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The Study of Differences in Public Acceptability towards Urban Road Pricing

Xiaoli HAO[a], Xianglong SUN[b], Jian LU[a,b] *

[a]*Graduate Research Assistant, School of Transportation, Southeast University Sipailou #2, Nanjing, 210096, P. R. China*

[b] *PhD Research Assistant, School of Transportation, Southeast University Sipailou 2#, Nanjing, 210096, P. R. China*

Abstract

Road pricing was regarded as an effective instrument to reduce traffic congestion and environmental-related problems in metropolitan areas. However the low public acceptability was always one of the biggest barriers to implement this measure. In order to solve the problem above, this paper uses cluster analysis approach to identify groups of car users with a similar background in relevant socioeconomic variables and compares their responses to road pricing. Four groups are identified: short-distance travel and low-income people, long-distance travel and low-income people, short-distance travel and high-income people, long-distance travel and high-income people. Those groups indeed differ in their acceptability towards urban road pricing and factors affecting their acceptability. While there were no significant difference in acceptability among four groups from the results. Finally, this paper proposes various suggestions towards different groups to improve their acceptability by analyzing characteristics and attitude to charging practices in those groups.

Keywords:Urban road pricing; Public acceptability; Cluster analysis; Difference

1. Introduction

In the past research, there was no exact definition about public acceptability. Public acceptability of road pricing could be defined as public attitude towards road pricing that whether they are willing to implement this measure or their wish whether accept its implementation. Public acceptability plays an important role in implementing because public is not only participants but also beneficiaries of road pricing. Although road pricing

* Jian LU. Tel.: 15295507811; fax: 025-83795645.
E-mail address: 871489211@qq.com

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has been considered as an effective instrument for reducing traffic congestion by many experts and scholars, low public acceptability is still one major obstacle for its wide-spread implementation.

Individual differences in public acceptability of road pricing schemes have mostly been studied with respect to the available household income. The assumption is that people with high income support road pricing to a higher degree than people with low income. The reason is that people with high income also have a higher value of time and thus are willing to pay more for uncongested roads. However, the empirical results are mixed. Rienstra et al. (1999) found a positive relationship between acceptability and income, while Rienstraeta (1999) found no significant relationship. Some scholars even found a negative relationship between income and acceptability.

Schade (2000) states a similar inconsistent picture concerning age, gender and education. For example, Rienstraetal (1999) found a positive relationship between age and acceptability, Jaensirisaketal (2005) found a negative one and Golob (2001) found no relationship. For gender Golob found a tendency that women support road pricing more strongly. However in Edinburgh men prefer road pricing. Concerning education a positive relationship was found by Rienstraetal whereas Harrington (2001) found a negative one.

Although there was an uncertain relationship between each variable and public acceptability, the previous research had shown that the most important variables determining different reactions towards road pricing were income, age, gender, education, frequency of car use and place of residence. According to previous research and our national condition, this paper determines the variables of cluster analysis as income, age, educational background, gender and place of residence - working.

2. Data Description

2.1. Data Collection

The investigation place was Vehicle Administration and car parks in charging area. First of all, investigation personnel explained survey purpose to respondents, and then, respondents would complete writing. During filling, investigator could provide necessary instruction for interviewees, but no guiding to avoid affecting results.

This survey distributed 1200 questionnaires, 1053 valid questionnaires were returned and recovery rate was 87.8%; rejecting 105 questionnaires which missing data points exceeded 51 or more than 8 questions chose the same answer, 897 valid questionnaires were applying for analysis accounting for 74.8% of the total.

2.2. Distribution of Data Distribution Characteristics

Socioeconomic characteristics included six indicators: gender, age, education background, family composition, income, place of residence-working, in addition, commuting tools used as basic statistical information. Table1 reflects the sample distribution.

Table1. Distribution of sample characteristics

Socioeconomic characteristics	Percentage	Socioeconomic characteristics	Percentage
		Age	
Gender		<30	10.2%
Male	92.4%	31-40	24.4%
Female	7.6%	41-50	30.7%
		51-60	23.5%
		>60	11.2%
Income		Place of residence – working	
<3000	16.5%	Center—center	14.4%
3000-5000	44.3%	Center—periphery	8.6%
5000-8000	24.8%	Periphery—center	66.7%
>8000	14.4%	Periphery—periphery	10.3%
Household composition		Education background	
2	13.3%	High school or below diploma	41.2%
>3	22.5%	College diploma or undergraduate diplomas	48.7%
	64.2%	Master or above diploma	10.1%

3. Analytical Methodology

3.1. Clustering Method

K-means algorithm is one of essential cluster algorithms and in this paper would apply it. First of this algorithm is to select k points as initial cluster centers randomly, then calculates distance between each sample and cluster center then samples will assign to the class where distance is shortest. At last calculates new cluster centers of new adjusted class until there is no change between two cluster centers which means samples do not require adjustment and clustering criterion function Jc has converged.

This paper uses the K-means clustering algorithm，it is an dynamic method and its iterative process adopts batch modification method which each iteration should examine whether the classification of each sample is correct, if not, algorithm will adjust that sample. After adjusting the whole sample, this algorithm would modify the cluster center and move to next iteration. In the next iteration, if all the samples are and there would be no change in cluster center, which means clustering criterion function Jc has been convergence and algorithm ends. The framework of the algorithm is as following0 (Jianhui Zhang, 2007):

(1)There is a data set including n samples, I=1，selects k initial cluster centers Zj(I)，j-i，2，3，…，k；

(2)Calculates the distance between each data object and cluster center D(xt，zj(I))，i-1，2，3，…，n，j=1，2，3，…，k，if D(xt，zj(I)) meet following formula.

$$D(x_i, Z_K(I)) = \min\{D(x_i, Z_K(I)), j = 1,2,3,...,n\}, x_i \in w_k \quad (1)$$

(3)Calculates square sum of error and clustering criterion function Jc:

$$J_C(I) = \sum_{j=1}^{k} \sum_{k=1}^{n_j} \left\| x_k^{(j)} - Z_j(I) \right\|^2 \quad (2)$$

(4) If $\left|J_C(I)-J_C(I-1)\right|<\zeta$,then the algorithm ends; otherwise I=I+1, calculate k new cluster centers.

$Z_j(I)=\frac{1}{n}\sum_{i=1}^{n_j}x_i^{(j)}, j=1,2,3,...k$, return to (2).

3.2. Sample Clustering

Public attitude towards road pricing had significant differences for various socioeconomic backgrounds, but groups with similar background might have common points towards measure. This paper uses cluster analysis to explore diversity in difference and common in one group towards road pricing then compares their responses to road pricing. The purpose of cluster analysis was to determine the main target group for road pricing and establish well foundation for implementing and improving this measure.

The clustering of this study consists two steps. Firstly, using minimum distance clustering found cluster centers and determined initial cluster centers. Secondly, we define the appropriate number of clusters. In order to identify the most appropriate number of clusters, the statistical indicators for cluster solutions range from 2 to 7.The result indicated that when the number is 4,the distance between cluster center was the biggest which meat there were obvious differences between groups and this clustering was better than others. When the number was 4, the distances between cluster centers can be shown in Table2.

In addition, during clustering, people always expected each group including equal samples. However, above target is difficult to achieve, so one principle determining the number of category is to find out decile classification as much as possible. When 897 samples were divided into class 2-7, the number of samples in each group was shown in Table3. Comparing the number of samples in each group, dividing into categories 2, categories 4, and categories 5 was relatively satisfying. Finally, according to actual situation and application purpose, this study divides 897 samples into 4 categories.

Table2. Distance between final cluster centers

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Cluster1	0	1.916	1.892	2.477
Cluster 2	1.916	0	2.341	1.728
Cluster 3	1.892	2.341	0	1.894
Cluster 4	2.477	1.728	1.894	0

Table3. Number of samples in each class

	1	2	3	4	5	6	7
Ward method(7)	115	93	204	98	182	142	63
Ward method(6)	115	99	155	204	182	142	
Ward method(5)	213	155	204	182	143		
Ward method(4)	215	215	170	297			
Ward method(3)	212	157	528				
Ward method(2)	369	528					

The first group, short-distance travel and low-income people, majority is young , the household consists of single or two adults , education background is generally high school or below diploma. Trip distance of this group is shorter than others and their residence is close to work place both of which are all central area or outskirt area. The usage rate of car in this group is very low, because they have a short commuting distance and they can take full advantage of public transport and other modes.

The second group, long-distance travel and low-income people, the structure of the second is similar to the first, majority is young, economic status and education background also has common points. Consequently they have a long commuting distance, moreover, taking public transport or other modes is generally inconvenient. Despite the income of the second is not high, but their private cars take an important role in the structure of their travel.

The third group, short-distance travel and high-income people, majority of third group is middle-aged, the household consists of two or three and few single. The usage rate of private car is very high in their daily life and work travel for their good economic condition.

The fourth group, long-distance travel and high-income people, the structure of fourth is similar to the third, majority is middle-aged. However, comparing the third one this group has a long commuting distance, so their dependence on private cars is the highest.

3.3. Clustering Results Analysis

Table4 shows the results of acceptability in four groups and there are no significant differences in acceptability among them. From the statistical result, the acceptability of the third is much higher than others. The main reason is that their life and work place are both in toll area or outside region so their trip did not go through the toll area, in addition, those people has much higher income also has a higher value of time. The result from table indicates public attitude towards road pricing is negative because the public has little knowledge about it and lacks confidence in alleviating congestion through the measure.

Table4. Acceptability of different groups

	First group	Second group	Third group	Fourth group
1	20.20%	43.20%	7.70%	39.80%
2	27.40%	44.50%	10.80%	43.50%
3	9.80%	1.90%	7.20%	4.20%
4	23.10%	7.30%	37.60%	8.30%
5	19.50%	3.10%	36.70%	4.20%
Difference between groups	Jonckheere-Terpstra*，P=0.09>0.05 n.s			

Table5. Choice of work trip mode among groups

	First group	Second group	Third group	Fourth group
Continue using after paying	41.30%	54.10%	69.30%	76.20%
Public transport	30.50%	22.20%	8.40%	5.60%
Staggered rush hour plan	4.30%	3.50%	4.70%	3.10%
Others	23.90%	20.20%	17.60%	15.10%

Table5 shows the result of trip mode split in different groups which assumes the road pricing had implemented. The tendency of continuing using private cars in the fourth is higher than other groups. Because their commuting distance is long, the usage of other mode is inconvenient and their income is enough to burden transportation costs, so road pricing has less influence in this group. The rate of using public transportation coped with this road pricing in the first group is the highest. The main reason is their short commuting distance, convenient public transportation and low income. However, majority of people chose continuing using private cars and the proportion of selecting public transport or other travel is similar in various groups. In addition, there is no significant difference in choosing staggered rush hour plan among four groups and the rate is very low for working time is fixed and people has smaller space in selecting staggering.

4. Suggestion

In order to obtain the majority public support for road pricing and guarantee measures implementing smoothly, this paper proposes some advices to increase public acceptability combining with results of this study.

4.1. Fairness

The fairness of road pricing the public cared about mostly was the use of government vehicles, the allocation and management of tax. There were about 2.3 million government vehicles which annual expenditure was 150 billion to 200 billion undertaking by taxpayer. The cost of those cars isn't charged by themselves which would lead unfairness when implemented road pricing. In order to achieve relatively fair, road pricing could follow the example of limiting official vehicles fuel consumption and allocate a certain amount of congestion charging consumption for every government car. Such measure could prevent the waste of official cars and reflect the fairness of road pricing.

When the road pricing implemented, the high-income people with higher time value is willing to pay road pricing to get faster travel however the low-income people don't want or afford the addition travel costs caused by this measure. It is unfair for the low-income and government should provide transportation subsidies for those people to reflect vertical equity. The second group in this paper formed by low-income and long commuting distance people, so tax subsidy should tend to this group. Furthermore in order to achieve horizontal equity, part of the tax should be used for commuter subsidies and reducing some tax concerning vehicle users so that people would think the charging have been paid back and policy would become more equitable and less hindered. The low-income and short commuting distance people constitute the first group that would have largest people transferring to public transport if road pricing implements, therefore those people should be supported by horizontal equity.

4.2. Effectiveness

Effectiveness does not affect public acceptability directly in this paper, but it is still necessary to publicize the effectiveness of it. Public and decision maker might not have a deep understanding on road pricing for no implementing experience about implementing those measure such as road pricing, therefore, decision maker should publicize the principle of this measure, effect of the measures and successful experience of foreign. Those publicity campaigns might not be accepted by car users and they did not have confidence in effect of this measure. As a result, it is essential to make a particular design for this part of users in social propaganda .The third and fourth group with higher income expect to continue using cars, therefore, we could emphasize moral duty and public welfare of reducing car using.

Developing Alternative Travel Modes

For the second group it is necessary to develop alternative travel modes so that people could not afford road pricing can travel successfully. Generally, alternative measures are developing public transportation and improving the level of public transport.In order to reduce marginal cost of driving undertaking by vulnerable group, government could develop alternative travel modes and ameliorate transportation options.

4.3. The Packages of Stimulating and Impetus Measures

Cooperating with other measure such as reducing individual income tax could contribute to improve the acceptability. On the one hand public have to charge for travel demand, however, on the other hand people get benefits from this payment measures for instance decreasing individual income tax if several measures packages. During several measures packages, government could consider the needs of different groups for example for the low-income we could increase the investment on public transport to provide alternative travel modes for them and for high-income government can cut down their individual income tax.

Except recommendations based on the results of this study, this paper proposes some advices to increase acceptability after summarizing the experience of foreign.

(1)Proposing the clear justification for implementing the road pricing

Charging policy not only is considered an effective solution, but also is the only way to solve the traffic problems at this stage. But people are often accustomed to consider roads as free facility, therefore paying for road would cause strong opposition of people. If you expect people to accept charging for road and parking, we must have some convincing reasons. The purpose of road pricing is not charging, instead it focuses on improving the traffic and environmental conditions. The best reason is that road charging is the most appropriate approach to solve traffic problems nowadays.

(2)Clearing the goal of charge policy

Although the effectiveness of road pricing might be well, this effectiveness could not be guaranteed and depended on our definition of charge targets. We must determine the value and expectation of implementing road pricing, so that this measure would be considered to meet all interests. For example Stockholm concrete objectives were set: reduce traffic volumes on the busiest roads by 10 % to 15 %, improve the flow of traffic on roads, reduce emissions of pollutants harmful to human health, improve the urban environment as perceived by Stockholm residents, provide more resources for public transport, and improve road safety outcomes. Those concrete objectives made public believe that this measure was not only on paper, but they could benefit from it.

(3)Clearing the charge system characteristics

Before implementing we should determine most characteristics of toll system including the level of charging, charging method, charging area and charging time. Generally, simple charging method and fixed rate is easier to be accepted by public. The explicit charge system could make contribute to understand of road this measure. The various possible techniques are outlined below.

Table6.Various techniques of road pricing (Blythe P, 2005)

Type	Example	Benefits	Drawbacks	Suitable conditions
Windscreen	Singapore prior to 1998	Very simple to implement	Visual inspection required	Underdeveloped regions; Small traffic flow
System based on DSRC	Singapore since 1998	Allow the vehicle to be identified; Simple, fair, high efficiency	Need to install vehicular unit; Large prophase investment	Developed regions; Highway with large traffic flow

Based on automatic number plate recognition	London congestion charge	Without vehicular unit; Have little influence on speed	Low efficiency; Be vulnerable to weather	Not apply to urban road
Based on GPS and GSM	Traffic charge in Switzerland	New technology; Have no influence on speed	Hard t manage occasional users	Developed regions

(4)Carrying on pre-test before formal implementing

Billström (Karolina Isaksson, Tim Richardson, 2007) former mayor of Stockholm says in retrospect that: It wouldn't be possible to vote in advance, because then you wouldn't know what you vote about. /. . ./ This is an issue where people need to get a chance to see for themselves, to get an experience 'is it good?', 'Is it bad?', 'How can it be improved?', and so on. I was convinced that the referendum should be held after the trial. Carrying on pre-test before the formal implementing can not only provide experience for decision maker but also supply a buffer for public to accept road pricing. This is the experience Stockholm provided to us. Through small scale experiments, residents could have a more comprehensive understanding about road pricing and not just look it as a charging policy.

(5)The content and price information about this system must be publicized by credit institutions or individuals.

5. Conclusions

The ultimate purpose of this study is to improve the public acceptability and provide reference design for traffic managers. The main research results of this paper as follow.

(1)Individual samples were clustered into four groups: short-distance travel and low-income people, long-distance travel and low-income people, short-distance travel and high-income people, long-distance travel and high-income people based on individual characteristics by cluster analysis.

(2)This paper had analyzed their acceptability towards road pricing: second group was the lowest and third group was the highest, however, there were no significant difference among four groups. If this measure implements, fourth group will have most people choose using private cars and most people in first one will transform to take bus. Overall, the low-income is more willing to reduce using cars than the high-income.

(3)This paper proposed various advices from the point of equity, effectiveness, developing alternative travel modes and the packages of measures to increase the acceptability of public for the four groups. In order to reflect horizontal equity and vertical equity, tax were used to compensate the first group and the second group. The third and fourth group could emphasize moral duty and public welfare of reducing car use.

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