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Research on the Effectiveness of Taxi-hailing Apps Subsidy Scheme based on the Ratio of Taxi Demand and Supply

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Abstract

As the taxi-hailing apps and subsidy system grow more popular, more and more residents begin to use this app. Whether the difficulty of taking taxi problems get effectively relieved has become a hot issue, to solve this problem, we qualitatively analyzed the changes between before the subsidy and after the subsidy at first, then analyzed the linear relationship between the ratio of taxi demand and supply and waiting time quantificationally through SPSS, then compared the ratio of taxi demand and supply before the subsidy with that after the subsidy, and find that the ratio of taxi demand and supply reduced when subsidy exist, it shows that the subsidy makes taking a taxi easier.Secondly, by quantificationally analyzing the difficulty of taking taxi before the subsidy and after the subsidy, concluding the influence of subsidy on the ratio of taxi demand and supply: the subsidy of driver and passengers are influenced by resident travel time distribution and the population density. By using SPSS to do curve regression analysis, and find out the expression which matched perfectly. According to the travel time distribution ratio and population density weight calculated an expression of subsidies of drivers and passengers. Finally, using the multivariate linear regression, analyzed the relation between the ratio of taxi demand and supply and subsidies of drivers and passengers, obtained the expression. Then use this expression to get the ratio of taxi demand and supply of before the and after the subsidy, the conclusion is that when allowance one unit of subsidy to the driver, the ratio of taxi demand and supply will decline 2.1%; when allowance one unit of subsidy to passengers, the ratio of taxi demand and supply will increase 1.4%.

Keywords: *Multiple Linear Regression; Curvilinear Regression Analysis;Fitting; Taxi-hailing Apps Subsidy*

1. Introduction

In 2014, the two taxi-hailing apps Didi, Kuaidi began a fierce competition: January 10th, Didi announced that they begin to use Wechat paid, the drivers and passengers can get 10yuan by using this app, ten days later, Kuaidi and Alipay announced that they put out the same Subsidy Scheme[1]. Since then, the two sides are more with their sponsors Tencent and Ali crazy throwing money, subsidy war objectively promote the development of online taxi industry[2]. taxi-hailing apps subsidies are derivatives from various apps in the mad scramble for the market in the background of profit model and space in the Internet industry[3]. Among them the most prominent are Didi and Kuaidi.The purpose of competition between two apps is attract more consumer groups, improve the market share of their products, achieve win-win through the competition[4]. Many passengers and taxi drivers have got the obvious benefits indeed, subsidies greatly facilitated the use of taxi-hailing apps. However, taxi-hailing apps also has its drawbacks[5]. Many elder passengers who cannot use smart phone have to face the problem that take a taxi is more difficult than before, the peak of the payment system sometimes will fall into paralysis, pay error and so on. Therefore, how to set up subsidies has become an urgent problem to be solved, how to make subsidy better adjust the allocation of taxi resources is the purpose of this paper.

2. The Contrast of Subsidies before and after the Degree of Difficult or Easy of Taking a Taxi

2.1 The qualitative analysis of the subsidies before and after about the degree of difficulty of taking a taxi

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The determination of relationship between 'the ratio of demand and supply' and 'the passengers' waiting time First, the influence of subsidy scheme to 'take a taxi is difficult' in qualitative analysis. The most intuitionistic index of 'the degree of difficult or easy of taking a taxi' is the passengers' waiting time, however, the statistic of the passengers' waiting time is very little, so according to searched only a set of data about 'the ratio of demand and supply' and 'the passengers' waiting time', and establish the relationship of 'the ratio of demand and supply' and 'the passengers' waiting time'. The data shown in the following table:

Tab.1 'The ratio of demand and supply' and 'the passengers' waiting time'

the ratio of demand and supply	the passengers' waiting time	the ratio of demand and supply	the passengers' waiting time
1.103	11	0.49	4
0.95298	9	0.469	4
⋮	⋮	⋮	⋮
1.010737	10	0.478	5
0.663	6	0.35	3

Curve regression analysis is applicable to only two related variables, when not immediately according to the observation data to determine a best model, can use the curve estimation in numerous regression model to look for a simple and more appropriate models, so do the above data of the curve regression analysis through SPSS, find out the best fittest expression about 'the ratio of demand and supply' and 'the passengers' waiting time'. The results shown in the following table:

Tab.2 Model summary and parameter estimates

equation	model summary		parameter estimates		
	R square	F	constant	b1	b2
linear	0.983	1953.237	-0.294	9.961	
logarithmic	0.844	184.096	8.976	5.492	
secondary	0.983	955.022	-0.454	10.464	-0.329
composite	0.849	191.623	1.911	5.169	
power	0.975	1334.145	9.627	1.047	
index	0.849	191.623	1.911	1.643	

By above R square data in table 2, find out the linear model can better fit the data trends, so use the linear model. According to the parameter estimates in table 2 can know for linear equations about 'the ratio of demand and supply' (N) and 'the passengers' waiting time' (T) is:

$$T_i = 9.961N_i - 0.294 \quad (1)$$

Taking Nanjing as an example, analysis of a taxi's subsidy scheme whether alleviate the 'the difficulty of taking taxi' problem. The subsidy policy of taxi began in June 2012, collected after the subsidy of the ratio of demand and supply in Nanjing one day. Specific data as shown in the figure below:

Fig.1 The ratio of demand and supply in Nanjing one day

Then read out the ratio of demand and supply from the picture each time, shown in the following table:

Tab.3 After subsidy of 'the ratio of demand and supply' and 'the ratio of empty taxi' in Nanjing

Time	The ratio of demand and supply (%)	The ratio of empty taxi（%）	Time	The ratio of demand and supply (%)	The ratio of empty taxi（%）
0:00-1:00	21.0	79.0	1:00-2:00	16.5	83.5
2:00-3;00	12.0	88.0	3:00-4；00	7.5	92.5
⋮	⋮	⋮	⋮	⋮	⋮
22:00-23;00	43.5	56.5	23:00-24；00	36.0	64.0

Collected before the subsidy of the ratio of demand and supply in Nanjing one day. Specific data as shown in the table below:

Tab.4 Before subsidy of 'the ratio of demand and supply' in Nanjing

Time	the ratio of demand and supply(N)	Time	the ratio of demand and supply(N)
6:00-7:00	1.213	7:00-8:00	0.953
8:00-9:00	1.011	9:00-10:00	1.314
⋮	⋮	⋮	⋮
22:00-23:00	0.606	23:00-24:00	0.606

Analyse subsidies before and after the change of 'the ratio of demand and supply'.First, the data of before and after Nanjing subsidies 'the ratio of demand and supply' through the SPSS K - S test of goodness of fit. Use K - S test of goodness of fit by two groups of data, K - S text is based on the analysis of the differences between the two

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distributions, judge whether the sample observations from specifies the overall distribution. The basic idea is: do cumulative frequency distribution by the date of sequence classification, compared with observation experience cumulative frequency distribution, and concluded their biggest deviation value. Then, on a given level of significance to test whether the deviation value is occasional, check whether it conforms to normal distribution. Test results as follows:

Tab.5 The single sample test of Kolmogorov-Smirnov

	Before subsidy of 'the ratio of demand and supply'	After subsidy of 'the ratio of demand and supply'
Kolmogorov-Smirnov Z	0.863	1.148
Asymptotic significance(On double sides)	0.446	0.144

The null hypothesis of the K - S test is two groups of data obey the normal distribution, due to bilateral asymptotic significant values greater than 0.05 of subsidies before and after 'the ratio of demand and supply', two groups of variables of the null hypothesis obey normal distribution, isn't the small probability event, so the two groups of data obey the normal distribution. Under this premise, T test is used to analyze the differences of two groups of data; In addition, the two groups of data are the date of subsidies for before and after, so there are correlation between data. To sum up, choose paired sample t test analysis the correlation of the above two groups of data eventually.
Then through SPSS paired sample t test was carried out by the data, T test results shown in the following table:

Tab.6 Paired sample test

	Mean value	Standard deviation	Standard error of the mean	The difference of the 95% confidence interval	
				Floor level	Upper limit
Before subsidy of 'the ratio of demand and supply'-after subsidy	0.303738	0.390819	0.092117	0.109389	0.498088

Table 6 is the result of the difference T test, T test of the null hypothesis is 'the ratio of demand and supply' have no significant difference before and after the subsidy, from the double side of the t test P values: 0.004<0.05, can know the null hypothesis is a small probability event, 'the ratio of demand and supply' exist significant difference before and after the subsidy, and prove whether subsidies have obvious effects on 'the ratio of demand and supply'. So according to the characteristics of sample size, mean, standard deviation and so on, the analysis results are as follows:1) From standard deviation can know the standard deviation of 'the ratio of demand and supply' after the subsidy is smaller than before the subsidy, so 'the ratio of demand and supply' after the subsidy are more stable.2) From mean can know that subsidies after the mean of 'the ratio of demand and supply' are smaller.
Informed by formula (1) know that waiting time is proportional to 'the ratio of demand and supply', so subsidies after the mean of 'the ratio of demand and supply' are smaller, also reduce waiting time. And through the formula can also be learned that subsidies before and after waiting time shown in the table below:

Tab.7 The contrast between 'the ratio of demand and supply' and waiting time

Time	'the ratio of demand and supply' before subsidies	waiting time before subsidies	'the ratio of demand and supply' after subsidies	waiting time after subsidies
6:00-7:00	1.213	11.788	0.120	0.901
7:00-8:00	0.953	9.199	0.330	2.993
8:00-9:00	1.011	9.774	0.490	4.587
⋮	⋮	⋮	⋮	⋮
21:00-22:00	0.606	5.747	0.480	4.487
22:00-23:00	0.606	5.747	0.435	4.039
23:00-24:00	0.606	5.747	0.360	3.292

From table 7 can know the following conclusions:1) 6:00-11:00 after implementation of subsidy policy greatly reduce waiting time; Although the waiting time between 10:00-16:00 increased, but compared with it increasing very little, and not lead to take a taxi is difficult. The waiting time of 16:00-24:00 also reduced a little.2) Subsidies greatly reduce the waiting time during rush hour, and it has great help to relieve the problem of 'the difficulty of taking a taxi'.

2.2 The quantitative analysis of the subsidies before and after about the degree of difficulty of taking a taxi

Collected the data of residents travel time distribution and population density respectively about drivers and passengers subsidies, the data shown in the following table:

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Tab.8 Residents travel time distribution and population density respectively about drivers and passengers

residents travel time distribution	The driver subsidies	The passengers subsidies	population density	The driver subsidies	The passengers subsidies
0.0548	10	10	0.96	15	15
0.1507	12	12	0.92	13	13
⋮	⋮	⋮	⋮	⋮	⋮
0.0274	8	8	0.12	11	10
0.0274	10	6	0.05	13	13

The driver subsidies in 'J' and the passengers subsidies in 'K'. The influence factors of 'the ratio of demand and supply' are J and K, the influence factors of J and K are residents travel time distribution (T) and population density (Q).

First, analyse the effect of the population density to the driver subsidies. Using the curve regression analysis through SPSS, and find out the best fittest expression. The data shown in the following table:

Tab.9 Model summary and parameter estimates

equation	model summary		parameter estimates			
	R square	F	contrast	b1	b2	b3
Cubic equation	.974	124.761	15.408	-44.033	55.228	-10.487

Three curve fit of the model is best, according to table 10 can know the expression about population density and the driver subsidies is:

$$J_1 = 15.408 - 44.033Q + 55.228Q^2 - 10.48763Q^3 \quad (2)$$

Then, analyse the effect of the population density to the passengers subsidies, use the same method named 'model summary and parameter estimates', conduct the three relational expression about driver subsidies and residents travel time (J_2), passengers subsidies and population density (K_1), passengers subsidies and residents travel time (K_2). Expressions as shown below:

$$J_2 = 4.190 + 52.572T \quad (3)$$

$$K_1 = 14.685 - 42.762Q + 60.006Q^2 - 16.578Q^3 \quad (4)$$

$$K_2 = 18.708 + 3.933\ln(T) \quad (5)$$

In the influence of the driver subsidies, the weight of population density is 70% and the weight of residents travel time is 30%, so calculated the comprehensive expression of the driver subsidies:

$$J = 70\% \times J_1 + 30\% \times J_2 = -7.34Q^3 + 38.66Q^2 - 30.82Q + 15.77T + 12.04 \quad (6)$$

In the influence of the passengers subsidies, the weight of population density is 70% and the weight of residents travel time is 30%, so calculated the comprehensive expression of the passengers subsidies:

$$K = 70\% \times K_1 + 30\% \times K_2 = -11.61Q^3 + 42Q^2 - 29.93Q + 1.18\ln T + 57.67 \quad (7)$$

Next analyze the relationship between the ratio of taxi demand and supply (N), driver subsidy J and passenger subsidy (K) data found in the following tables:

Tab.10 Passengers and drivers subsidies and 'the ratio of demand and supply'

drivers subsidies	passengers subsidies	'the ratio of demand and supply'	drivers subsidies	passengers subsidies	'the ratio of demand and supply'
15	15	0.76	3	4	0.36
13	13	0.67	7	7	0.4
⋮	⋮	⋮	⋮	⋮	⋮
12	12	0.58	8	8	0.5
11	10	0.47	10	6	0.48

According to the data of Table 10, using SPSS multiple linear regression analysis, get the following table:

Tab.11 The coefficient of 'the ratio of demand and supply'

model	B	Standard error	t	Sig	VIF
constant	0.458	0.023	7.005	0.000	
drivers subsidies	-0.021	0.006	1.940	0.062	6.175
passengers subsidies	0.014	0.006	3.949	0.000	6.175

According to the "non-standardized coefficient" of Table 11,obtained the expression of the ratio of taxi demand and supply, driver subsidy and passenger subsidy:

$$N = -0.021J + 0.014K + 0.458 \quad (8)$$

Then test the feasibility of the above method.

Tab.12 The model summary

Model	R	R square	Adjust the R square	Standard error	Durbin-Watson
1	0.936a	0.877	0.868	0.05440	1.267

1) In Table 12, R is adjusted to 0.877, which means model fitting effect is good. The D-W test is about 1.5, so the independent variable does not have self-correlation

2) The VIF<10 in Table 11, so there is no collinearity between variables.

From the above two point test results can conclude that the method of multiple linear regression can explain the relationship between the ratio of taxi demand and supply, passenger subsidy and driver subsidy well. Through the expression (8), put the collection of drivers and passengers subsidies into the expression, get the ratio of taxi demand

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and supply in variety of subsidies as shown in the table below:

Tab.13 subsidies before and after 'the ratio of demand and supply'

drivers subsidies	passengers subsidies	subsidies after 'the ratio of demand and supply'	subsidies before 'the ratio of demand and supply'
10	10	0.388	0.458
12	12	0.374	0.458
7	7	0.409	0.458
⋮	⋮	⋮	⋮
8	8	0.402	0.458
10	6	0.332	0.458

From table 13 can be seen: the ratio of taxi demand and supply is greatly reduced after the subsidy, which is to ease the difficulty of taking taxi.

The quantitative influence of subsidy program to the difficulty of taking taxi is:When the driver get a unit of subsidies, the ratio of taxi demand and supply fell by 2.1%, when a unit of subsidy is provided to the passenger, ratio of taxi demand and supply increased by 1.4%.

3. Conclusions

Firstly, the key points of the whole paper are analyzed data by using SPSS, especially in qualitative and quantitative analysis before and after the subsidy. The analysis is comprehensive, it can be more convincing to explain whether taxi subsidy based on the ratio of taxi demand and supply is effective to ease the difficulty of taking taxi problem, and draws the following conclusions:1) The standard deviation of the ratio of taxi demand and supply is smaller with taxi subsidy, so the ratio of taxi demand and supply is more stable after the taxi subsidy, and the mean value becomes smaller.2) Subsidies greatly reduce the waiting time in the peak period, so it can ease the difficulty of taking taxi problem very well.3) When the driver get a unit of subsidies, the ratio of taxi demand and supply fell by 2.1%, when a unit of subsidy is provided to the passenger, ratio of taxi demand and supply increased by 1.4%.

From the above conclusions can be learned: When the driver is subsidized, the ratio of taxi demand and supply is low, the resident can be faster and more convenient to take a taxi on the roadside, which play a certain role in ease the difficulty of taking taxi problem. When only the passengers are subsidized, passengers who use taxi-hailing apps will increase, resident use the apps can take a taxi more convenient, while people who take taxi on the roadside will spend more time on waiting. Thus, although the taxi-hailing apps subsidy program can ease the difficulty of taking taxi problem effectively，it can not solve the problem of urban residents taking taxi completely.

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