The Comparison of Travel Patterns between Taxi and Private Car at Beijing Capital International Airport Area

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Abstract: In last two years, the rapid development of Internet based ride-sharing has brought great changes to travel pattern of residents. However, few studies has been made to find out the unique travel patterns of Internet based ride-sharing. In this paper, License plate data at the Beijing Capital International Airport area are used to study the travel patterns of taxis and private cars. By comparing the trip records of taxis and private cars, two indicators, the distribution characteristics of vehicle volume and the balanced patterns of time, are selected to identify the ride-sharing cars from private cars. The results showed that there are more taxis than private cars arrival the airport in the evening and the arriving time of private cars is more concentrated. Finally, we used these indicators identify the ride-sharing vehicles from private cars. All these findings will be useful for further research and policy making.

Keywords: Internet Based Ride-Sharing; Travel Pattern; Beijing Capital International Airport

1 INTRODUCTION

Along with the exponentially booming of mobile payment market in China, Internet based ride-sharing, was implemented to reshape resident' travel pattern the last two years. For example, Didi, a network transportation company, provides the ride-hailing service APP, which connect 10 million ride-sharing vehicles with 250 million registered users. On one hand, Internet based ride-sharing service has improved the efficiency of both travelers and drivers; on the other hand, several problems could be caused with the rapid growth of the number of Internet based ride-sharing vehicles. First, the platform provides the services to both taxi drivers and private car drivers. Thus more and more "taxis" are running on the road, which could increase the burden of the traffic, especially in the area of CBD, Airport and so on. Second, illegal operation of ride-sharing services has the potential safety hazard, which should be taken into the supervision of government regulation.

In order to evaluate the influence of ride-sharing, two problems should be solved first:

1) What is the difference of travel patterns between taxis and private cars?

2) How to identify Internet based ride-sharing vehicles from private cars based on the characteristics of travel pattern that shown in problem (1).

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License plate data is one of the most important data that be used to analyze traffic status or travel pattern in the last few years [4]-[6]. The GPS data of taxis (as probe vehicles), could be used to study the traffic flow dynamics over road networks [7] and analyze land usage[8]-[9]. Several studies had also researched the characteristics of individual driver, or the travel characteristics of taxis based on OD demand[10].

Different from all previous studies, this paper made two contributions which could be summarized as follows:

1) The differences of travel pattern between taxis and private cars at Beijing Capital International Airport area.

2) The method to identify ride-sharing vehicles from private cars based on characteristics of taxi travel pattern.

The rest of this paper is arranged as follows: Section 2 presents the license plate data used in this paper. Section 3 provides two selected travel behavior indicators: the distribution of vehicle volume (the number of taxis and private cars enter the airport in the evening) and the balanced patterns of time (the frequency distribution of taxis and private cars enter the airport in different time periods). Section 4 presents the method to identify ride-sharing vehicles from private cars. Finally conclusions are given in Section 5.

2 DATA DESCRIPTION

Beijing Capital International Airport is the largest airport of china and the throughput of passengers has reached 70 million in 2015. Since there are great demand of taxis and Internet based ride-sharing, the area of Beijing airport is chosen as the research scenario in this paper.

The data that used in this paper, including:

1) License plate data: 40 days license plate data of about 10 million taxis and private cars, including the plate number, and the arriving time or departure time.

2) The position of observing point at exits, entrances and the terminals. There are 9 observing points including 9 exits or entrances around the airport area, which are shown as the so called K markers plotted in Fig.1.

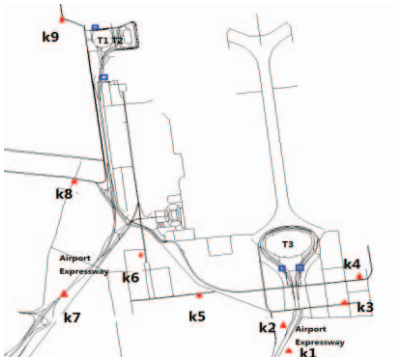


Fig 1. The observing point in the area of Beijing Capital International Airport

In this paper, data pre-processing is carried out in the following steps:

1) The duplicate trip information and the trip data that vehicles enter and leave airport could not be matched were removed from original data set.

2) The vehicles which have observed at the exits or entrances (k5, k6, k8) were removed, as the number of vehicles through these points was less.

3) As pointed out in many studies, driving behaviors can be influenced by many factors. For example, vehicle traveling patterns are notably different in working-days and weekends or holidays. Therefore, the original data are divided into 2 date sets.

- Date Set 1 (DS1): Jan. 19-23, 26-30, Nov. 2-6, 9, 10, Dec. 1-4, 7-10 workdays.
- Date Set 2 (DS2), Jan. 17, 18, 24 and 25, Nov. 1, 7, 8, 28, 29, Dec. 5, 6 weekends.

3 A COMPARISON OF TRAVEL PATTERNS BETWEEN TAXIS AND PRIVATE CARS

In this section, the distribution characteristics of vehicle volume, set as IDX1, and the balanced patterns of time, set as IDX2, are selected as the indicators to show the different of travel patterns between taxis and private cars.

3.1 The Distribution Characteristics of Vehicle Volume

In order to reveal the different travel patterns of the taxis and private cars, the distribution characteristics of vehicle volume are shown and analyzed in this section.

Fig.2 and Fig.3 show the arriving amount of taxis and private cars in workdays (DS1) and weekends (DS2) respectively. It was shown that the arriving amount (IDX1) of taxis was declined less than private cars during 20:00 to 5:00 both in workdays and weekends. This is because the taxi drivers will enter airport in the evening to take passengers, but few private car drivers go to the airport in the late evening.

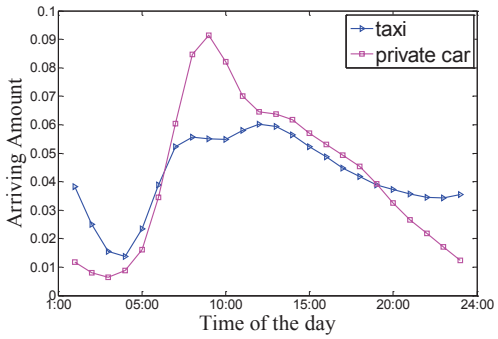


Fig 2. Arriving amount of taxis and private cars in workdays

The arriving amount of the taxis during 20:00 to 5:00 is greater than 30%, however, the arriving amount of private cars is less than 20%. Since ride-sharing drivers could have the same behaviors with taxi drivers, therefor the arriving amount maybe used for identifying the Internet based ride-sharing from private cars.

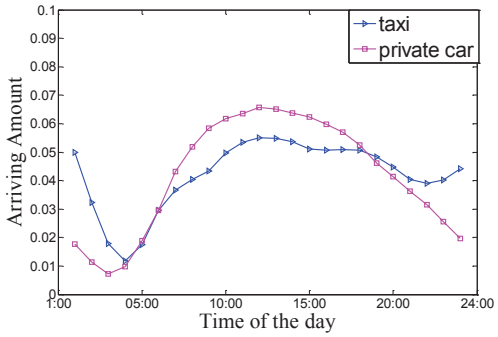
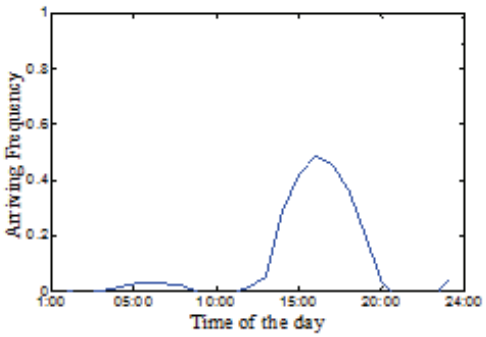


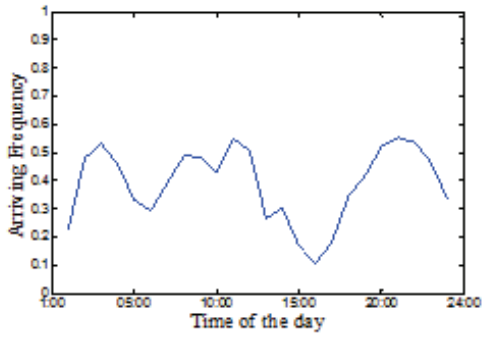
Fig 3. Arriving amount of taxis and private cars in weekends

3.2 The Balanced Patterns of Time

The arriving frequency (IDX2) distribution of a vehicle in different periods is represented whether it had stable time enter the airport. In order to explore the different distribution characteristics between taxis and private cars, we selected the vehicles that have the same frequency enter the airport during 40 days. It was shown in Fig.4 and Fig.5.

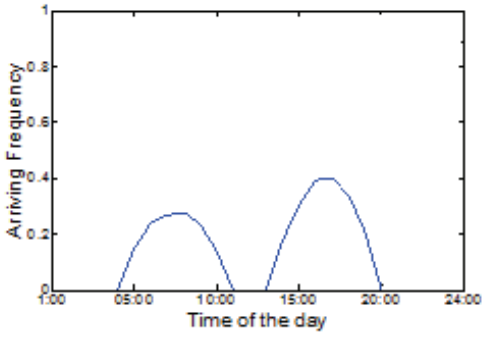


(a)

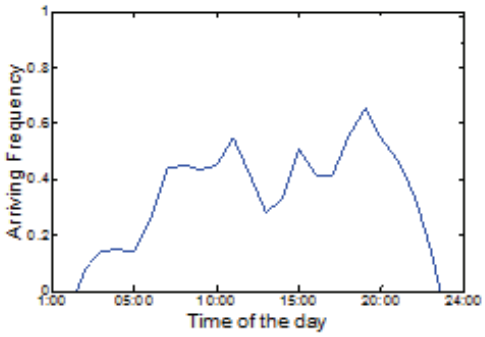


(b)

Fig. 4 The arriving frequency distribution of taxis in different periods was divided into (a) non-uniform and (b) uniform



(a)



(b)

Fig 5. The arriving frequency distribution of private cars in different Periods was divided into (a) non-uniform and (b) uniform

Fig. 4 and 5 compare the balanced patterns of arriving time between the taxis and private cars. Both of them could be divided into two patterns—uniform or non-uniform. The number of the taxis with uniform pattern is larger than that of the private cars. It is because the taxi drivers need to take passengers may in anytime of a day, while the most private car drivers enter or departure are centralized in commuting time. We marked the time which has trajectory records as tag 1, otherwise, marked as tag 0. (there are twenty-four tag 0 and tag 1 in all). If the vehicles meet one of the following conditions, it could be classified as uniform pattern.

- Condition1: The number of tag 1 is larger than tag 0.
- Condition2: The number of tag 1 is greater than 3 and there is one lag 0 at least between every two tag 1.

4 INTERNET BASED RIDE-SHARING IDENTIFICATION METHOD

Based on the above conclusion of the different travel patterns between taxis and private cars, the following steps are taken to identify the ride-sharing vehicles from the private cars.

First, the private cars with high arriving frequencies are taken into account. Then two indicators which mentioned in the 3.1 and 3.2 section are used to identify the ride-sharing.

Second, the distribution of arriving amount of individual vehicle is drawn. If the number of a certain vehicle enter the airport during 20:00 to 5:00 is greater than 0.3, this vehicle will be considered as a taxi or Internet based ride-sharing. As show in Tab.1, there are 78% of taxis conform to this standard, and 30% of private cars conformed, that private car travel pattern is similar to taxi and maybe the ride-sharing.

Third, the distribution of arriving frequency of each vehicle enter the airport was calculated. If the distribution of arriving frequency is more well-distributed, then it could be considered as a taxi or ride-sharing. As show in Tab.2, there are 88% of taxis conforms to this standard, and 37% of private cars conformed.

Finally, there are 13% of private cars in accordance with the two indicators at the same time. And these private cars are more likely to be taxis.

Table 1 Arriving amount test result

IDX1	Taxi	Private Car
<=0.2	17%	61%
(0.2 0.3)	5%	9%
>=0.3	88%	30%

Table 2 Arriving frequency test result

IDX2	Taxi	Private Car
uniform	88%	37%
non-uniform	12%	63%

5 CONCLUSION

In this paper, the travel patterns of both taxi and private car are analyzed based on the vehicle data at Beijing Capital International Airport area. It is shown that the group and individual travel patterns between taxis and private cars are much different, especially the arriving amount in the evening and the arriving frequency. The private cars with the similar arriving amount and arriving frequency characteristic are possibly the Internet based ride-sharing vehicles.

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