

Analysis on Commercial Carpooling Applications' Further Development in China

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Abstract. As the internet develops, ride-hailing applications have become an integral part of people's life. Carpooling is one of plenty forms of service that the ride-hailing platform usually provides. As a service in which users share the cost evenly, choosing a ride-sharing service inherently provides users with an economic advantage compared with other forms of ride-sharing service. However, the market for ride-sharing services is not as broad as the overall online ride-hailing market, and the market for carpooling services has not yet reached saturation, indicating that the industry still has room to expand. The article uses the Game theory to justify the expanded possibility of carpooling exists, as well as choosing to carpool shows the best response for both passengers and local drivers among all types of service offered by ride-hailing platforms. Then, the article points out factors that influence users' diverse attitudes toward carpooling in China, based on the data collected from the questionnaire. Finally, the article combines the feedback results of the questionnaire survey and relevant case studies, such as the research on DIDI, to give the carpooling service market a strategy to amplify the advantages of carpooling to stabilize the existing customer base and make up for the disadvantages to increase the potential customer base.

Keywords: Commercial Carpooling; ride-hailing platform; Game theory; questionnaire.

1. Introduction

Online ride-hailing is now widely accepted by the public as the internet and smartphone are popularized. This industry is a dominant representative of the Internet of Things (IoT). Online ride-hailing service is a platform that connects passengers and driving service suppliers, usually through internet applications and websites. As passengers enter their destination, the online system will send the requirement and passenger's location to local drivers, as one of the drivers chooses to match, the order starts to get into effect. Nowadays, about 25% of the entire US population uses ride-sharing at least once a month [1]. In China, about 44% of internet users use online ride-hailing by the end of 2021[2]. As this service is internationally popularized, passengers can tailor their itinerary to their preferences and situations, for example, people can choose the type of vehicle they favored. In recent years, the function of "carpool" is derived.

Carpooling is a method when more than one passenger shares the same vehicle, and the total expense is divided equally among each. The idea of car-sharing (aka carpooling) is getting ground due to, at least in part, its simplicity, cost-effectiveness, and affordable choice of transportation [3]. This suggests that carpooling becomes a new trend in recent years due to its plenty of advantages. Choosing to carpool has to do with individualism, in which people are not deciding in an economically rational, being affected by personal variables [4]. Also, carpooling is a sharing behavior, in an era of growing environmental awareness due to global warming and the greenhouse effect, environmentalism is inextricably linked to sharing behavior like carpooling [5]. Carpooling service conforms to a variety of modern concepts. While serving customers who recognize the advantages of carpooling services, it also serves groups that recognize these modern concepts, and attracts groups that recognize these concepts to participate in the trial of carpooling services.

Carpooling also produces considerable economic benefits. Nowadays, Autonomous transportation provides opportunities for local drivers to become carpooling drivers. With the combination of a road pricing system and carpooling, carpooling is conducive to improving capital penetration and economic prosperity [6]. What is more, carpooling continued growth and expansion of many suburbs [7]. Thus, carpooling enriches the connection between urban areas and suburban areas, which

promotes the coordinated development of urban and rural areas, and increases the traffic density in suburban areas, thereby further contributing to regional economic growth.

2. Justifying expand possibility for carpooling industry with Game Theory

For both sides of system users, carpooling can be a game with two different players, demonstrating different payoffs and Nash Equilibrium (NE) with different characteristics of players. A Nash equilibrium is a set of strategies, one for each of the n players of a game, that has the property that each player's choice is his best response to the choices of the $n-1$ other player [4]. By classified discussion of the different situations of carpooling with game theory, we can tell the comparatively best condition, thus figuring out the most appropriate solution by deducing the following assumptions. Assuming the precondition that both driver and traveler are rational.

In each game, the underlined payoff is the best payoff that one player makes as a response to the action of another player.

2.1 Free-rider behaviour

In the game that Table 1 shows, NE (0,0). Since with no payment, the driver will not lose if the driver does not accept the passenger. Additionally, if the passenger does not decide to hitch, there's no effect on both side since the behavior does not exist. This suggests that without a reward mechanism, the NE would be the traveler not to hitch and the driver not to accept, which means no interaction between the driver and the passenger. In this game, the prevailing player is the driver.

Table 1. Game matrix

		Traveler	
		Hitch	No to hitch
Driver	Accept (if hitch)	<u>2</u> , <u>1</u>	<u>0</u> , <u>0</u>
	No to accept (if hitch)	<u>8</u> , -5	<u>0</u> , <u>0</u>

2.2 Carpooling with fair-payment, both passenger and driver are cooperative

In the game Table 2 shows, NE (8,8) (0,0). Since both players are cooperative, the Nash equilibrium exists while the passenger hitch and the driver accept, or the non-interaction situation. For the driver, the acceptance could be profitable, as for the passenger, the carpooling meets the passenger's need, thus, (8,8) is the best response since it is beneficial to two players, which the passenger hitch and the driver accept. Same as the previous condition, when there is no interaction between the driver and the traveler, no loss and no gain is also the best response for each.

Table 2. Game matrix

		Traveler	
		Hitch	No to hitch
Driver	Accept (if hitch)	<u>8</u> , <u>8</u>	<u>0</u> , <u>0</u>
	No to accept (if hitch)	4, -8	<u>0</u> , <u>0</u>

2.3 Carpooling with fair-payment, driver cooperative, passenger under special occasion

In the game that Table 3 shows, NE (8,2). The traveler is under urgent condition, and choosing to hitch is better than not, if choosing not to hitch, the loss will happen. The passenger's dominant strategy is to hitch. Since the acceptance of driver is profitable, so the driver has the motivation to accept.

Table 3. Game matrix

		Traveler	
		Hitch	No to hitch
Driver	Accept (if hitch)	<u>8,2</u>	<u>0,-10</u>
	No to accept (if hitch)	<u>4,-8</u>	<u>0,-10</u>

2.4 Carpooling with fair-payment, which the driver cooperative, passenger not cooperative

In the game that Table 4 shows, NE (0,1). Since the passenger is not cooperative, the interaction does not exist between the driver and the passenger. The only condition makes different payoff exists is that the choice not to hitch meets the passenger’s need.

Table 4. Game matrix

		Traveler	
		Hitch	No to hitch
Driver	Accept (if hitch)	<u>0,0</u>	<u>0,1</u>
	No to accept (if hitch)	<u>0,0</u>	<u>0,1</u>

2.5 Driver cooperative, passenger deciding between carpooling or taxi

In the game Table 5 shows, both driver and passenger are rational, NE (8,8). The passenger and the driver are both cooperative, the difference is that the passenger need to decide whether to share the ride or not. Assuming another passenger is cooperative, the best choice is to carpool, since the travelling cost is less than travelling alone in the taxi in a same journey. As for the driver, the acceptance is profitable since the reward mechanism exists. The driver’s dominant strategy is to accept the hitch from passenger.

Table 5. Game matrix

		Traveler	
		Hitch	No to hitch
Driver	Accept (if hitch)	<u>8,8</u>	<u>8,6</u>
	No to accept (if hitch)	<u>-2,0</u>	<u>-2,0</u>

3. Analysis on personal variables based on questionnaire

From the five different possible conditions, we can tell, unless the driver or the passenger is non-cooperative to take a online car-hailing, choosing carpooling is a strategy that leading to the best response. Combining with the assumption that both driver and the passenger are rational, choosing carpooling is more economically efficient in possible situations than choosing other types of online car-hailing service. Moreover, it is not only gradually promoting a convenient lifestyle through Increasing availability of location-based mobile services, but also a sustainable commuting chosen by new generation which representing the ecological-friendly concept [7-9].

However, people show different attitudes towards carpooling because of factors like different gender, age group, region and culture, economic situation and so on. In addition, “attitude towards carpooling, enjoyment of being sociable, trust in other people, environmentalist identity and the role of the family circle and peer group,” are more influential than classical variable previous mentioned [4]. People recognize carpool from negative perspectives in these factors will not choose carpooling while using online ride-hailing.

Based on the result of the questionnaire, which aims to collect different opinions toward carpool, with 189 total samples and 175 valid samples since the analysis in this article excludes zero-experience user of car-hailing platform, the people deny to use carpool occupies 30%, 70% of data accept carpooling which include 14.3% would accept carpooling only if they are in special occasion.

With the precondition that the questionnaire's data base covers all possible users in China, shows the customer's willingness for carpool only occupied about 55% of the platform users, representing the potential market for carpooling reached 55%, and the real proportion for carpool market in the whole ride-hailing market is less than 55%, even less than a half. Standing on the business perspective, since more than half of the users have certain limitations on the cognition of carpooling service, the carpooling service still has the possible space to expand the commercial market by stabilizing exist customers and attracting potential customers. For example, more people can experience carpooling service through media publicity, so as to gradually become users of carpooling service. Meanwhile, the negative image of carpooling service in the cognition of the public can be made up by formulating and improving the platform's functions and regulations.

According to results of the questionnaire survey, people are unwilling to carpool because of the fear for personal safety (75%), difficulty to adapt (58%), and low-cost performance (25%), illustrated in Fig.1.

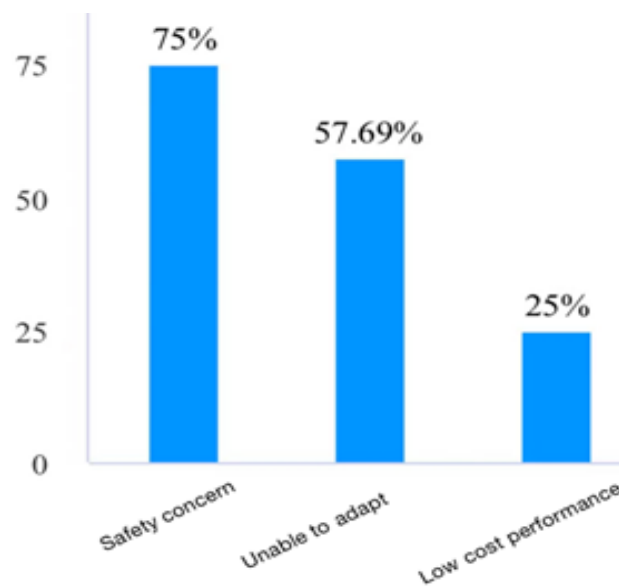


Figure 1. Survey of reluctance to choose ride-sharing services

These suggests biggest deterrent is security concerns to personal safety, the fear to the unknown stranger traveling with, and the fear to the unknown driver. 14.3% people are not willing to use carpooling unless special occasion happens, in other words, putting carpooling on secondary priority while choosing ride-hailing service. Reasons like urgent issues requiring the passenger to get to the destination as soon as possible, hard to get taxi or other form of ride-hailing service, greater economic advantage to choose carpooling in a long journey, are drew from the questionnaire. People are willing to take carpool because its low cost (63.2%), convenience (55.1%), and less time consuming (44.9%), illustrated in Fig.2.

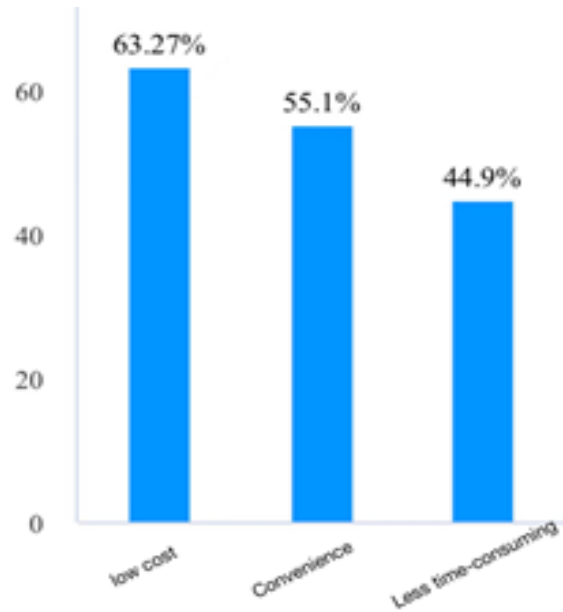


Figure 2. Survey of willingness to choose ride-sharing services

The ride-hailing system not only includes passengers, but also local drivers. Based on the questionnaire, 49% of ride-hailing platform users are willing to be the local driver and provide the carpooling service. Half of the platform users believe that they can benefit from commercial carpooling service for several reasons illustrated in Fig.3, which 38.4% of them believe being a local carpooling driver will lower the traveling cost, 20.9% of them believe they can earn money from the service, 17.4% of them consider this as a way to participate in a part-time job, 12.8% of them believe they can get to know more people and increase social participation, 9.3% of them believe this can solve traffic issue, and 1.1% of them believe this is environmental friendly.

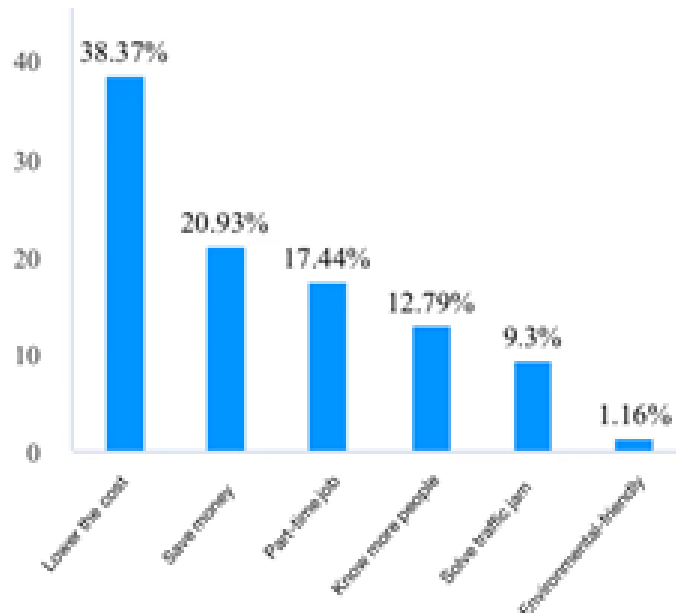


Figure 3. Survey on the benefits of offering ride-sharing services

On the other hand, not everyone wants to be carpooling driver. Firstly, they might not have a private car which is an essential condition to be a local driver. Secondly, they do not need to make extra money in this way. Also, they might have a strong sense of privacy and want to keep a distance with unfamiliar strangers. Motivations to carpool are both individualistic, and collectivistic [4].

4. Strategy Analysis

Since more than half of the users have certain limitations on the cognition of carpooling service, as previous analysis towards the result of the questionnaire mentioned, the carpooling service still has the possibility to expand the commercial market. For example, more people can experience carpooling service through media publicity, so as to gradually become users of carpooling service. Meanwhile, the negative impact of carpooling service in the eyes of the public can be made up by formulating and improving rules.

To maximize the positive aspect, optimizing the functionality of the platform is of great importance. A case study to DIDI, China's largest one-stop travel platform which covers and makes great success in carpooling, indicated that business in IT platform industry are different from traditional industry. Ride-hailing industry is in a dynamic environment, which require strong ability to cope with the dynamic changes. More importantly, an industry looking for breakthrough should focus more on the relationship between business model innovation and dynamic capabilities [10]. To attract more potential consumers, carpooling industry can apply more creativity on the service's value instead of its functionality. For example, the publicity and promotion of carpooling services can be upgraded from a conceptual perspective, 70% of carpoolers in the San Francisco area used to be public transportation users, and only a little more than 10% were former car users [11]. This group of data points out that most users of carpooling services now overlap with the user groups of public transportation, which reflects that the overlapping of personal values and concepts has attracted some public transportation users to become users of carpooling services. In pursuit of a broader market, the promotion of the industry should focus on the aspects like saving money, environmental protection, and public welfare.

Despite of the publicity, large businesses in this industry can send coupons to current customers to stabilize them and encourage them to raise the using frequency. In the growth stage of DIDI, travel coupons, as well as traffic coupons are widely issued [12]. For instance, if DIDI continues this form in the carpooling service sector, drawing on past successful cases, the passenger flow of large platforms will gradually increase. According to pig's payoff in game theory, which also known as free-rider game. In the pig's payoff, the game player with non-cooperative characteristic of the small pig has greater payoff in the pursuit of its own interests than the game player with cooperative characteristic of the big pig, and the Nash equilibrium in this game is the situation that the big pig work and the small pig wait to share the benefit [13]. In this case, if DIDI reach success, other companies in the same industry will also benefit from larger market scale, hence keep enlarging the scale.

The biggest reason why people are reluctant to choose carpooling services is the concern about personal safety. This is not without trace, since the development of carpooling services, safety issues caused by rides have repeatedly been reported in the news. For example, a homicide case will cause social media platforms to react negatively towards ride-sharing services, thereby increasing market risk for ride-sharing services. At this time, through appropriate algorithm detection and analysis, can help service platforms to estimate perceptions that consumers have of their products and to foresee potential market risks [14]. In addition, the rules and regulations of the platform need to be improved in a timely manner based on the results of the algorithm. The platform should also strengthen the screening of users, such as reminding users of the code of conduct before they start the service experience, or monitoring users' violations, warning bad users before using the service, or even prohibiting the use of the service, so as to ensure the safety of more users' safety.

5. Conclusion

Driven by multiple factors such as technology, cultural concepts, society, and economy, online car-hailing has become a potential IoT service method. Among them, carpooling services are unique and still have a development trend of market expansion. This paper uses the game theory in the analysis of the possibility of carpooling service market expansion, and relies on the questionnaire

survey data to obtain the reason analysis and comparison of users' attitudes towards carpooling services. On the basic strategy of stabilizing existing customers and attracting potential customer groups, three constructive suggestions are put forward to fit the dynamic changing industry environment. They are respectively, first of all, the promotion of carpooling services will be closer to the concept level of the new era, in order to seek the expansion of customer groups. Secondly, for existing users of the platform, more coupons will be issued to stabilize existing customers and increase the frequency of platform usage. Finally, the introduction of innovative monitoring systems or algorithms, as well as platform usage rules and regulations, and the strengthening of platform user screening will make up for the shortcomings of carpooling service platforms.

There are still imperfections in this article, such as the detailed suggestions in the strategy are not comprehensive enough. There are still many research directions that can be studied, such as the modeling of monitoring platforms. Scholars are welcome to submit ideas and suggestions.

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