems in order to improve and expand their implementation and development. This section summarizes findings that focus on the identification of motivations and constraints that users may face when using NP ride-sharing services. The objective is to use this information to identify current and potential NP ride-sharing drivers and travelers to be targeted when designing NP ride-sharing.

5.1. Travelers and ride-sharing

The relationship that exists between demographic, behavioral characteristics and NP ride-sharing is found to be intricate according to the findings of the surveyed literature. NP ride-sharing research results on travelers' characteristics and attributes tend to refer to identical factors, which can be categorized in various ways; for example, Buliung et al. [9] classified NP ride-sharing factors as socio-demographic, spatial, temporal, automobile availability, and attitudinal, whereas Neoh et al. [25] grouped them into internal or external to the commuter. Although the terms ride-sharing and carpooling are used interchangeably in the literature, the term NP ride-sharing (defined in section 3) is used thoroughly here.

With respect to personal characteristics, Kaufman [19] indicated that socio-economic characteristics do not play a significant role in the choice of NP ride-sharing, which is in agreement with other studies that state that NP ride-sharing is not associated with socio-demographics, gender, age and educational level [6]. Income is negatively associated with ride-sharing, which means that as the household income increases the likelihood to use NP ride-sharing decreases. More recent data from the National Household Travel Survey in the US [24] indicates that NP ride-sharing travelers generally have lower incomes, and minorities (typically Hispanics and African Americans) tend to ride-share more than other racial and ethnic groups [26]. Higher vehicle ownership is found not to favor the utilization of ride-sharing services [16]; however, a study in China showed that the ride-sharing adoption rate was similar between households with cars and those without [32]. The tendency to adopt ride-sharing services is higher among individuals in households with more workers than vehicles, compared to other individuals. The presence of children, elderly persons, or both, in the household is likely to have a negative effect on the adoption and frequency of use. In terms of marital status, travelers between the ages of 25 and 34 were more likely to make trips (96%) versus non-commute trips (80%) by using NP ride-sharing services, and they were more likely to be single or married without children [28].

Another factor for which findings vary in the literature is the age of travelers. Females, younger workers, and those who live with others are more likely to ride-share [20]. However, Ciari and Axhausen [9] found that female individuals in Switzerland are less attracted to ride-sharing, maybe for security concerns. In terms of trip characteristics, commuters who travel longer distances were found to be more willing to use NP ride-sharing services. Similar findings were also reported for public transport student travelers who would need to transfer between transit lines to reach their residence [28]. Thus, a higher number of required transfers between public transport lines to complete a commute is a determining factor that may affect positively travelers to participate in NP ride-sharing systems. However, the in-vehicle time for public transport services was found to have a marginal impact on travelers' propensity toward ride-sharing [28]. Based on transport mode shares for US, Australia, UK and Canada, there is some evidence that NP ride-sharing services and public transport may be competitors and that in the absence of adequate public transport services commuters opt for ride-sharing [4].

Psychological barriers, attitudes and perceptions have been found to affect more the decision to use ride-sharing services than socio-demographics [31]. Research showed that enjoying travel with others, environmental considerations, travel time saving, and vehicle cost-sharing affect at a significant level the choice to use ride-sharing services [22]. Reduced stress and travel time savings through the use of High Occupancy Vehicle (HOV) lanes in the US are some of the results of using NP ride-sharing services [28]. For this reason, potential increases of travel time as a result of increases in the number of ride-sharing travelers, could lead to dissolution of newly formed ride-shares. Transport cost and travel time have been found to be associated with ride-sharing and being one of the main reasons for participating in NP ride-sharing services [6, 8].

Frequently cited barriers to NP ride-sharing formation and use include: rigid scheduling and lack of matches between drivers and travelers [23]. Several incentives have been provided occasionally to ride-sharing travelers, including reward programs that may provide money or gift cards for ride-sharing, access to green zones, etc. Such incentives showed that ride-sharing may attract participants from either single occupancy vehicles and/or public transit [14]. Also, NP ride-sharing services are more likely to be used when an organization, such as a company, university, etc., provides this service in their premises.

5.2. Drivers and ride-sharing

The drivers provide ride-sharing services and they are considered independent private entities. This approach is different from most traditional forms of passenger transport, where an authority or company owns vehicles and/or employs drivers. Ride-sharing users can offer a ride as a driver or request transport as a traveler. If the driver and the traveler agree on the proposed arrangement, the driver picks up the passenger at the agreed time and location. Several surveys have been conducted to study the traveler's behavior; however, a few focuses on the driver's behavior. Respondents with a preference for driving only or riding only accounted nearly for 50% and 53%, respectively [5]. Nearly, 33% of the respondents stated that they would rather not offer a ride in the evening (18:00-24:00), while more than 52% of passengers stated that they would not accept a ride in the evening [12].

For drivers, a traveler's profile is an important factor. Travelers whose social network profile appears unattractive or incomplete have a lower chance of finding a ride offer. Therefore, it becomes essential for potential travelers to have a trustworthy profile, including a picture and education or job details, and contact information on a social network (e.g., LinkedIn, Facebook or Ride-sharing application). This challenge has been largely addressed through the development of increasingly sophisticated ride-matching systems.

It is worth mentioning that other studies concluded that younger and older people tend to be passengers, while middle-aged people tend to be drivers [28]. Finally, drivers appear to avoid sometimes ride-sharing as they do not like delegating the driving task to others, which causes anxiety and stress (usually studied as 'locus of control') [25, 31].

5.3. Ride-sharing user types

Very limited information exists on the trip purpose of NP ride-sharing users, compared to the exploration of demographic characteristics for specific ride-sharing user groups, such as for the workers and students. Similarly, as most studies focus on commuting for work or education purposes, leisure/recreation trips are usually not investigated. Reinforcing our conclusion regarding leisure/recreation trips, Wilkowska et al. [33] suggest that little analysis is performed on trip purposes other than work, while Li et al. [22] found that only 11% of single-occupancy vehicle trips were associated to leisure/recreational purposes, compared to 72% of high-occupancy vehicle trips (i.e., 2 or 3 passengers) that were associated to leisure/recreation purposes. Teal [29] identified three types of NP ride-share users based on how they ride-share: 1) Household (use only with household members), 2) External (use with unknown individuals), and 3) Passengers (use only as travelers).

Nevertheless, FP ride-sharing services are preferred compared to NP ride-sharing services for leisure trips. For FP ride-sharing services, leisure trips rank first between trip purposes for different cities in US, India, Brazil and Chile, while work trips are ranked second [30]. Similarly, a survey on FP ride-sharing trip characteristics, showed that 67%, were social or leisure in nature (such as trips to bars, restaurants, and concerts or visits to friends or family) in contrast to just 16% of trips that were work related [11].

Table 1. Ride-sharing user types and description

Ride-sharing user type	Description and characteristics
Household work user	**Trip to work with at least one other worker from the same household** Low-income; Age 25–49; Mode of transport for commuting - Car as driver and public transport; Travel time savings; Being in a multi-person household; Having more licensed drivers in the household than vehicles; Existing family members/friends who ride-share; Travel time saving.
Solo work user	**Trip to work with unrelated individuals** Younger commuter; Family members/friends or colleagues who carpool; Travel time saving; Cost savings; Flexibility; Finding someone with the same location and schedule; Desirable user's profile.
Education user	**Trip for educational purposes with or w/o unrelated individuals** Low-income level; Undergraduate; Single/divorced; Flexible work time; Time saving; Concern for sustainability; Travel longer distances to the university; Low application fee; Desirable user's profile; High number of required transfers in public transport.
Recreation/ entertainment user	**Trip for recreation and entertainment purposes with or w/o unrelated individuals** Age 18-29; Relaxation while traveling; Enjoy travel with others; Get work done while traveling; Cost saving; Concern for sustainability.

Categorization of ride-sharing users (i.e., travelers and drivers) is based on the user's trip purpose. An understanding of the user's characteristics in relation to the trip purpose will provide the basis for developing a successful ride-sharing system. Given that the purpose of trips varies for different urban forms and locations, it is important to embrace a significant share of current and potential ride-sharing users covering a wide area of activities. Taking into account the objective of this section, four user types are considered that cover the majority of trip activities, as shown in Table 1. Recent data suggest that household NP ride-sharing likely represent the largest share of arrangements [23]. However, NP ride-sharing should be considered for recreation/entertainment

activities as some of them are fixed in terms of time, day and place (e.g., grocery shopping, training).

The user types in Table 1 refer to both travelers and drivers, as there is no evidence that role preferences are associated with specific trip purposes. Sharing roles, opposed to drive-only or travel-only, has shown to affect success of ride-sharing. Sharing roles and resources appears to be the preferred approach, as participants look to acquire both the economic advantages of driving, and the perceived psychological benefit of being a traveler [21].

6. Conclusion

This study offers a contribution to the understanding of ride-sharing services through an extensive review of definitions, ride-sharing systems, legislation and user characteristics. A comprehensive understanding of these aspects should be supplemented by major institutional support and recognition, including the definition of monitoring and evaluating programs to consider short and long-term outcomes [13].

The provision of ride-sharing strategies is a rather interesting and complicated task that should take into account local and regional characteristics (i.e., demographics, economy, users, geography, transport). Findings show that a combination of personalized information about ride-sharing users, and well-structured incentives delivered via social media can be successful in encouraging the uptake of ride-sharing.

Additionally, it becomes important to examine the factors related to solo driving in each society and decide customized interventions to target the behavior of solo drivers. Initiatives that aim to encourage solo drivers to start ride-sharing, could address some of the perceptions around the comfort and the convenience of driving alone versus ride-sharing. Incentives include toll cost reduction, HOV and green zone access, free or discounted parking access in public or private areas, public transport ticket discounts and collection of points that may be redeemed in collaboration with selected companies. These incentives are provided in agreement with private companies or public authorities. There are several cases of ride-sharing systems that were initiated in the framework of research projects or by specific companies and universities, which proved to be very successful and contributed to the overall promotion of ride-sharing systems. For this reason, almost all EU Member States are in the process of identifying the ways in which ride-sharing could be allowed, without benefiting one sector over another and without causing issues to the economy

7. References

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