

# **Barriers to a Successful and Sustainable Dynamic Car-pooling System**

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Abstract

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With technology developed in recent years, dynamic car-pooling has started to become a phenomenon. Compared to traditional car-pooling, dynamic car-pooling apps allow users to car-pool on-demand with their smartphone, getting matched with drivers and other riders near-instantly. Although this has solved previous communication and information problems in car-pooling, the mobile technology has so far not reversed the decrease in the trend of car-pooling. This study aims to examine problems in dynamic car-pooling systems and propose practical solutions. While several determinants of car-pooling have been reported in the literature, much less is known about the barriers and problems of dynamic real-time car-pooling systems: what constitute as main barriers for dynamic car-pooling, what is the nature of these barriers, and where do these barriers come from.

By categorizing general car-pooling problems through literature review, this study identifies key issues and gaps that have not been studied or have not been studied in depth. Then, this study analyzes current barriers to successful and sustainable dynamic car-pooling systems from various perspectives through interviews. The result shows that the future for dynamic car-pooling is challenging, needing not only technical and financial solutions, but also user-studies focusing on travel behavior to achieve a greater success.

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## Chapter 1. INTRODUCTION

### 1.1 RESEARCH CONTEXT AND PROBLEM STATEMENT

Auto ownership is widespread in North America. In 2001, 92.1% of U.S. households owned at least one vehicle, and more than 60% of U.S. households owned two or more vehicles (Statistics, National Household Travel Survey, 2003). For example, even in Seattle, the metropolitan area with a dense population, still over half the population drive alone to work. This might explain why highways such as SR-520 and I-90, and Seattle downtown are congested all the way during rush hours.



Figure 1 Car-pooling Commuter (Statistic Brain, 2017)

In order to deal with the inefficient auto ownership and rising fuel costs, during recent years, car-pooling, a predominant form of ride-sharing in which people share a car to travel to a shared destination, has attracted more attention.

Many research projects are focused on car-pooling, citing benefits such as reduced fuel consumption and emissions, reduced congestion during peak hours, and reduced parking costs for travelers. However, since the 1970s, car-pooling has not been as successful as the public expected. Rather, it has decreased its share as a travel mode. Reasons behind this failure identified by previous scholars are: inefficient information sharing - insufficient numbers of drivers and riders (Heinrich, 2010), people's incompatible and different schedules and routes (Amey et al. 2011), and unfamiliarity with the concept of car-pooling (U.S. Department of Transportation, 2000).

With technology developed in recent years, dynamic car-pooling (drivers and passengers could match each other on demand nearly instantly) through mobile applications has started to become a phenomenon. Although this addressed previous communication and information problems in car-pooling, the mobile technology did not totally change the decreasing trend of car-pooling.

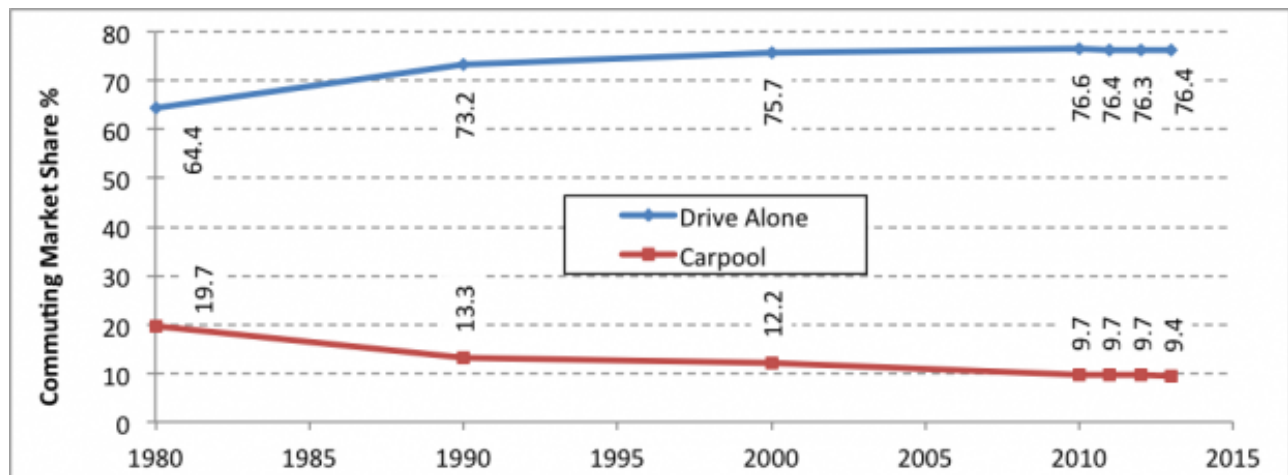


Figure 2 Decreasing Market for Car-pooling (AASHTO, 2013)

According to Figure 3, car-pooling is less popular over the years, decreasing from 19.7% in 1980 to 9.4% in 2013 in the commuting market. Many car-pooling companies, even with a dynamic

mobile technology, still lack ability to attract customers, and past studies did not sufficiently address this problem and identify barriers.

## 1.2 RESEARCH OBJECTIVES

The main objective of the thesis is to find problems in dynamic car-pooling system and practical solutions. While several determinants of car-pooling have been reported in previous studies, less is known about the barriers and problems of dynamic real-time car-pooling system. By introducing and defining dynamic ride-sharing problems, and by illustrating and outlining the optimization challenges that arise when developing technology to support ride-sharing, this study hopes to encourage more research by the transportation science and logistics community in this exciting, emerging area of public transportation.

The study addresses following research objectives:

1. Investigate the nature of barriers that impede the success of dynamic car-pooling, help planners have a better comprehensive view about the dynamic car-pooling.
2. Examine and identify gaps that the previous scholars didn't cover.

In order to achieve these objectives, a literature review is conducted, car-pooling users and transportation companies are interviewed and their responses are analyzed.

The audience for this paper is dynamic car-pooling transportation companies and multi-modal transportation planners. The study will be useful and supplement their market studies, and explore the future possibility to improve the service and overcome current technical or social barriers.

### 1.3 RESEARCH QUESTIONS

This thesis will attempt to address following questions:

- What constitute as main barriers (economic, social/behavioral, technological, institutional, etc.) for dynamic car sharing?
- Which barriers or problems have previous scholars not covered in their studies?
- Where do these barriers come from? What is the nature of these barriers?
- What are possible ways to overcome these barriers?

### 1.4 DEFINITION OF TERMS

#### *Traditional Car-pooling*

Traditional car-pooling is not a for-hire commercial service. Riders do not hail a car-pooling, and drivers do not profit as they do with a taxi or as they do with transportation network companies.

Traditional car-pooling means people pooling from a common origin to a common destination, for example, employees from the same workplace could share the ride if they live close to each other. The traditional media being used are newspaper, poster, website, etc. It usually needs riders and drivers negotiate and arrange the trip before the start of the trip.

#### *Casual Car-pooling (Ad Hoc Car-pooling)*

Casual car-pooling is different from a traditional scheduled car-pooling because of its ad-hoc nature. Casual Car-pooling usually is defined by 2 or more people sharing the vehicle to make a trip. Drivers and riders, in this case, have no pre-arranged agreement.

### *Mobile (App)-based Car-pooling*

Smartphones with GPS navigation systems has enhanced the efficiency of car-pooling services, allowing shared trips to be planned and organized by using dedicated smartphone applications ("apps"). (Lervåg et al. 2014) In a mobile-based car-pooling, an app is often used by passengers to specify source and destination, time to be served, maximum time to be delivered, number of people, and how much they are willing to pay for the ride (in case of a taxi ride this should be the taxi cost of a sole trip). The app is also used by car owners and drivers, who need to specify the following: source, destination, leaving time, maximum allowable time to be at the destination, price per kilometer and the vehicle capacity. (Santos et al. 2015)

### *Dynamic (Real-time) Car-Pooling*

Dynamic car-pooling is a most recent way to combine the traditional car-pooling and casual car-pooling. A car driver and passenger(s) usually share a vehicle based on an automatic ride-matching process. Same with traditional car-pooling, the car driver has his/her own trip plans and offer unoccupied seats for passengers going in the same direction at the same time. The difference is that in dynamic car-pooling the matching process is completed instantly, often by a smart phone. Smartphone with GPS will quickly respond and get the location near instantly, and thus enable car sharing to be “dynamic” and on demand. The ride-matching is usually facilitated by a mobile matching application, based on offers and requests from drivers and passengers input of their location and departure time respectively. Same with casual car-pooling, the trip is not pre-arranged and non-recurring trip. Since Uber and Lyft are mostly hiring part-time drivers to do the service, the driver and riders do not share the same route as what dynamic car-pooling

does. In this study, Uber and Lyft are not included in the investigation because they did not seriously satisfy the definition of dynamic car-pooling.

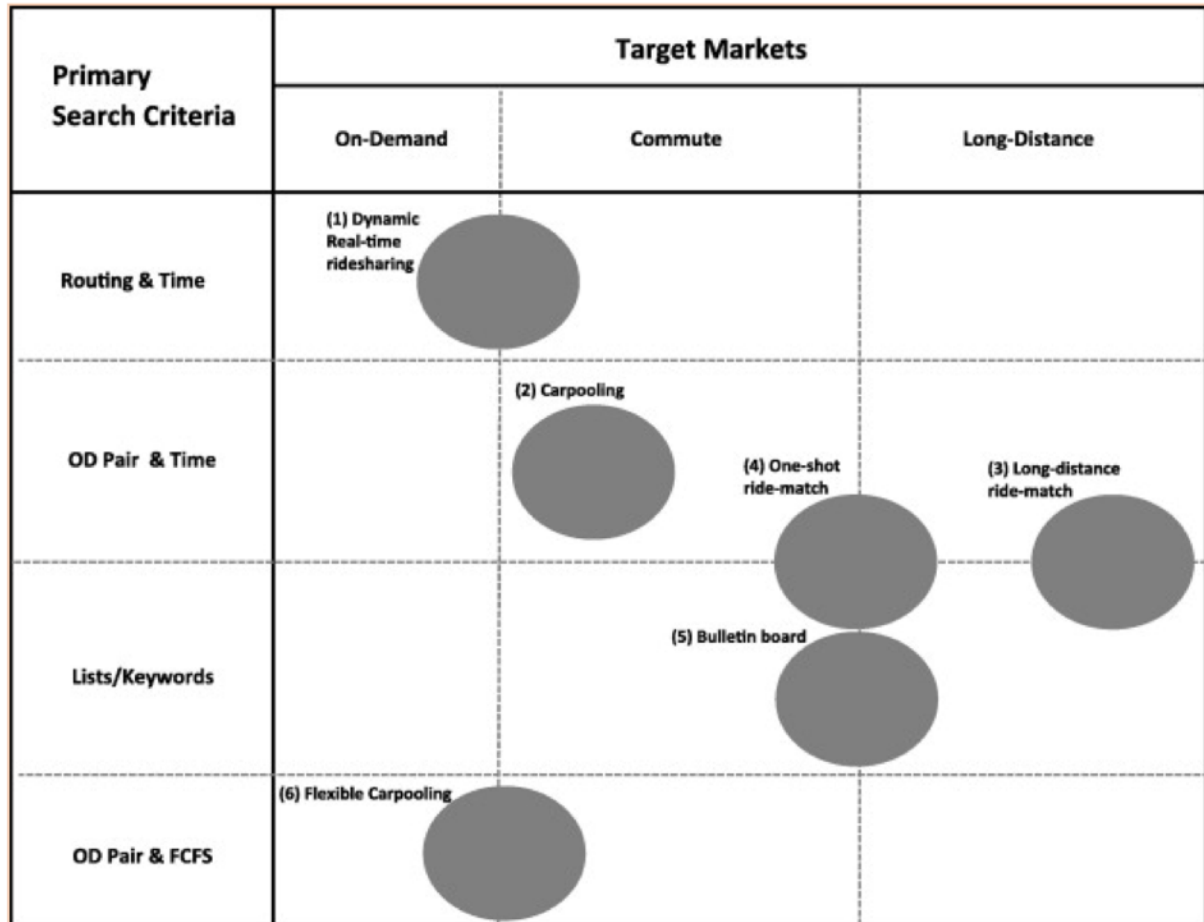


Figure 3 Six Classes of Ridesharing Matching Agencies (Masabumi et al. 2013)

As showed in Figure 4, Masabumi and co-authors in 2013 categorized ride matching agencies into 6 categories according to the target markets. Some agencies match riders by routing and matching time schedule, typically for mobile-based car-pooling. Some match its original destination, and time schedule, this is typically for regular car-pooling, ride-match on one-shot, and long-distance travel. For the bulletin board, newspaper, or paper-based car-pool, the match is based on the key-word and lists. This is the least efficient car-pooling, since that will require users to read the whole paragraph to find their riders. Dynamic car-pooling is the most recent

class, it is frequently used as dynamic car-pooling, and it is relatively efficient and no needs for prearrange and negotiation. It does not need riders and drivers share the exactly same pick-up and drop-off locations as long as they are on the route of the driver's original trip.

### *Cost-Sharing*

The trip cost, such as: fuel, gas, road fees(tolls), etc. are shared by the car-pooling drivers and passengers. In this case, the passengers pay drivers reasonable reimbursement fees, and drivers share their traveling cost and risk with their traveling companions.

### *Non-recurring trips*

Real-time ride-sharing often focuses on single, non-recurring trips. The trip between two or more people is initiated instantaneously, which is different with traditional recurring car-pooling, which is based on the long-term commitment, and will occur not just once, but every period.

### *Pre-arranged Trips*

The trip is planned before its departure.

### *The Successful and Sustainable Dynamic Car-pooling System*

Due to dynamic car-pooling system is relatively a new concept, there is very few of existing literature that clearly defines how successful and sustainable dynamic car-pooling system should look like. Also, although the enabling technology is available, car-pooling success stories are still in short supply. In this paper, successful and sustainable dynamic car-pooling system depends on some factors: 1) Technological setup, this means the app is able to match people on demand and

carry out the payment system. 2) Have enough customers and able to maintain a certain volume of demand. Some scholars consider that “a dynamic car-pooling system must be able to match 100 random trip requests at any time” (Dailey, 1997). People in the dynamic car-pooling community most of time could successfully match their rides, and are willing to use this service again when they want to commute. 3) Could cater people’s requirement, including having a flexible schedule, reliable service, securable payment function, etc. 4) The company have enough funding or income to support and maintain their service, including seed money in the initial stage from investment company.

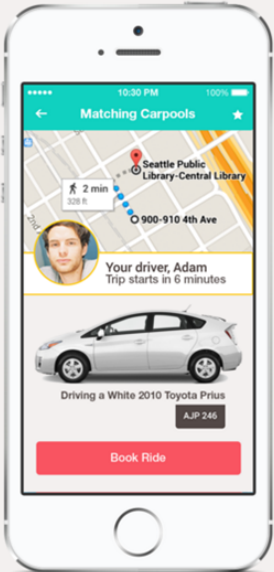
## So, you need a ride!

You may not know them yet - but you have neighbors and colleagues who go the same way every day! iCarpool helps you find, connect and carpool with drivers going your way in a matter of minutes. Here's how it works.

**1. Choose Your Destination**  
Use the App to let us know where you want to go.

**2. Review Matching Carpools**  
The App shows you trips that will be happening in the next few minutes that match your travel requirement.

**3. Book Your Ride**  
Review the matches and book your ride. You can choose based off cars or drivers.



**4. Ready for Pickup**  
Make your way to the pickup stop. We'll mark it on the map for you.

**5. Enjoy Your Carpool Ride**  
Once your car arrives, show the boarding pass to the driver and get in the car. You're on your way!

**6. Rate Your Driver**  
When the ride is over, the App automatically deducts the fee from your account. Make sure you rate your driver.

Figure 5 Dynamic Car-pooling App (Go Redmond.com, 2016)

## 1.4 THESIS STRUCTURE

This thesis intends to address the car-pooling problems specific to dynamic car-pooling. The first chapter introduces the problems related to dynamic car-pooling, as well as defining terms, goals, objectives and specific questions explored in this thesis. The second chapter describes the research approach and summarizes the methods of this study.

The third chapter is the literature review, which identifies research gaps in previous studies. Although there are some previous publications using qualitative or quantitative methods to summarize general car-pooling problems, few conclusions were made in past studies to explore problems and barriers specific to dynamic car-pooling. In this part, general car-pooling problems are summarized, and gaps in previous studies are identified.

The fourth chapter presents issues and barriers collected from interviews of people from various dynamic car-pooling perspectives, including dynamic car-pooling companies, passengers, and drivers. Interview results are analyzed. Specific barriers and issues related to dynamic car-pooling are identified.

The last part is the fifth chapter, which is the discussion and conclusion of the study. It summarizes problems revealed by this study, and possible future solutions.

## Chapter 2. METHODOLOGY

Previous studies mostly focus on the general car-pooling barriers. There is not sufficient literature directly addressing challenges and barriers for dynamic car-pooling from a qualitative aspect. The methodology of this research involves a 2-part analysis, and both aspects are qualitative.

1. The first part of research is a review of the existing literature on car-pooling. Literature review identifies general car-pooling problems, and builds a framework and knowledge foundation for studying dynamic car-pooling. Barriers and problems of general car-pooling that have been already identified in the previous literature are summarized and categorized into economic, social/behavior, institutional and technological categories. The literature review part also investigates which barriers or problems have previous researchers not addressed in their studies, and identifies problems that could be emphasized in the second part (interviews).

2. The second part of research involved a series of interviews with dynamic car-pooling companies, innovative providers, riders, and drivers. Emphasis will be placed on the following research questions:

- Combined with literature review, which barriers or problems have previous scholars not covered in their studies?
- What is the nature of these barriers?
- What are possible solutions to these problems?

The interviews are focused on providing an in-depth examination of barriers to dynamic car-pooling, by collecting detailed face-to-face answers, and directly addressing representatives of different stakeholder groups on how they perceive the dynamic car-pooling challenge.

Interview questions are designed to answer research questions in different categories (economic, social/behavior, institutional, technological), and from different perspectives (company representatives, passengers, drivers). (See Appendix B)

Each interview is conducted in 45 minutes to 1 hour. The whole process is recorded by field notes. The study uses qualitative analysis to transform data into findings, including: reduce the volume of raw information, sift significance from trivia, and identify key sentences that could answer research questions.

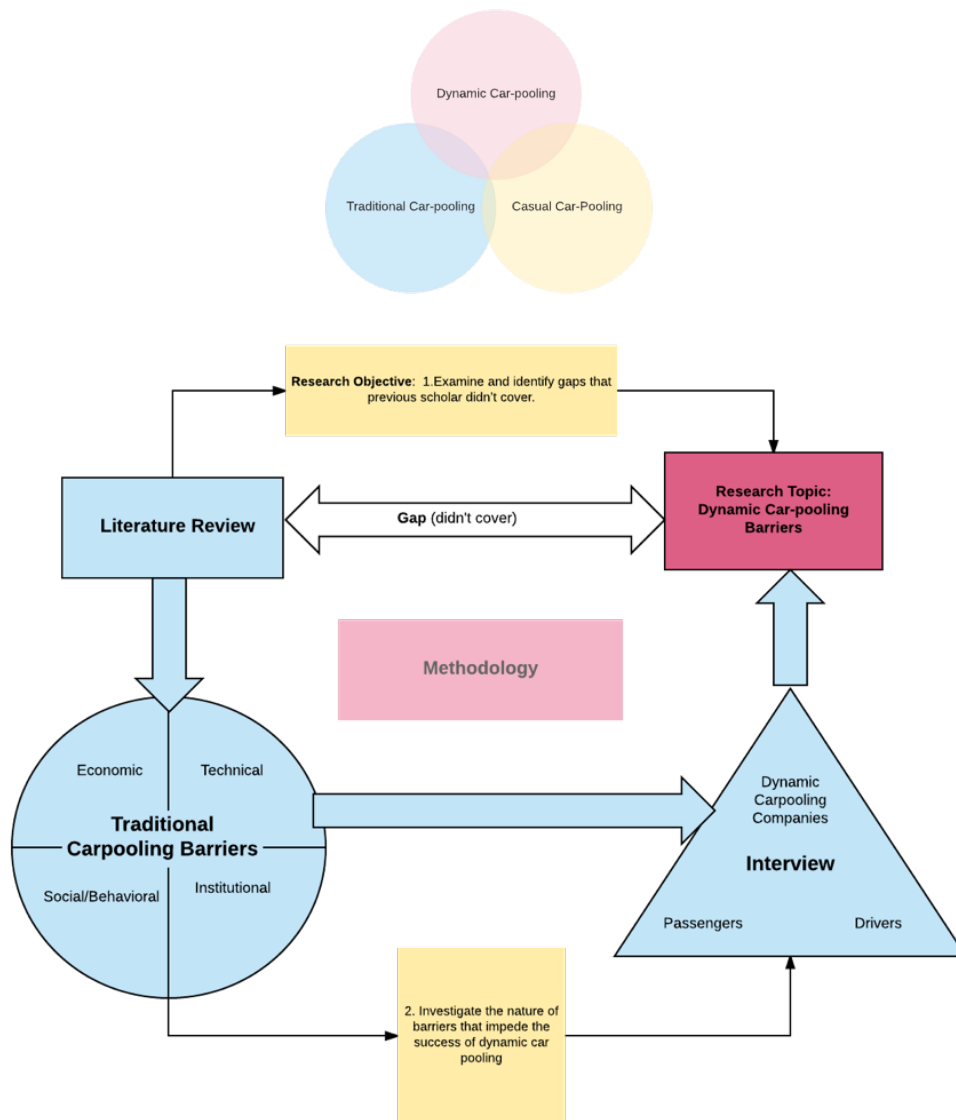


Figure 2 Conceptual Framework

## Chapter 3. LITERATURE REVIEW

### 3.1 DYNAMIC CAR-POOLING STUDIES

Since dynamic car-pooling is a relatively new concept, many previous studies mainly focused on developing matching or routing algorithms that could help car-pooling achieve greater efficiency, while ignoring the social and behavioral aspects.

In recent years, the development of internet technology has motivated scholars to establish network platforms as a mechanism for organizing car-pools. Many studies (Martino et al. 2011) focus on enabling GPS function, social network login function, and routing algorithms. In 2014, Hammadi and co-authors also proposed a dynamic optimization model in order to alleviate the impact of heavy processes on the quality of car-pooling service provided and response time. (Hammadi et al. 2014) These studies both focus on reducing the time wasted for users by hand-typing their locations, and negotiating with each other. Also, it helps drivers to quickly arrange pick-ups.

Some other studies are proposed to solve the privacy problems while using user's GPS location and personal data. For example, in 2014, Shin-Yan Chiou and co-authors proposed a mobile, dynamic, and privacy-preserving matching system for car and taxi pools in order to protect user privacy. (Chiou et al. 2014) These studies allow users to engage with the system without fear that their personal information may be leaked to unauthorized parties. Third party attackers are unable to obtain the key information of users such as intended destination.

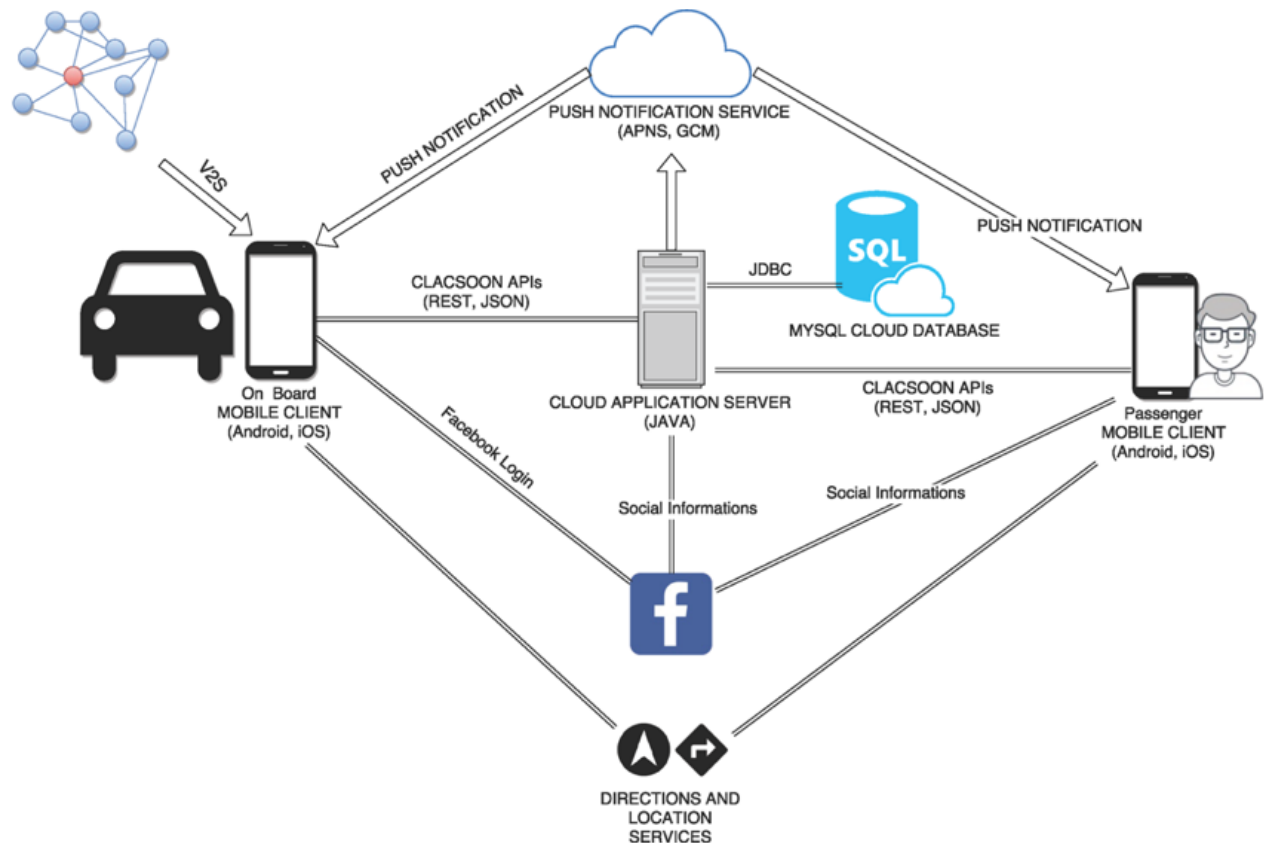


Figure 7 Example From CLACSOON System About How Dynamic Car-pooling Works (Mallus, 2016)

### 3.2 DYNAMIC CAR-POOLING BARRIERS

Although there is some literature about dynamic car-pooling, few of them comprehensively address the problems in the dynamic car-pooling.

In 2011, Amey (Amey et al. 2011) concluded some opportunities and challenges of car-pooling, although it did not directly address the problems specifically in dynamic car-pooling, but it gave other scholars a comprehensive review about challenges faced by car-pooling market.

<b>Barriers</b>	<b>Economic Challenges</b>	Imperfect Information High Transaction Costs Subsidies Favoring Other Transportation Modes Decreasing Costs of Vehicle Ownership
	<b>Social/Behavioral Challenges</b>	"Stranger Danger" Power Mismatch and the Need for Mutual Dependency Reliability of Service Schedule Flexibility Consistency of Expectations
	<b>Institutional Challenges</b>	Insufficient Institutional Collaboration Business and Revenue Model Service Competition within a Market
	<b>Technological Challenges</b>	Measure of Successful Rideshare Trips Establishing a Common Rideshare Data Specification

Table 1 General Car-pooling Barriers Identified in Literature Review

### 3.2.1 *Economic Challenges*

#### *Imperfect Information*

The economic theory points out that the information asymmetry is one of the market failures. In the car-pooling world, drivers and passengers willing to share rides may not have any way of identifying one another. In dynamic car-pooling, even drivers and passengers could successfully match with each other, they know little about each other's personality and travel behavior. What is the driver's driving history? Does either the driver or passenger have a criminal record? These information gaps can be important in determining one's likelihood of sharing a ride.

#### *Lack of Audience - "Critical Mass" Problem*

In 2010, a study in the San Francisco Bay Area finds out that only half of the survey respondents are willing to try real-time car-pooling. The finding based on the survey recommends not conducting a pilot project in a traditional sense, but incorporating real-time functionalities into

the Bay Area's existing rideshare program and committing to the service for the life of the existing rideshare system. (Heinrich, 2010) The study found that only one-fifth of commuters who drive alone to the campus would be interested in using dynamic car-pooling at least occasionally and live in areas where matches could be found. The commuters would prefer to arrange a shared ride at least the night before rather than immediately before the trip is made. Many of these travelers were unaware of current rideshare services, and some would be willing to find a regular car-pooling partner. The use of previous system and platform will have a higher potential to reach the critical mass and use existing funding.

The main reason gathered from riders who are not willing to try real-time car-pooling is: People are not familiar with how to use dynamic car-pooling app, and feel it is too complicated to use. So the study concluded that usability for dynamic car-pooling app plays an important role. Any car-pooling app needs to be user-friendly in order for people to use it frequently. This study (Heinrich, 2010) provides good analysis to the real-time dynamic car-pooling from user's perspective, but it's not sufficient to illustrate the barriers and challenges facing by other perspectives, such as companies perspective and driver's perspective.

#### *Subsidies Favoring Other Transportation Modes*

Amey and co-authors point out there are more policies or financial subsidies favoring other transportation modes, such as: bus, biking, walking, etc. These subsidies make other transportation modes more favorable while making car-pooling less appealing. (Amey et al. 2011) However, this reason is not very persuasive, as they didn't give any data or example to support this finding. First, culminating with the passage of the Intermodal Surface Transportation Efficiency Act in 1991, which favored high-occupancy vehicle (HOV) lane construction, there

are many benefit for people who share their car for others: designated car-pooling parking spots, discount tolling fees, etc. It can't tell the subsidies for car-pooling is less than other transportation modes. Second, the statement also suggests that the failure of car-pooling could be attributed to less subsidies from government and public. However, the increasing HOV lane miles is followed by the downward trend of car-pooling (Li et al. 2007). The failure of car-pooling might be due to other reason than the unbalanced policy or subsidies favoring other transportation modes.

#### *The Decreasing Cost of Vehicle Ownership*

Researchers believe that the average decreasing cost of vehicle ownership could make car-pooling less favorable (Amey et al. 2011) (Polzin, 2015): As the cost to purchase vehicles decreased, vehicle ownership rates have increased, and car-pooling and the use of public transportation has decreased.

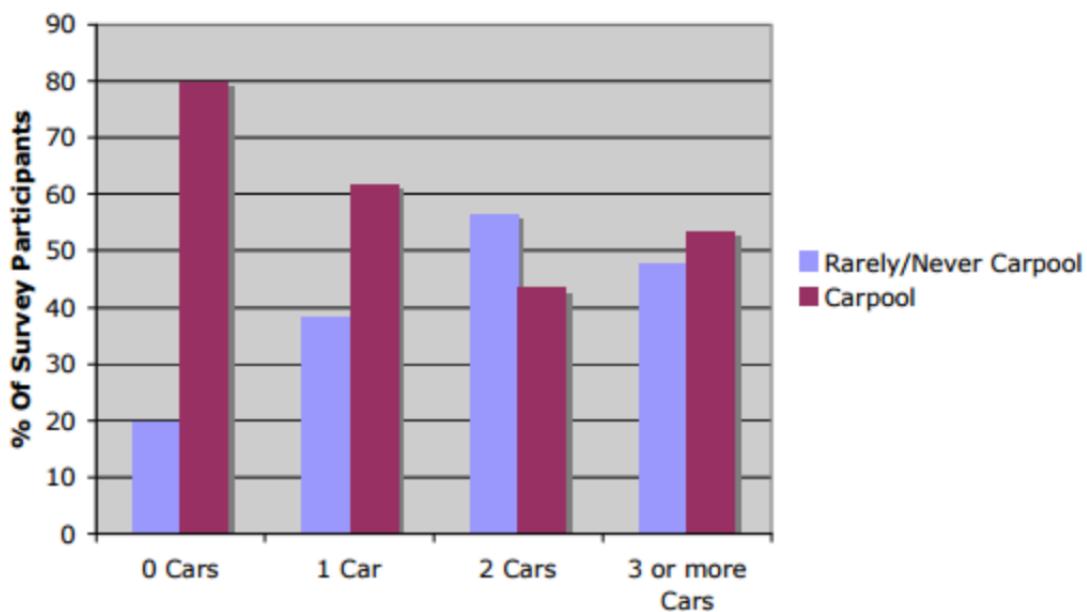


Figure 8 Car-pool Frequency vs. Number of Cars Owned (%) (Watts 2010)

### 3.2.2 *Social and Behavior Challenges*

#### *Reliability and Privacy Danger*

They also expressed her concerns on dynamic car-pooling: 1) they noticed that there is a trade-off between flexibility and reliability. Traditional rideshare lack in its flexibility, but it's quite steady and reliable. On the other side, dynamic car-pooling is flexible, but provide little service reliability. (Amey et al. 2011) However, they didn't explain why there is little reliability in the dynamic car-pooling. 2) there is also a trade-off between valuable travel data and loss of privacy. The open source of detail location and travel data, on the one hand, will be valuable for transportation companies and agencies. On the other hand, these will constitute a great danger of personal information leaking. (Amey et al. 2011)

#### *An identification of causality of failure*

Since there are often 2 or more riders involved in car-pooling. For instance, consider a driver and two passengers in a car-pooling trip. If the first passenger delayed appearing at the pick-up location which caused a dishonest activity for the second passenger regarding a pickup. It is unknown to the second passenger who caused the delay. Driver or the first passenger? How should passengers evaluate their experiences? A question is whether the second passenger has to identify the causality of the delay due to the driver, the first passenger, or something else. (Masabumi et al. 2013)

#### *Power Mismatch and the Need for Mutual Dependency*

Drivers need to rely on passengers to gain access to the faster moving High Occupancy Vehicle lanes, or to avoid vehicle tolls, or to share the fuel cost and other expenses. Passengers rely on drivers to avoid driving by themselves, time and expenses for parking, etc. In both traditional and casual car-pooling arrangements, it is the mutual dependency and mutual benefit between drivers and passengers that allow car-pooling to be sustained over the long term. In most of the cases, a driver has greater power to control the departure time and route, riders may need to sacrifice some of their own interest in order to make the trip. According to Amey, this power mismatch is often “overcome” by switching driver’s role and rider’s role in another day. However, in dynamic car-pooling, since the trip is made instantly, every trip is made with different drivers and riders. Drivers and riders may not have the chance to switch the role on a next-day trip. It is necessary to know in this case, if either part feels uncomfortable with the role, the car-pooling cannot be successful and sustainable in the long term.

### *Travel Consistency*

People may be getting used to their old travel habit: the type of vehicle they used, the kind of driver/passengers they met. For a one-time car-pooling, since rider and passenger are not familiar with each other, the car type, and the behavior of each other, the drop-off and pick-up location, it is more difficult for them to getting used it and even try it for the first time. People like to keep their consistency in their transportation behavior. However, previous literature did not provide enough examples and data to support this point in the context of dynamic car-pooling. This point is often illustrated together with the “stranger danger”.

### 3.2.3 *Institutional Challenges*

#### *Insufficient Institutional Collaboration*

Amey (Amey et al. 2011) pointed out that there is a challenge lies in encouraging each of these stakeholder groups to collaborate with one another and take action in those areas in which they have an advantage. For example, private car-pooling companies have the platform to connect drivers and riders including: GPS or network enabled function, and reputation system for drivers and riders to rate each other. Large employers often have the ability to influence travel behavior through providing more spots for car-pool only. Government agencies have a critical role in creating incentives for car-pooling, such as high-occupancy vehicle lanes, and developing effective policies to support car-pooling, such as modifications to taxi regulations.

One of the challenges is how to take advantage from a different perspective, and achieve greater collaboration in the car-pooling field.

#### *Business and Revenue Model*

A distinct challenge, from the perspective of the private rideshare service provider, is how best and continuous to generate revenues from a rideshare arrangement. Generally, providers use four approaches to revenue generation: (a) car-pooling offering matching services for free, and rely on advertisement for profit. (b) charged for a small percentage from driver and riders transactions. (c) developing customized commuter information tools for employers and institutions, and charge the employers or institution certain fees. (d) developing car-pooling services for public agencies and charging for certain benefit. (Amey et al. 2011)

#### 3.2.4 *Technological Challenges*

##### *Common Data Specification and Integration of Multimodal Travel Information*

A large technological challenge is the creation of a common data specification for storing and transmitting car-pooling information. If competition within markets continues, it is possible that there are multiple, non-connected ride matching databases, with no single service having sufficient participants to reach a critical mass. The example could be if two or more similar car sharing companies exist in a common geographic area, these companies might have their own customer database, which might not be sufficient because some potential customers are in another company's database. The essential preliminary step may be to enabling the aggregation of car-pooling trips from multiple databases and eventually setting the stage for integrated, multimodal travel information. Currently, many rideshare matching services seek to attract as many participants as possible to increase the probability of matching up a driver and passenger. However, most services can search for matches only within their own system. (Amey et al. 2011)

### 3.2.5 *Summary*

Previous studies are mostly focusing on the general car-pooling barriers, there is not sufficient literature directly addressing challenges and barriers for the dynamic car-pooling. Although dynamic car-pooling is much different than the traditional car-pooling in that it reduces transaction cost (time and money for negotiation and reach a consensus between two parties), it raises more concerns about privacy and reliability of service. This study will attempt to directly point out what barriers dynamic car-pooling companies are facing, and how these barriers are different with traditional car-pooling.

## Chapter 4. DYNAMIC CAR-POOLING STAKEHOLDER PERSPECTIVE

This section presents different perspectives in regard to studying barriers in dynamic car-pooling.

The objectives of the interviews are to:

1. Investigate problems and barriers for current car-pooling companies (reaching critical mass, making profit, etc.)
2. Investigate user-experience problems in the dynamic car-pooling system. Understand why users do, or do not, want to keep using the dynamic car-pooling app.
3. Analyze which general car-pooling problem have been solved by dynamic car-pooling, and which have not been solved.

Each interview was conducted over 45 minutes to 1 hour. Interview questions were grouped into three stages, with each question corresponding to a general car-pooling problem as stated above.

(See appendix A)

### 4.1 INTERVIEWEE DEMOGRAPHIC AND SAMPLING

The targeted population for the interview is dynamic car-pooling companies and users, including drivers and riders. The subjects chosen for interviews are:

- a) Two representatives from dynamic car-pooling companies. Both are high-level managers, because they may have more consistent knowledge about dynamic car-pooling, and better understanding about the resources/challenges their companies are facing.
- b) Four dynamic car-pooling riders, including two students and two workers. The students both live in densely-populated school district areas, while the two workers live in suburban areas. It is assumed that students may have more travel cost concerns compared to workers.

c) One dynamic car-pooling driver.

Users and drivers are chosen and contacted via registered accounts on car-pooling sites.

Since dynamic car-pooling is a relatively new topic, deep knowledge about the field is scarce.

Though the public is familiar with services like Uber-Pool and Lyft-Ride, very few know about dynamic car-pooling, where drivers are not company employees. The purpose of this study is to analyze barriers and challenges for dynamic car-pooling, which requires interviewees to have prior experience in either using or operating dynamic car-pooling. Due to limited time and resources, this study chose respondents with specific experience in the area for more in-depth questions and answers. Although only seven people were chosen for interviews, each provided different perspectives on dynamic car-pooling, and have direct relationships with the service.

## 4.2 PRIVATE COMPANIES PERSPECTIVE IN DYNAMIC CAR-POOLING

To investigate current barriers for car-pooling, interviewees were asked to identify problems that were solved by the dynamic car-pooling app which were left unsolved by past car-pooling systems. One dynamic car-pooling company recently switched from an online system to a mobile app. A representative from this company was interviewed within the research sample, providing motives for switching their service, and a description on how the dynamic car-pooling system solved some problems in previous systems. Areas addressed by the mobile application include imperfect information, high transaction costs, and schedule flexibility.

### 4.2.1 *Advantages and Opportunities Compared to Traditional Car-pooling*

These are some quotes from the survey respondents:

*"We conducted some market surveys in Redmond. The result showed that people regard flexibility as one of the top considerations while car-pooling.... People just want to go when they are free... so we decided to implement the dynamic car-pooling app to solve this problem "*

*"Trips are not stable all the time. Sometimes, people change their trip at last minute, which causes some discomfort and unreliability to users of the system. Real-time car sharing solves this by enabling people to make decisions at right before their departure. This increase in trip flexibility significantly decreased the trip cancellation rate..."*

*"... While users are on the road, they won't always have access to wi-fi or laptop, so a mobile app on a portable device helps immensely..."*

All interviewees described solutions to general car-pooling problems that were largely solved by the dynamic car-pooling system, including: flexible schedule and accurate timing, convenient car sharing information, and almost zero cost. These also served as a motivation towards developing the mobile app over other channels to solve general car-pooling problems.

#### 4.2.2 *Main Problems & Barriers*

The main barriers and challenges identified by dynamic car-pooling companies are being able to reach critical mass, and gaining revenue.

##### 4.2.2.1 *Critical Mass Problem*

a. *Difficulty balancing drivers and riders*

The most frequent issue described in the interview is a "lack of audience", which can be referred as the "critical mass" problem. According to all interviewees, the matching process for dynamic car-pooling is a mutual process, which means that not only do riders want to find drivers, but drivers, as part of the user base, also want to find riders. In this case, critical mass is difficult to achieve, since the assumption for dynamic car-pooling is that for each rider, there is a corresponding driver in this system going in the same direction. According to the dynamic car-pooling company, they do not have enough drivers to satisfy various requests from riders.

*"We currently lack in drivers. People are more likely to take the car-pooling ride than driving the car. We have a list of people requesting for the ride, but we only have few drivers willing to accept the demand. The incentive for reimbursement is not enough to encourage drivers to share his/her own car and participate in the service"*

The lack of drivers causes a greater impact than the lack of passengers. For example, for each driver, there are one or more riders going in the same direction. If a driver is unable to continue, his drop will negatively affect one or more rider's probability to find another driver, which can cause multiple riders to discontinue using the app. If fewer people use the app, the app shifts further from critical mass. This forms a vicious circle.

#### *b. Targeting Large Employers*

The interviewees shared some recommendations to solve the critical mass problems:

- 1) Traditional car-pooling companies have an advantage in achieving critical mass, if they can successfully switch these users from their original system (website, forum, email list) to their new application.

*" We found that the best scenario for a dynamic car-pooling company is to have a healthy amount of users and drivers at the beginning. These users could be existing customers switching from their web service to the mobile app, or their other service to car-pooling service... "*

2) Another effective way for companies to reach critical mass is to target large systems, like organizations, corporations, schools, etc.

According to an interviewee, in a small system with random people, the chance for getting a match for a ride is very little, nearly zero. However, if they intentionally select people from a similar background or geographic location, the matching probability could be much higher.

*"We've done some marketing before doing the dynamic car-pooling trial, but none of that is very effective. Then, we tried reaching out to large employers, or specific areas. In these cases, people have either same destination or departing location, so it's much easier to accumulate users. Also, people tend to trust the companies' recommended services rather than seek similar services by themselves."*

*"These large corporations often have designated car-pool parking spots. Parking is always a big issue for people to choose whether he/she want to drive his/her car... so we are seeking partnerships or pilot projects in order to solve this problem"*

Based on the interviewee's opinion, partnership with schools, agencies, and large employers could be one of the most effective ways to solve the critical mass problem. For example, large employers could help dynamic car-pooling build their trust among their customers (employees

from the same company). Also, by targeting groups of people with geographic and schedule similarities, the car-pooling service will be more likely to achieve critical mass.

#### 4.2.2.2 Revenue Problem

*"We currently have two development teams working on the matching process.*

*One is working on time matching, and another is working on location matching.... Hiring engineers and doing mass marketing need a lot of money, while making one successful trip is not very easy and rewarding..."*

*"We use a share-the-expense car-pooling model, where riders are charged 26 cents per mile. The revenue is then split between drivers and our company.*

*However, the rate needs to be able to incentivize drivers while also not being too expensive for riders. This is a difficult balance. In the past, government used to operate car-pool services, and sometimes they even reimbursed the car-pooling trip."*

During the conversations, some interviewees also expressed their financial concerns. Since only passengers pay for the service, and the income is split between drivers and dynamic car-pooling agencies, dynamic car-pooling services can only generate trivial income per trip. Unless there is a big pool of passengers and a large number of trips per day, dynamic car-pooling companies, especially startups, cannot hire engineers to maintain the service in both the short and long term.

### 4.3 PASSENGERS PERSPECTIVE IN DYNAMIC CAR-POOLING

Past studies about ride-sharing demonstrated the importance of consumer behavior. Cited behaviors are: travelers prefer flexible schedules and user-friendly application, etc.

At the beginning of the interview, interviewees were asked about circumstances under which they would consider real-time car-pooling instead of other modes of travel, and what made them start to use it.

*"I use the app only when I find a match, I usually send out my location and schedule a day before my departure, because I don't want to take the risk of not being able to find a ride for work."*

*"The biggest reason why I'm trying this is the price. Sometimes the price is as cheap as public transportation, but the service is much more comfortable... I use it if I find a match, and always check the app before I take a long distance trip."*

*"I tried the app when I first heard about it. After failing several times to find a match, I now only use it when other transportation is hard -- either taking too much time, or requiring too much walking."*

According to interviewees, the biggest motivation for them is the affordable price and comfortable service. Due to the difficulty in finding a match, some people only use it opportunistically, while some people use it if they plan to do long distance trips, where a car is necessary. Most riders like checking the app the day before departure, so they have buffer time to consider other options if they can't find their ride match. One interesting finding is that most rider interviewees are not using dynamic car-pooling in real time, or last-minute before

departure. The reason behind this is that dynamic car-pooling comes with a large uncertainty of being able to find a driver in real-time due to the limited user pool. Passengers also need to consider budgeting extra travel time in case a driver is late, or the driver needs to pick up others, so they won't be late for work. To solve this problem, many car-pooling companies provide users the option to save their schedule, and to notify them when there is a ride-match.

Although dynamic car-pooling apps enable flexible schedules on a user-friendly platform, they still have a long way to earning the full trust of their users. Common feedback related to the barriers of car-pooling have been identified and summarized below:

#### 4.3.1 *Hard to find matches*

The first problem identified is that users sometimes are unable to use the app to find travel partners. This directly impacts their ability to use the app, and their motivation to keep using it. When there are other transportation alternatives readily available, it is possible for users to switch to another mode of travel other than dynamic car-pooling, and get used to that method.

*"In the majority of cases, I send a request through the app, and get the result saying there is no match.... It's very discouraging sometimes, because if I use Uber-Pool, or Lyft-Ride, or other car-pool apps, I am usually able to find a ride-match"*

*"I would say it's very difficult to find a driver, especially if you are going a long distance. For short distances, the driver might unwilling to take you because it's not very profitable. For me, car-pooling short distances is very unnecessary, and it's usually more convenient to take the bus. "*

*"I have been trying this app for the last month, and I've only been matched 3 times. Most of the time, I didn't get matched. I think we need more riders and drivers."*

*"It is sometimes uncertain whether or not you can find ride partners, but I eventually found a driver who has the same route and schedule as me. Instead of using the app, the driver offered me a personal agreement for a lower rate."*

As one interviewee developed a personal arrangement with a driver, it might also be the case that riders and drivers organize their own arrangement, to deal with the uncertainty of finding a driver, and to avoid paying for the car-pooling company. Since dynamic car-pooling companies have few critical services beyond matching drivers with riders, it is possible for drivers and passengers to build their own contracts after being matched. With a similar schedule and route, they can skip the involvement of the dynamic car-pooling company, and make the trip on their own. This phenomenon might explain a previous point in the literature: that travelers like to have some routine in their travel behavior. driver/passengers, the car type, pick-up and drop-off location, etc.

#### 4.3.2 *Time Uncertainty*

When asked about impressions of their car-pool drivers, other passengers, and their dynamic car-pooling experience, all interviewees reported some satisfaction with their dynamic car-pooling experience. Yet, two of them talked about the problem of time uncertainty that would affect their user experience and rating for drivers.

*"Once I took the car-pool from downtown to my place, the driver picks up other two riders after taking me, which spend more time than expected. The GPS got messed in downtown, and driver had to call riders, and hanging around in a congested roadway to find them"*

*"I use it only when I have time to use it. If I'm in a hurry, I'd rather take Uber, Lyft, etc."*

*"It's hard to expect driver's commitment to the service. They are often delayed or off the route. Sometimes when the short 2 min waiting grace period pass, and they didn't see you there, they even can leave it and cancel the ride. Which present a very challenging situation for you, since you need to quickly seek for other transportation options at that time in order to get to your location"*

Time uncertainty might also be a factor to consider. If GPS functions are inefficient in some areas; other passengers take more time than expected, or drivers and riders waste more time to identify each other, the dynamic car-pooling trip will get delayed. Nowadays, since people are time-constrained and have a busy schedule, they like their travel time to be manageable.

However, in dynamic car-pooling, if a rider chooses a driver, they don't know whether the driver will get delayed, how long it will take for both of them to identify each other and start a ride, how much riders the driver is going to take, and how long it will take for driver to identify, pick-up, and drop other riders. As a result of these factors, riders experience a lack of certainty for their time.

Furthermore, since it is a peer to peer car-pool, and there are few professional mechanisms (eg: hired driver, secured service), people feel more insecure about their service and time. The

driver's responsibility is unenforced, and the user is not exclusive – meanwhile, adding more passengers means more uncertainty with time.

#### 4.3.3 *Data Security*

When asking about user concerns about personal data and privacy, some of their primary concerns focused on payment security and the exposure of personal information.

*"I don't want to input my credit card information on the website or app that many people haven't heard of it or use it. "*

*" I think it's more reliable than the previous car-pool, because I will no longer need to post my picture, and some of my information on the website for the matching purpose"*

*" I'm worried about my private data might be saved by car-pooling companies or individuals. As I type my social network data, my phone number and email, my home location and work location into the system, I start to realize that people could use this information to make a profit. "*

*" it might seem more reliable if my friends or some people I know is using it, or if there is number of views written by other users at app store"*

In general, people feel that they have more private space when using the app as compared to traditional car-pooling (post, website, etc): When using traditional matching tools (posts, website, etc.), riders have to post their profile picture, location and contact information to the public. For the mobile app, the matching process is automatic, instant and private (people won't

see the data and your selection). They are able to have a sense of security and privacy because only the system, their ride matches, and themselves know personal information.

However, the data still exists and is stored. The automatic matching process needs users to connect their phone numbers, emails, and even social networks. These data require a reliable company to store them and not to sell them for commercial use.

Furthermore, companies might benefit from secure payment methods and refund policy. For example, the car-pooling company would be able to issue an immediate electronic receipt for users to check the amount of money they spend right after the purchase. Companies might also benefit from allowing users to have at least two-factor authentication: such as a password for the app and fingerprint authentication (such as amazon app on the IOS system). Finally, dynamic car-pooling companies need to have quick-response customer service and reasonable refund policies that are easily accessible on their app.

#### 4.3.4 *User Interface Problem*

*"The app sometimes is hard to navigate. When I first time using it, I spent half an hour to find how to add two or more route. Since the first route I typed did not successfully find a match, and I'm not having only one trip per day, I want to keep more routes in my dashboard to increase my probability to get matched. However, I didn't find it, and I don't have that patience to play with it, so I switching to another app "*

*"When first time I got the boarding pass (a confirming receipt for users to have the ride), I don't know how to use it and there is no description about how to use it, and I don't know where is the pickup location if I don't call driver"*

*" There is no straightforward and clear way to contact customer service."*

*"Every time I use this app, I learn something. It's a little bit hard and complicated for me. The instruction for using the app is very heavily in text and hard to read"*

While using different apps could generate different user interface problems, some common user problems are identified in dynamic car-pooling apps: confusing customer service, unclear instruction for app usage, the lack of a display for pick-up locations on a map (the map on the app only showing driver and rider's position), etc.

#### 4.4 DRIVERS PERSPECTIVE IN DYNAMIC CAR-POOLING

Past studies on car-pooling often neglect driver perspectives, the reason behind this might be that drivers in some types of car-pooling are hired by the company, and are not part of the user base for the system. In the dynamic car-pooling system, drivers play an important and unique user role – they are providing the actual service while they are also users. The quality of their service might determine the success of dynamic car-pooling trip.

##### 4.4.1 *Mismatched Expectation and Multitask Problem*

*"Sometimes passengers expect you as professional as Uber driver or Lyft driver, but I'm not. I'm a normal people driving to the workplace and I don't come to that place because of you. Some passengers expect me to do the service for them, for example, they want me to come to the nearest place and*

*waiting for them. instead of treating me as a friend to share the ride, showing respects to my time, this sometimes make me feel very discouraging "*

*"Driving around and picking up multiple passengers sometimes is a challenge for me. When using the app, it only shows how many passengers, and where are them. Some places are not able to park and wait for them for too long, then I need to talk to them about pick up location. After that, I need to find them one by one. I hope the app could help initiate a group conversation, so I don't need to talk to multiple people individually. Since passengers sometimes are very close, I also wish I could let them all come to one pick up place, then I can pick up them all at one time, not stop by stop."*

According to the driver, there is a mismatch of expectations between drivers and passengers. Passengers might expect to enjoy a personal service where drivers would be willing to spend time to pick them up, while on the other hand, drivers are not hired to drive. They accept passengers mainly because they want to share ride and traveling expenses, in the condition of not wasting too much time and energy for the work.

In addition, drivers do not want to talk to people one by one when there are multiple riders. So, it would be helpful to drivers if dynamic car-pooling companies could help to address time-based concerns and to enable them to focus on driving.

#### 4.4.2 *Technological Problems*

*"I'm not able to ride with same people for multiple days. I hope the app could enable this function -- having the favorite list and block list for passengers. So*

*we have a better chance to ride with familiar people and block the rider if we have unpleasant experience "*

*"The payment method is also confusing. I can only see how much is charged for passengers in my ride, but I'm unable to see how much I could actually receive in total."*

According to the interviewee, dynamic car-pooling apps should provide more technical support and special app features for drivers, like a favorites list to enable them to ride with familiar people. Also, apps should have a clear payment statement, and the ability to enable drivers to schedule rides with the same people in multiple days.

Having passenger-centric culture is common to many car sharing companies. Dynamic car-pooling companies need to be user-centric, helping not only riders, but also providing technical service and customer support to drivers.

#### 4.4.3 *Safety & Privacy*

*"Drivers are more likely to get into danger than passengers... Being a driver, you need to provide some identification to the car-pooling company, but passengers need nothing. They can simply click and get permission to other people's car... Which sounds very dangerous sometimes... we have 2 terms, day driver and night driver, I only work at days... Because when I drove at night, there is a great chance to pick up drunk people... We, as a driver, also the car's owner, I value my car as my own space, my private goods. I don't want to get random people into my car, and I worried about the misbehavior of passengers in my car. "*

*"Also, sometimes it's very annoying when someone talks to you and ask you some questions when you're focusing on driving a car. "*

Every car owner values his/her car as his/her private space, it is often as sensitive to invite others into one's car as it is to invite others into one's home. Offering an empty seat to someone does not mean the driver is not worried about their private space being infringed upon. While in the car-pooling system, drivers need to certify themselves and be granted permission to drive, whereas passengers have no pre-requisites to get into cars if they are willing to pay for it. This presents a potential danger to the driver, and a challenge for dynamic car-pooling: how to qualify one's credential while not affect people to quickly get started, in which situation can driver refuse to give a ride?

## Chapter 5. CONCLUSION

### 5.1 DISCUSSION

Although this study reached its goals, there were some unavoidable limitations.

First: the limited size of the interviewee pool. Although the study chose experienced and dynamic car-pooling perspectives to serve informational purposes, resource and time constraints limited the total number of interviewees to only seven. A small sample cannot reliably represent the overall population. However, as stated in a previous section, they all had over half a year experience participating in dynamic car-pooling, and represented diverse perspectives. If a problem/concern has been put forward by these experienced participants, it means the problem most likely inhibits successful participation and contribution to the dynamic system, and thus constitutes a barrier for the overall success and sustainability of the dynamic car-pooling system.

Second: admittedly, different people have different feelings and experiences with different dynamic car-pooling apps. Not everyone encountered the same problems discussed in this thesis. Many more factors impede the development of dynamic car-pooling than have been addressed in this thesis.

### 5.2 CONCLUSION

#### 5.2.1 *Literature Review Gaps*

Most previous literature I reviewed is focused on barriers for general car-pooling, while little attention is focused specifically towards dynamic car-pooling. Although dynamic car-pooling can solve many traditional car-pooling problems, it has not made car sharing more popular, and it might raise new problems that traditional car-pooling does not have (“critical mass” problem,

time uncertainty, personal arrangement outside of company, etc.). Also, since dynamic Car-pooling (also called Real-time Car-pooling) is a new booming field, current research on the topic is insufficient, especially if limited to qualitative study.

Previous studies found “critical mass”, revenue, user-interface, multi-task, and safety/privacy to be problems and barriers to successful car-pooling systems. However, it is also critical to assess barriers and challenges from perspectives other than users, including those from the companies and drivers. On the topics of multi-task and safety/privacy, previous literature mainly focused on studying these problems within general car-pooling. They did not specifically explore how these problems apply to dynamic car-pooling situations. Finally, for user-interface problems, previous studies were not specific on which functions of the apps should be improved.

### 5.2.2 *Main Barriers*

This study conducted interviews with three groups of people: Dynamic car-pooling company representatives, passengers and drivers. The findings for main barriers are described in the table below:

	Perspective	Category	Problem	Possible Cause
Barriers for Successful and Sustainable Dynamic Car Pooling	Company	Economic Challenges	"Critical Mass" Problem	The nature of Dynamic Car Pooling assume driver and passenger are balanced and trips are self supplied Hard to find balance between rider and Targeted on Large Employers
		Institutional Challenges	Revenue Problem	Tech centered while low benefit
	Passengers	Economic Challenges	Hard to Find Match (Driver)	Motivation for Continually Using
		Social/Behavioral Challenges	People have personal arrangement with familiar driver	Travel consistency's expectation and "stranger danger"
			Time Uncertainty	Driver's not commitment to time, time to pick up other riders, etc. may cause
		Technological Challenges	Reliability and Data Privacy	Specifically in payment security and refunding policy
			User Interface Problem	No straight forward customer service, unclear instruction of how to use the app, no features of pick up location showing on the map (the map on the app only showing driver and rider's
		Driver	Social/Behavioral Challenges	Mismatched Expectation
	Multi-task Problem			Pick up multiple person and talk to them could be challenging
	Safety/Privacy Issue			People are pairing with strangers without knowing each other personality and behavior.
Technological Challenges	Technological Problem		Payment , Lack feature for ride with same people in multiple days,	

Table 2: Barriers for Successful and Sustainable Dynamic Car-pooling

Table 2 summarizes main problems gathered from interviews to explore how different entities perceive challenges in dynamic car-pooling systems. "Possible cause" indicates possible reasons that constitute the roots of each problem. Specific explanations are provided below:

(1) *"Critical Mass" Problem*

Previous literature concluded that there is a lack of audience for car-pooling, especially dynamic car-pooling. (Heinrich, 2010) However, they do not give sufficient reasons for why too few people are participating in it. The interview targeted this problem.

Dynamic car-pooling assumes that the numbers of drivers and riders are balanced, and that trips are self-supplied among these two groups (Eg: There will always be enough drivers to satisfy rider's demand). However, these are perfect conditions. In a real-world context, this is not true in most circumstances. There will always be either not enough drivers to satisfy rider demand, or not enough riders to satisfy driver demand. If a driver loses interest in participating, it will affect multiple passengers' probability of getting a ride. Passengers will also lose interest after several failures to match with a ride. So on and so forth, it can form a vicious circle. To solve this problem, company perspectives think targeting large employers is one potential solution. First, since employees or staff who share a workplace will have at least one OD (Origin-Destination) point which is the same, and their places to live are likely to be geographically close to each other. Instead of randomly targeting people, targeting a group of people who have similar geographic interests will be more likely to produce ride matches. Second, employees are more likely to trust their company's recommended transportation system. In this case, the large employer company can help those dynamic car-pooling companies build their reliability and reputation among their employees.

### *(2) Revenue Problem*

There are many dynamic car-pooling companies in the startup stage, reliant upon seed money and earnings from their users. The earnings coming from passengers is usually split between the driver and the company. Thus, the company receives a very small amount per ride. This problem will be relieved after the car-pooling company gets more popular in their service area, having a large pool of users like the companies Uber and Lyft.

### *(3) People Have Personal Traveling Arrangements With Driver*

Since dynamic car-pooling service is basically a matching service, drivers and riders can organize their own trips after the initial match if they find they have a common trip schedule. It is hard to maintain the need for a long-term matching service once a driver and a rider are already connected to each other, and can generate trips by themselves.

After a rider and a driver get matched, they may find their schedules are consistent and compatible with each other. In this case, they could make their own arrangement outside of a dynamic car-pooling company to save money and time. The rationale behind this is that when people have a choice, they prefer a familiar ride (with familiar ride partner, car type, etc) instead of different vehicles and people every time. This problem also differentiates dynamic car-pooling companies from Uber and Lyft.

### *(4) Time Uncertainty*

Users are unsure about how long they will take to travel. There are many factors that could contribute to travel delay. Since drivers are not directly hired by companies, they do not have strict time requirements or punishments if they do not arrive on time. Furthermore, the time needed to pick up and drop off other passengers is unclear. Thus, users often feel a little insecure travelling through dynamic car-pooling. Dynamic car-pooling companies might need to pay more attention to strengthening driver time commitments, while not negatively affecting driver participation rates in car-pooling. Dynamic car-pooling companies also need to give a more clear and accurate time estimate before every ride.

### *(5) Reliability and Data Privacy*

When using a dynamic car-pooling app, participants are often concerned about their mobile payment, how they will be charged, data security, and refund policies in case the ride is canceled.

### *(6) User-interface and Technological Problem*

Because many people may not be familiar with the process of dynamic car-pooling, apps need to provide an easy-to-understand interface and a clear introduction for new users. Specific issues include: lack of straightforward customer support functionality, difficulty in adding two or more routes into a schedule, confusing payment method, and the inability to schedule consecutive rides with the same people.

### *(7) Mismatched Expectation*

Riders might have professional expectations for drivers, while drivers have their own schedule for work and other commitments in addition driving. This might cause discomfort for drivers if riders treat them like taxi drivers. This might include asking drivers to wait for too long, or asking drivers to detour too much from their original route. Furthermore, when drivers need to pick up multiple riders during the trip, they sometimes need to negotiate with and pick up passengers one by one. This presents a multi-tasking problem for drivers. Any passenger delays will add further tasks for the driver and expand the total time for travel for every other rider in the vehicle. To address this problem, the app could include some group chat functions, or functions that may help drivers to conduct multi-pick-ups.

### *(8) Safety and Privacy Issue*

Previous studies often focused on passenger perspectives about safety and privacy issues.

However, drivers care for their safety and privacy as much as their passengers. In dynamic car-pooling, since people are pairing with strangers, they often have no impressions of personality and behavior before the ride. This might present a great challenge for users every time they meet with a new person in a new ride. This challenge applies particularly to drivers, since every time they need to let a stranger get into their private space, they might feel unease or consider whether the ride is worth it. This problem also happens in Uber and Lyft. There are no effective solutions yet.

#### 5.2.3 *Summary*

Through a series of interviews, this study found that there are some critical challenges that could impede the development of successful dynamic car-pooling systems. These problems might be more critical for start-up companies in this field. The future for dynamic car-pooling is very challenging and demands not only technical solutions, but also travel-focused user studies to solve problems.

For dynamic car-pooling companies, it would be easier to reach critical mass by starting trials with partnered corporations or academic institutions (e.g. universities). Companies should also provide more prompt, easy-to-access customer support in addition to other services that make the companies themselves worth using in the long term. The car-pooling app needs to provide an easy-to-understand interface and helpful introduction for people who are new to this field.

For government and public institutions, incentive programs and car-pool-friendly policies are needed. For example, government could provide more car-pool parking spots throughout the

city. Since people, including driver, will find a designated car-pooling parking spot, they will use car-pooling app more often in the congested and populated area. Government could also invests some valuable dynamic car-pool programs, especially start-ups.

For future studies, if resources and time permit, it would be better to include more experienced and diverse car-pooling participants in the interview process, especially to demonstrate problems from the often-neglected driver's perspective. In addition, future research could incorporate the perspective of government transportation agencies, and discuss how could public-private partnerships play a role in dynamic car-pooling system.

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## **APPENDIX A: INTERVIEW GUIDE**

\*The interviews are planned to take around 45 minutes.

\*Ask for permission to tape record the interview. If not permitted, take notes.

\*Anonymity of the interviewee will be protected.

\*Explain briefly the topic and focus of the study.

### *Interviewee Demographic in Brief:*

*Group 1:* Dynamic Car-pooling Companies Representative(2): including 1 co-founder of the app company, 1 program manager of the dynamic car-pooling company. Age: 30-50. Male.

*Group 2:* Dynamic Car-pooling Users (4): including 2 students, and 2 employees. Age: 20-30. 3 Female and 1 Male.

*Group 3:* Dynamic Car-pooling Drivers (1): Age: 20-30. Male.

### *Interview Objectives:*

1. According to the identified general car sharing problems in the literature review, ask interviewees about which general car-pooling problems have been solved by dynamic car-pooling, and which have not.
2. Investigate problems and barriers for car-pooling companies to running their services (reaching critical mass, making profit, etc.)
3. Investigate user experience problems in dynamic car-pooling system. Understanding why users don't want to keep using dynamic car-pooling app, or why they want to keep using

it. What are some features of dynamic car-pooling system that made them feel uncomfortable and made them stop using.

*Interview questions for car-pooling companies:*

*Getting started:*

1. What motivated you to start this dynamic car-pooling app?
2. How is this app different from other types of car sharing, like traditional or web-based car sharing?
3. How does this app encourage more people to engage in car-pooling?

*Top Issues:*

4. From your perspective as a founder of dynamic car-pooling app, what did you find to be the main barriers and difficulties for real time car-pooling?
5. How could that be improved?

*Specific Issues:*

6. How does this app deal with the “critical mass” problem (user-base can’t reach the critical volume to achieve success)?
7. What could dynamic car sharing companies do to
  - a) protect users data? b) increase the reliability of service?
8. Did you build any partnership with other agencies? Do you think it's successful and enough?
9. What do private companies expect from government agencies in terms of helping promote car-pooling programs?
10. What are the technological difficulties to providing the service?

11. What are the financial difficulties to providing the service?

*Interview questions for car-pooling users (Passenger, Driver):*

*Getting Started*

1. How often do you use real-time car-pooling service? Are you currently still using that? Why?
2. Typically, under which circumstances will you consider real-time car-pooling instead of other travel modes?
3. When did you start using dynamic car-pooling (using mobile device to match drivers/riders on demand)? What made you to start using it?
4. Have you tried using other ways of car-pooling outside of this app? How does that compare with this dynamic car-pooling app?

*Main Problems:*

5. Were you satisfied with your dynamic car-pooling experience? What are the main problems or difficulties you encounter while using the car-pooling app?
6. Do you see yourself continuing to use the dynamic car-pooling app in the future? Why?
7. What will encourage you to continue using a certain car-pooling app?

*Specific Issues:*

8. Do you feel you are unable to find car-pooling partners sometimes when using the app?
9. How did you feel about your car-pooling drivers (passengers)?
10. Did you feel comfortable car-pooling with other strangers?
11. When you are using the app, are you worried about your personal information been exposed?  
What features of app will help you build your trust for the company?
12. Do you have any technical difficulties to using the app? For example?

## APPENDIX B: INTERVIEW TABLE

<i>Thesis Goal</i>	<i>Specific Goal</i>	<i>Interview Questions</i>	<i>Interviewee Perspective</i>	<i>Examples from the interviews for statements fitting into the category</i>
<p>Investigate the nature of barriers that impede the success of dynamic car-pooling.</p> <p>Examine and identify gaps that previous scholars didn't cover.</p>	Identify previous general car sharing problems solved by dynamic car-pooling	What motivated you to start this dynamic car sharing app?	Dynamic Car-pooling Company	"We conducted some market surveys in Redmond. The result showed that people regard flexibility as one of the top considerations while car-pooling... so we decided to implement the dynamic car-pooling app to solve this problem"
		How is this app different from other types of car sharing, like traditional or web-based car sharing?	Dynamic Car-pooling Company	"...Real-time car sharing solves this by enabling people to make decisions at right before their departure. This increase in trip flexibility significantly decreased the trip cancellation rate..."
		Have you tried using other ways of car-pooling outside of this app? How does that compare with this dynamic car-pooling app?	Car-pooling Users, Car-pooling Drivers	"The biggest reason why I'm trying this is the price. Sometimes the price is as cheap as public transportation, but the service is much more comfortable... I use it if I find a match, and always check the app before I take a long distance trip."
	Identify General Challenges	What did you find to be the main barriers and difficulties for developing a mobile app for real time car-pooling?	Dynamic Car-pooling Company	"We currently lack in drivers. People are more likely to take the car-pool ride than driving the car. We have a list of people requesting for the ride, but we only have few drivers willing to accept the demand. The incentive for reimbursement is not enough to encourage drivers to share his/her own car and participate in the service"
		What are the main problems or difficulties you feel while using the car-pooling app?	Car-pooling Users, Drivers	"In the majority of cases, I send a request through the app, and get the result saying there is no match.... It's very discouraging sometimes, because if I use Uber-Pool, or Lyft-Ride, or other car-pool apps, I am usually able to find a ride-match"
		Do you see yourself continuing to use the dynamic car-pooling app in the future? Why?	Car-pooling Users, Drivers	"It is sometimes uncertain whether or not you can find ride partners, but I eventually found a driver who has the same route and schedule as me. Instead of using the app, the driver offered me a personal

			agreement for a lower rate.”
Economic Challenges: imperfect information	Do you feel difficult to find car sharing partners? Do you feel you are unable to find car sharing partner using the app?	Car-pooling Users, Car-pooling Drivers	"I would say it's very difficult to find a driver, especially if you are going a long distance. For short distances, the driver might unwilling to take you because it's not very profitable. For me, car-pooling short distances is very unnecessary, and it's usually more convenient to take the bus. "
Economic Challenges: "Critical Mass" problem	How does this app deal with the “critical mass” problem (user-base can’t reach the critical amount to achieve success)?	Dynamic Car-pooling Company	"We've done some marketing before doing the dynamic car-pooling trial, but none of that is very effective. Then, we tried reaching out to large employers, or specific areas. In these cases, people have either same destination or departing location, so it's much easier to accumulate users. Also, people tend to trust the companies' recommended services rather than seek similar services by themselves."
	How does this app encourage more people to engage in car-pooling?	Dynamic Car-pooling Company	"We found that the best scenario for a dynamic car-pooling company is to have a healthy amount of users and drivers at the beginning. These users could be existing customers switching from their web service to the mobile app, or their other service to car-pooling service... "
Social/Behavioral Challenges: "Stranger Danger" , Power mismatch and mutual dependency	How did you feel about your car-pool drivers? How about other passengers?	Car-pooling Drivers, Car-pooling Users	"It's hard to expect driver's commitment to the service. They are often delayed or off the route. Sometimes when the short 2 min waiting grace period pass, and they didn't see you there, they even can leave it and cancel the ride. Which present a very challenging situation for you, since you need to quickly seek for other transportation options at that time in order to get to your location"
	Were you satisfied with your dynamic car-pooling experience? Did you feel comfortable car-pooling with other strangers?	Car-pooling Users, Drivers	"Also, sometimes it's very annoying when someone talks to you and ask you some questions when you're focusing on driving a car. "

	Social/Behavioral Challenges: Reliability / Privacy	When you are using the app, are you worried about your personal information been exposed? what features of app will help you build your trust for the company?	Car-pooling Users, Drivers	" I'm worried about my private data might be saved by car-pooling companies or individuals. As I type my social network data, my phone number and email, my home location and work location into the system, I start to realize that people could use this information to make a profit. "
		What could dynamic car sharing companies do to protect users data and increase the reliability of service?	Dynamic Car-pooling Company, Users	" it might seem more reliable if my friends or some people I know is using it, or if there is number of views written by other users at app store"
	Institutional Challenges	Did you build any partnership with other agencies? Do you think it's successful and enough? What are the resources that you currently need the most?	Dynamic Car-pooling Company	" people tend to trust the companies' recommended services rather than seek similar services by themselves."
	Technological Challenges	What are technology difficulties to providing service?	Dynamic Car-pooling Company	"We currently have two development teams working on the matching process. One is working on time matching, and another is working on location matching.... Hiring engineers and doing mass marketing need a lot of money, while making one successful trip is not very easy and rewarding..."
		Do you feel about any technical difficulties to using the app? For example?	Car-pooling Users, Drivers	"When first time I got the boarding pass (a confirming receipt for users to have the ride), I don't know how to use it and there is no description about how to use it, and I don't know where is the pickup location if I don't call driver"
	Possible ways to overcome these barriers	Exploring Recommendations	How could that be improved?	Dynamic Car-pooling Companies, Car-pooling Users, Drivers

		What will constitute as a motive for you to continue using a certain car-pooling app?	Car-pooling Users, Drivers	"The biggest reason why I'm trying this is the price. Sometimes the price is as cheap as public transportation... "
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