EFFECTS OF ROAD PRICING SYSTEMS ON ACCEPTABILITY

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Abstract: This study uses a stated preference (SP) technique to evaluate road pricing systems. It examines the effects, on acceptability, of system features, including: charging levels, charging methods (fixed charge per day, time-based charge, distance-based charge and delay-based charge), charged times and charged areas, and system benefits including: travel time reduction, environmental improvement and revenue use. It also studies the influence of selfish and social perspectives. The main source of data was from an SP questionnaire survey conducted on residents of Leeds (UK). The key findings about the acceptability of different road pricing characteristics are discussed.

Key words: road pricing, acceptability, stated preference (SP), and selfish and social perspectives.

1. INTRODUCTION

Generally, increasing car use leads to more problems; for example, increased congestion and damage to the environment, which in turn lead to a decrease in the quality of life. Therefore, it has been suggested that car use should be controlled (Goodwin et al., 1991). One transport policy to do this is road pricing. Road pricing is a transport policy for charging motorists a fee for using their vehicles within specific areas or on specific roads. Recently, various terms have been used in parallel with the term road pricing, e.g. road user charging, congestion charging and congestion pricing, and more specific terms, e.g. cordon pricing, road tolling, value pricing, variable pricing, peak period pricing.

Initially, it has been suggested by economists (e.g. Pigou, 1920; Vickrey, 1955, 1986; Hau, 1992a) that road use should be charged on the grounds of economic efficiency by charging the difference between the marginal social cost and the marginal private cost of a journey. This charge is theoretically equal to the external costs, which drivers impose both on other car users and society. As a result of the charge, demand of road use would be reduced. Then, transport planners (e.g. Ministry of Transport, 1964; May, 1975, 1992) have proposed that road pricing is an appropriate technique for managing travel demand in order to alleviate traffic congestion, to reduce the environmental impacts from traffic and to generate revenue to finance transport services and infrastructures.

However, so far the only successful implementations of road pricing have been the Area-Licensing Scheme (ALS) in Singapore in 1975 (Holland and Watson, 1978), which was replaced by electronic road pricing in 1998, and cordon pricing in three Norwegian cities: Bergen in 1986, Oslo in 1990 and Trondheim in 1991 (Larsen, 1995). Many other countries are also interested in implementing of road pricing; for example, Hong Kong, Netherlands, Sweden, UK and USA (see Hau, 1992b; May, 1992; Lewis, 1993). In UK several local authorities, e.g. London, Leeds, Edinburgh and Bristol, are interested in road pricing since the central government gave new powers to decide whether they want to implement road pricing and to provide them to use the revenue for investment (DETR, 1998a, 1998b). The most recent proposal (GOL, 2000; GLA, 2001) was prepared for London, where the scheme could be in place in 2003.

One of the main barriers to implementation of road pricing is how to design acceptable and effective schemes. This is possibly because it is not very clear how people will perceive the benefits and respond to different road pricing systems.

The benefits of pricing scheme do not seem to be appreciated by individuals. People may feel they do lose because of the charge (Small and Gomez-Ibanez, 1997). They may not want to pay for what was free (Giuliano, 1992; Small, 1992). Many car users also see themselves as 'captive' to the charge and do not perceive personal benefits (Giuliano, 1992). However, individuals are likely to be willing to pay for things they wish to acquire (Jones, 1998). These lead to a hypothesis that road pricing would not be acceptable to the public, especially to car users who face the charges, unless some benefits are perceived as either self benefits or community benefits, or both. If pricing is to be introduced, car users will have to be convinced that its benefits are worth paying for (Giuliano, 1994). In other words, people may vote for a policy that makes them better off; makes their lives easier, more comfortable and less stressed; improves the environment; and makes the economy more efficient (Goodwin, 1997).

The features of a road pricing scheme are likely to directly influence individuals' travel behaviour; through variation in charging level, charging method, charged period of time and charged area. Some car users may respond to a charging system by paying and driving. Some may respond by changing travel behaviour; for example, using another mode, changing their route, changing time of travel and so on. Public acceptance of the system would relate to whether they are satisfied with these responses. In summary, the details of the scheme: how charging is administered and how the benefits are returned to the public, will affect both the public's attitude towards the scheme and their behaviour.

These two characteristics of road pricing, benefits and systems features, are important in the design processes. The research aims to identify factors to improve acceptability. The main study objective is to investigate the effects of different road pricing systems on public acceptability and how the public perceive and evaluate road pricing benefits and features.

The research also studies the influence of individual preferences or interests, both selfish and social perspectives, on the acceptability. Some people may not accept the policy because they lose benefits even though the public gain. On the other hand, some people may accept it because society as a whole is better off. These perspectives may deeply influence individuals' propensity to accept and support the policy.

This paper reviews briefly previous studies of acceptability in the second section. Then it reports the study methodology in the third section. The stated preference (SP) approach has been used to examine the effects of benefits and the system features of road pricing on acceptability, in terms of voting behaviour. The main survey was conducted in Leeds in January 2001. The analysis results are presented in the fourth section, followed by the conclusions.

2. ACCEPTABILITY OF ROAD PRICING

Several attitudinal surveys towards road user charging have been carried out in UK during the last decade. The results are presented in Table 1.

Table 1. Review of Acceptability of Road User Charging in UK

Case study	Source	Year of survey	Results
Nationwide	Jones (1991)	1991	30% support
Nationwide	Taylor and Brook (1998)	1993, 1995	18% in favour in 1993 25% in favour in 1995
Nationwide	CfIT/MORI (2000)	2000	27% support
London	NEDO (1991)	1991	43% acceptance
London	GOL (2000)	1999	53% of respondents agreed it was a "good thing" 30% of car users agreed it was a "good thing"
Cambridge	Thorpe et al. (2000)	1994	34% acceptance (In the survey the residents in the city centre were exempt from the charge.)
Bristol	Collis and Inwood (1996)	1996	32% acceptance
Newcastle upon Tyne	Thorpe et al. (2000)	1998	48% acceptance (In the survey the residents in the city centre were exempt from the charge.)
Leeds	Schlag and Schade (2000)	-	8%-16% supported (depended on regimes)
York	Schlag and Schade (2000)	-	10%-23% support (depended on regimes)

The results show that public acceptability of road user charging is low, and does not seem to have increased over time (from the nationwide surveys' results). It is supported by less than a third of respondents for the nationwide surveys and the surveys in cities outside London. For the surveys in Cambridge and Newcastle, acceptance is higher than the others; this is because the residents in the charged areas were to be exempt from the charge, and the majority of respondents (about 70%) from both cities were less frequent car users (once a week or less) or non-car users. In London the charge is supported by about a half of respondents, but this figure is lower amongst car users. In London surveys, overall results are different from others probably because of the relatively high proportion of non-car users.

Acceptability of urban road pricing in other countries is also low, as reviewed by Luk and Chung (1997). However, the lesson from Oslo shows that acceptance has increased over time since implementation, from 28% responding positively in 1989 to 40% in 1995 (Odeck and Bråthen, 1997), and then to 46% in 1998 (Hårsman, Pädam and Wijkmark, 2000).

Factors that are likely to affect the acceptability of road user charging can be divided into two main groups relating to characteristics of road pricing. Firstly, benefits of the scheme include journey time reduction, environmental improvement and revenue generation. Secondly, scheme features include the level of charge, the method of charging, charged areas and the times of charging. These two factors can be controlled in the process of road user charging design, in order to improve the acceptability. Moreover, acceptability involves personal attitudes (for example, attitudes to transport problems, car use and public transport, and the perceived effectiveness of the scheme) and psychological issues (for example habit, car dependency and perception of freedom). It also involves personal constraints, which may include income, age, education, current transport mode used, frequency of car use, the availability of alternative modes, location of household and workplace, household type, and life style.

It has not been clear how people value the benefits and how their attitudes are affected by features of the system. So far it has been stated that proposals to use revenue for improving public transport or reducing tax significantly influence the acceptability (e.g. Jones, 1991; CfIT/MORI, 2000; GOL, 2000). It is uncertain that travel time reduction and environmental improvement are perceived as benefits from the charge by the public, and can influence the acceptability. For the charging system, it is known that complex systems such as time-based and delay-based charges, would not be accepted by the public (Sheldon, Scott and Jones, 1993), and a system with a known charge is preferable over a system with an uncertain charge (Bonsall et al., 1998; Bonsall and Cho, 1999). This knowledge is not sufficient for the design of an acceptable scheme. More details need to be studied; for example, effects of each system feature and benefit on acceptability.

3. METHODOLOGY

3.1 Design of Stated Preference (SP) Exercise

Stated preference (SP) methods are well known and widely used in transport studies. They are especially useful for studying non-existing market situations. The techniques are based on individuals' preferences and/or behavioural responses elicited when facing a set of hypothetical scenarios. The most recent and comprehensive details of SP methods can be found in Louviere, Hensher and Swait (2000). In this study an SP technique has been used for examining the effects of benefits and system features of road pricing on acceptability, in terms of voting behaviour. SP is appropriate because there is no road pricing system in UK (revealed preference (RP) cannot be used) and the effects of relevant attributes can be explained and compared to each other in quantitative terms, which is difficult in an attitude survey.

Two key influences of acceptability in the design process (see Section 2) are the benefits and the system features of road pricing schemes. Thus, the SP attributes were separated into two sets. Firstly, the benefits include: car travel time reduction, bus travel time reduction, environmental improvement, and benefits from use of revenue. Secondly, the system features include: level of charge, charging method, charged time period, charged area.

If all the attributes were presented in one exercise, respondents may ignore some attributes because there are too many variables to consider. To overcome this problem, separate designs were used. Five SP exercises were designed. Each exercise contained four attributes, three basic attributes plus an additional attribute:

- Exercise 1: charge, car travel time reduction, bus travel time reduction and environmental improvement;
- Exercise 2: charge, car travel time reduction, bus travel time reduction and revenue allocation;
- Exercise 3: charge, car travel time reduction, bus travel time reduction and charged area;
- Exercise 4: charge, car travel time reduction, bus travel time reduction and charged time;
- Exercise 5: charge, car travel time reduction, bus travel time reduction and charging method.

Levels of the SP attributes were developed through four pilot surveys (see Section 3.2). The set of attribute levels presented in Table 2 and 3 was found to be satisfactory in the pilots, and was used in the main surveys.

Table 2. Attributes and Their Levels in SP Exercises 1 - 4 (EX 1 - 4) in the Main Survey

Attributes[1]	Levels			
	0	1	2	3
Basic attributes				
Charge	£1	£3	£5	£7
Car delayed-time reduction	A quarter	A half	Three quarters	-
Bus delayed-time reduction	A quarter	A half	Three quarters	-
Additional attributes				
Environmental improvement (EX1)	As now	Slight	Substantial	-
Revenue allocation to public transport : tax reduction (EX2)	50 : 50	Public transport only	Tax reduction only	-
Charged area (EX3)	Wide area[2]	Small area[2]	-	-
Charged time (EX4)	7am – 7pm	7am – 10am	-	-

Note: 1. Attributes in each exercise are three basic attributes plus an additional attribute.
2. Wide and small areas are the areas inside Outer Ring Road and Inner Ring Road of Leeds.

Table 3. Attributes and Their Levels in SP Exercise 5 (EX 5) in the Main Survey

Attributes	Levels			
	0	1	2	3
Charge levels (depended charging method)				
Fixed charge (per day)	£1	£3	£5	£7
Distance-based charge	10 ppmile[1]	30 ppmile	60 ppmile	100 ppmile
Time-based charge	2 ppmin[2]	5 ppmin	8 ppmin	12 ppmin
Delay-based charge	5 ppdm[3]	15 ppdm	25 ppdm	40 ppdm
Car delayed-time reduction	A quarter	A half	Three quarters	-
Bus delayed-time reduction	A quarter	A half	Three quarters	-

Note: 1. ppmile is pence per mille, 2. ppmin is pence per minute, 3. ppdm is pence per delayed-minute

For each SP exercise, the fractional factorial design was used for selecting a subset of a full factorial design. Exercises 1 - 4 have 16 scenarios each based on four attributes (charging, car and bus travel time reduction, and another additional attribute). Exercise 5 has 64 scenarios designed from four methods of charging that have 16 scenarios each based on three attributes (level of charge, and car and bus travel time reduction). Only one exercise with four charging scenarios was presented to each respondent in order to minimise the effects of response fatigue.

3.2 Development of the SP Exercises

This study uses the SP technique to examine the effects of road pricing on acceptability. Since it is quite different from typical uses of the technique, this application of SP needed to be developed in order to be appropriate for the study. The critical points are how best to present the SP attributes, measure acceptability, and selfish and social perspectives.

A series of pilot studies (through four pilot surveys during August 1999 and July 2000), varying in their design of presentation and measurement, were undertaken resulting in the version used in a main survey. In this paper, a brief description of the levels of the SP attributes and the measurement of behavioural responses is presented as follows. (More details are reported in Jaensirisak, 2001).

3.2.1 Presentation of SP Attributes and Levels

Presentation of Levels of Charge

The levels of charge presented in the SP exercises 1 - 4 were fixed charges of £1, £3, £5 and £7 per day (shown in Table 2). The levels of charge for the other methods (shown in Table 3) are presented as rates of charge, estimated by applying average travel time and distance to work, from the National Travel Survey 1996/98, to the basic charge per day.

Presentation of Travel Time Reduction

In an SP exercise travel time changes are usually presented as absolute values. This is inconvenient for a paper-based survey where travel time reductions in the SP exercise are based on individuals' current travel time, because various sets of travel time and travel time change need to be prepared for different travel circumstances, and it may still imply unrealistic percentage changes for some respondents. Moreover, this requires much more time to distribute the survey forms because of the need to check that each individual receives the appropriate form. In the main survey, the description of proportional change (e.g. reduced by a quarter, a half and three quarter) were used for presenting the reduction since it was convenient for data collection, and was likely to be more familiar to the public than percentage change. The model estimation results in the pilot studies using this approach were also satisfactory.

A separate issue is whether travel time reductions should be related to total travel time or delayed-time. (Delayed-time is defined as the time spent moving slowly or stopped in congested traffic, at traffic lights, or bus stops.) This is important if the free flow time and delayed-time have different values. In practise, the delayed-time reduction is a direct benefit of the charge, which in turn results in reduction of total travel time. Therefore, reductions in delayed-time would be a more suitable measure for the study. In the pilot studies the model estimation results showed that the description of proportional changes in the delayed-time could be used for the main data collection.

Presentation of Environmental Improvement

The presentation of environmental variables is one of the main difficulties of SP design. The design needs to bear in mind that the more details that are presented the more complicated the survey to the respondent, and this may affect valuations of the other variables. In the main survey the description of environmental improvement ('slight' and 'substantial') was used, because it is simpler and likely to be more understandable for respondents than the percentage of improvement, which is in numerical form.

Presentation of revenue allocation

The revenue allocation was presented as proportion to public transport and to tax reduction. In the initial pilot survey, the proportions used were '50:50', '75:25' and '25:75'. In the final pilot survey, it was presented as '50:50', 'public transport only' and 'tax reduction only'. These are simpler for respondents to understand.

Presentation of systems features

System features, such as the method of charging, charged area and time, were unlikely to be a problem for presentation in an SP exercise. Respondents were told that the charge was related to the distance, time or delayed-time spent travelling on the roads inside the charged area. To indicate the areas of charge, a map was provided for each respondent. Times of charge were presented as 7am-10am and 7am-7pm. The results from the pilot surveys indicate that respondents understood these presentations.

3.2.2 Measurement of Behaviours

Measurement of Acceptability

Acceptability of road pricing was measured with a question assessing willingness to vote for different SP charging scenarios. Answers would be either 'Yes' or 'No'. The term 'vote for' was selected for use in the main survey because it directly measures whether people would accept implementation of the schemes.

Measurement of Selfish and Social Perspective

So far there are only a few studies attempting to measure selfish and social perspectives (e.g. Deniels and Hensher, 2000). A major barrier to doing this is that there is no consensus on how to set questions that are able to distinguish selfish and social perspectives in each individual. In this study, they were measured in terms of perception of benefits to themselves and to society. Respondents were asked to indicate how much they perceive benefits to themselves and to society on an 11-point scale, -5 to 5, defined between very detrimental and very beneficial.

3.3 Modelling Issues

A common analysis method for explaining choice behaviour is the standard multinomial logit model that expresses the probability (P) that an individual i chooses some alternative j as a function of the utilities (U) of the M alternatives in the choice set:

$$P_{ij} = \frac{e^{U_{ij}}}{\sum_{m=1}^{M} e^{U_{im}}} \quad (1)$$

The utility (U) for any alternative j is related to relevant attributes (X_j) representing the alternative and individuals' situation, e.g. time and cost:

$$U_{ij} = \sum_{k=1}^{K} \beta_{jk} X_{ijk} \quad (2)$$

The estimation process of utility parameters (β_{jk}) in equation (2) is widely based on the maximum likelihood estimation (MLE). The utility parameters (β_{jk}) can be interpreted as an estimate of the weight of attributes K in the utility function U_j of alternative j. A parameter is considered to be significantly different from zero at the 95% confidence level when its corresponding t-ratio (the ratio of the mean parameter to its standard error) has an absolute value greater than 1.96. Values of t-ratio as low as 1.6 are sometimes accepted representing the 90% confidence level. The overall model goodness-of-fit is considered using the ρ^2 likelihood index, which is parallel to the R^2 for linear regression. For logit models, values of ρ^2 between 0.2 and 0.4 are considered to indicate very good fit model (Louviere et al., 2000). Programmes for estimation of the parameters, their t-ratios and ρ^2 could be applied such as Limdep and ALOGIT.

In this study, for measurement of voting behaviour the SP exercises offered two choices: Yes and No for respondents to state whether they would vote for a scheme. The utility of vote 'Yes' is related to factors that influence the acceptability of the scheme including the benefits and system features of road pricing. The utility of vote 'No' is treated as zero.

The standard logit model applied to the SP data in this study is likely to be affected by heterogeneity problems. To over come this problem, flexible structure models have been suggested, for example the random-parameters logit model (Louviere et al., 2000). However in this paper only the standard logit model is used for the initial analysis, and the random-parameters logit model will be used for the full data set. Another expected problem, which may be produced from an SP data, is from repeated measurement. This assumes that multiple responses obtained from each individual are independent, but they may not true in reality. It is believed that the problem causes only reduction of the t-ratio, not parameter magnitude, and the more observations per individual the greater the effect would be. In this study, there were only four observations for each respondent. The problem may be low enough not to affect any high t-ratios. Nevertheless, this should be taken into account later in the study.

4. RESULTS

This section contains the analysis results from the main survey of residents of Leeds in January 2001. The analyses were based on 432 car users (70% are commuters), which are defined as those who usually use their cars for either work or non-work trips. Sample characteristics are given in Table 4. The results presented include: general public attitudes on current travel situation and road pricing, voting behaviour, perception of benefits to self and society, influence of the perception of benefits and prediction of acceptability of different road pricing systems.

Table 4. Sample Characteristics (n = 432)

Gender: Male	60%	Household annual income:	
Age:		< £10,000	7%
24 or under	1%	£10,000 - £19,999	17%
25 – 34	12%	£20,000 - £29,999	19%
35 – 44	18%	£30,000 - £39,999	12%
45 – 55	29%	£40,000 - £49,999	10%
55 or over	38%	> £50,000	14%
no answer	2%	no answer	21%

4.1 General Attitudes and Current Travel Situation

Car users in Leeds were asked to indicate how much they perceive traffic congestion and pollution in Leeds on a four-point scale. It was found that the majorities saw the problems as 'serious' or 'very serious', 75% for congestion and 67% for pollution, with minorities rating them 'slight' and 'no problem'. However, most of the car users stated that charging a fee for using a car would be unable to alleviate the problems. Only 29% and 27% of them agreed that the charge would be effective in reducing traffic congestion and pollution, respectively.

Surprisingly, when individuals were asked whether they found their current travel situation acceptable, 75% agreed even though they perceived serious problems from traffic. Current car journey time inside the Outer Ring Road (distance from the centre on average is about 6 kilometres) was gathered including both work and non-work trips. Car users were also asked to estimate their journey time if they were to travel by bus, as well as their car and bus delayed time.

Average journey times per day are shown in Table 5. In general, car users do not seem to spend a lot of time for travelling inside the Outer Ring Road of Leeds. However, perceived car and bus delayed-time are relatively large, particularly for bus. Proportion of delayed-time and journey time for work trips is higher than for non-work trips. The bus journey time also exceeds car journey time, as expected, particularly for commuters' work trips.

Table 5. Average Journey Time per Day inside the Outer Ring Road

Sample	Average Car journey time (per day)	Average car delayed-time (per day)	Average bus journey time (per day)	Average bus delayed-time (per day)
Commuters (304)				
- Work trips	34	13	58	25
- Non work trips	27	6	33	10
Non-commuters (128)				
- Non work trips	68	14	78	22

4.2 Voting Behaviour

Voting behaviours were analysed based on the standard logit model (Section 3.3) in order to explain the effects of characteristics of road pricing systems. Table 6 presents the coefficients and t-ratios of the SP attributes in the utility function of vote 'Yes' (the utility of vote 'No' is treated as zero). The results were analysed from the combined data of the five SP exercises

(Section 3.1). Two models were estimated basing on the different forms of car and bus delayed-time reductions. First, they are treated as absolute delayed-time reduction (in minutes). Second, they are in dummy variables of reductions of a half and three quarters in delayed-time. Overall, only 17% of the respondents vote 'Yes' for the schemes.

Table 6. Voting Models by Characteristics of Road Pricing System

Variables	**Model 1**		**Model 2**	
	Coff.	t-ratio	Coff.	t-ratio
Alternative specific constant (ASC) – Yes	**-0.7900**	**-4.6**	**-0.8537**	**-3.7**
Level of charge	**-0.0029**	**-8.3**	**-0.0029**	**-8.5**
Car delayed-time reduction	0.0137	1.6		
Bus delayed-time reduction	**-0.0084**	**-2.1**		
Car delayed-time reduction dummy - half			0.1145	0.7
Car delayed-time reduction dummy - three quarter			-0.3580	-0.2
Bus delayed-time reduction dummy - half			-0.0195	-0.1
Bus delayed-time reduction dummy - three quarter			0.0007	0.0
Environment dummy - slight improved	0.3039	1.0	0.2541	0.8
Environment dummy - substantial improved	**0.7700**	**2.8**	**0.7460**	**2.7**
Revenue dummy allocated to public transport	0.2073	0.6	0.1807	0.5
Revenue dummy allocated to tax reduction	0.2376	0.7	0.1782	0.5
Area of charge dummy - small	**0.7630**	**3.5**	**0.7968**	**3.7**
Time of charge dummy - peak time	**0.4916**	**2.2**	0.4	1.8
Method of charge dummy - distance-based	-0.2686	-0.5	-0.1163	-0.3
Method of charge dummy - time-based	-0.6078	-1.3	-0.6375	-1.4
Method of charge dummy - delay-based	-0.4198	-0.9	-0.4419	-0.9
No. Observations	1573		1613	
ρ^2 with respect to constants	0.07		0.07	

The estimation results indicate that level of charge has a significant negative effect on the acceptability, as expected. Road pricing systems would less acceptable if the level of charge increases. For the benefits of the system, in Model 2 car and bus delayed-time reductions do not have a significant effect. This may be because the specification does not account for the absolute amount of time saved. However, in Model 1 the effect of car delayed-time reduction is correct sign, and although it is not quite significant, it may become significant with more data. The effect of bus delayed-time reduction was expected to be of positive sign, but the result shows a negative significant effect. This is possibly because car users may not accept that car use is charged in order that bus journey time is reduced, which they may not see as a benefit to them. Alternatively, some may feel that reduction in bus times can only achieved by increasing car times and this would be detrimental to them. Substantial improvement of the environment has a significant positive influence on the vote. The effects of revenue use to public transport (100%) and tax reduction (100%) are not significantly different from the effect of the base scenario in which revenue is equally allocated (50% : 50%). For other system features, small-area charge (within the Inner Ring road) and peak-period charge positively affect public attitudes, compared to wide-area charge (within the Outer Ring road) and all day charge, respectively. This indicates that charge in a small area and during peak time is more acceptable than charge in a wide area and all day. For methods of charging, although the effects of distance-based, time-based and delay-based charges are not significantly different to the effect of fixed charge, they have negative signs which mean they are likely to be less acceptable than fixed charge. The model goodness-of-fit index, ρ^2 with respect to constants, is quite low, but it is typical of SP models (see Section 3.3).

4.3 Effects of Perception of Benefits to Self and Society on Voting

Table 7 presents the coefficients of utility function of vote 'Yes' with variables including perceptions of benefits to self and society, in order to show their effects on acceptability (more details presented in Jaensirisak May and Wardman, 2001). The perceptions of benefits were measured by rating on an 11-point scale, -5 to 5 (see Section 3.2.2). The estimation results demonstrate that the perceptions of benefits to self and society, which may relate to individuals' perceptions of the overall performance of road pricing systems, have the expected significant positive effects on the vote. The coefficient of perception of benefits to self is more than double the coefficient of perception of benefits to society, and its t-ratio indicates high significance. This indicates, as expected, that selfish benefits dominate social benefits. Nevertheless, we have shown that social consideration influence voting behaviour. The ρ^2 is quite high (for this type of model); the model explain the behaviour very well.

Table 7. Voting Model by Perceptions of Benefits to Self and Society

Variables	Coff.	t-ratio
Utility function of vote 'Yes'		
Alternative specific constant (ASC) – Yes	**-1.1226**	**-11.5**
Perception of benefits to self	**0.3715**	**11.7**
Perception of benefits to society	**0.1623**	**4.9**
No. Observations	1337	
ρ^2 with respect to constants	0.2529	

4.4 Perception of Benefits to Self and Society

The results of the perception of benefits to self show that 66% of the observations rated on the negative side (-1 to -5) of the scale, 20% on zero and only 15% on the positive side (+1 to +5). For perception of benefits to society, 36% were rated negative, 19% were zero and 45% were positive. Overall, the averages of perceptions of benefits to self and society are -2.3 and -0.2, respectively. They are significantly different from each other at the 95% confidence level. The results demonstrate that most of car users do not perceive benefits to themselves and some also believe that there will be no benefits to society. Moreover, when respondents rated on the scales, there was some positive correlation between the benefits to self and society. This means that if a rating is high on one scale, it tends to be also high on another. However the correlation is not high (0.4).

Table 8 presents the regression models showing the effects of system characteristics and the benefits of road pricing on the perception of benefits to self and society. For the perception of benefits to self, as expected, the level of charge has a significant negative effect; the higher the level of charge, the higher detriment to self. For the perception of benefits to society, the effect of the charge is also significantly negative, but the negative effect is not as high as on the perception of benefits to self. Environmental improvement has significant positive effects, which are much higher than its effects on the perception of benefits to self. We would expect respondents to regard environmental issues to impact more on social than selfish preference. There are no significant effects from the other characteristics. However, some effects are not far from significance and show the difference between the perceptions. Charge in a small area is perceived as having more benefits to self than in a wide area, but there are no different between the charged areas for the perception of benefits to society. Bus delayed-time reduction is perceived as a detriment to car users, but has no effect on the perception of benefits to society. Moreover, the constants in the models demonstrate that there are some other factors, which are not included in the model causing detrimental perception of benefits to self, but the factors do not affect the perception of benefits to society. Overall, model goodness-of-fit indexes (R^2) are very low for the regression model.

Table 8. Regression Models of Perception of Benefits to Self and Society

Variables	Benefits to self		Benefits to society	
	Coff.	t-ratio	Coff.	t-ratio
Constant	**-1.729**	**-11.0**	-0.0041	0.0
Level of charge	**-0.0017**	**-7.1**	**-0.0011**	**-3.9**
Car delayed-time reduction	0.0051	1.3	-0.0026	-0.6
Bus delayed-time reduction	-0.0077	-1.9	0.0003	0.0
Environment dummy - slight improved	0.546	1.6	**0.793**	**2.1**
Environment dummy - substantial improved	**0.731**	**2.2**	**1.685**	**4.4**
Revenue dummy allocated to public transport	-0.0929	-0.3	-0.123	-0.3
Revenue dummy allocated to tax reduction	-0.0219	-0.1	0.564	1.3
Area of charge dummy - small	0.513	1.9	-0.0903	-0.3
Time of charge dummy - peak time	0.0822	0.3	0.0817	0.3
Method of charge dummy - distance-based	0.810	1.6	-0.230	-0.4
Method of charge dummy - time-based	-0.451	-0.9	0.304	0.6
Method of charge dummy - delay-based	0.170	0.3	0.476	0.8
No. Observations	1346		1346	
R^2	0.06		0.04	

4.5 Prediction of Acceptability of Different Road Pricing Systems

This section presents results of prediction of acceptability of different road pricing systems. The results are produced from using the logit model (Equations 1 and 2 in Section 3.3) associated with the estimated-parameter coefficients of Model 2 in Table 6. The benefits of charging systems are fixed as the basic scenario that car and bus delayed-time is reduced by half, the environment is substantially improved and the revenue is allocated equally to public transport and tax reduction. System features: charging level, charged area, charged time and charging method are varied. Scenarios of charging are set as shown in Table 9.

Table 9. Examples of Road Pricing System Scenarios

Scenarios	Charged area	Charged time	Charging method
1	Inner Ring road	Morning peak time	Fixed charge
2	Outer Ring road	Morning peak time	Fixed charge
3	Inner Ring road	All daytime	Fixed charge
4	Outer Ring road	All daytime	Fixed charge
5	Inner Ring road	Morning peak time	Distance-based
6	Inner Ring road	Morning peak time	Time-based
7	Inner Ring road	Morning peak time	Delay-based
8	Outer Ring road	All daytime	Time-based

From the interpretation of the results of Table 6, voting is improved when the charging system has a fixed charge per day in the small area (within the Inner Ring of Leeds which is around the city centre) during the morning peak time. These are set as features of scenario 1. The different system features are presented in scenarios 2-8.

The prediction results of each scenario by the levels of charging are presented in Figure 1. Not surprising, in every scenario the higher the charging level, the lower the acceptability.

Scenario 1 receives the highest proportion of the vote, showing the it is the most acceptable. Voting for scenarios 2 and 3 shows that the system will be less acceptable when it covers the area inside the Outer Ring Road (wide charged area) or during daytime (long charged time). The proportion of the vote will be lower when charging is in the wide area and all day, in scenario 4. By comparing scenarios 5-7 to scenario 1, the results demonstrate that distance-based, time-based and delay-based charges are less acceptable than the fixed charge. However, the distance-based charge is just slightly less acceptable than the fixed charge. Time-based charge is the least acceptable. The acceptability will be very low when charging is based on time in a wide area during the daytime (scenario 8).

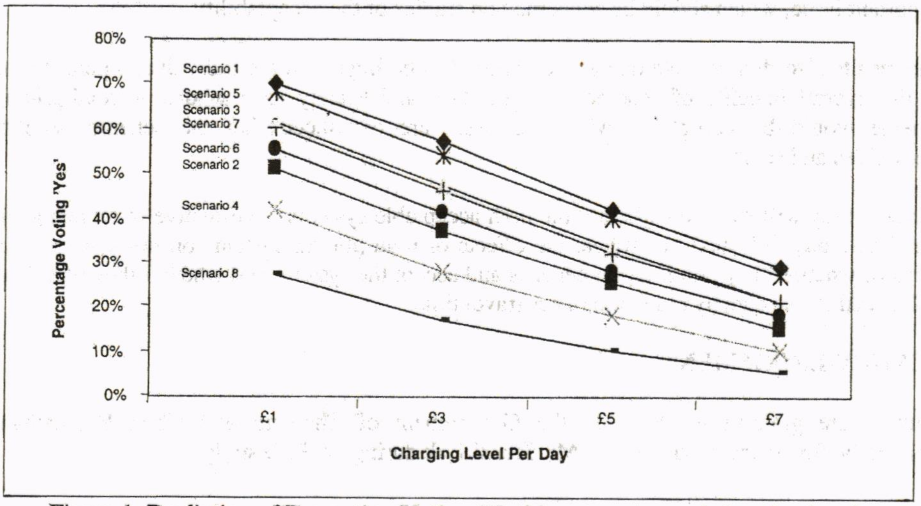

Figure 1. Prediction of Proportion Voting 'Yes' by scenarios and charging levels

5. CONCLUSIONS

The findings from car users are that acceptability of a road pricing system depends on its characteristics: the system benefits and features. The level of charge is the most sensitive factor on the acceptability, the higher level of charge, the lower acceptance. To increase acceptability of a road-pricing scheme, improvement of the environment is likely to help. Charging for a small area during peak-time is also likely to make a scheme more acceptable than charging in a wide area during the whole day.

Surprisingly, car and bus delayed-time reduction do not seem to help in improving the acceptability. Perhaps, it is because most of respondents accept their current travel situation and their car delayed-time is not very high. Another possible reason is that, in the case of urban road user charging, time reduction is difficult to compensate the charge because charging is immediate, quantifiable and tangible while time saving is vague and distance (Button, 1984; Giuliano, 1992). Experimental results from Harrington, Krupnick and Alberini (2001) also showed that time saved is not significant in improving voting for congestion pricing.

The proportion of revenue allocated to public transport and tax reduction also does not significantly affect the acceptability. For the methods of charge, the most acceptable charge is the fixed charge, followed by the distance-based, which is slightly lower. The delay-based and time-based charges are the least acceptable. This may be because the charge is more difficult to be estimated than the distance-based charge. Moreover, when these system features are combined, the prediction of voting shows that the system in which the charge is based on time spent in a wide area during daytime would approach very low acceptance. This could also be expected for the delay-based charge. Acceptability would be over 50% for a fixed charge per day of less than £4 inside a small area during the morning peak-time. Other scenarios with peak only charging within the Inner Ring Road and other charging mechanisms, and with all day fixed charges within the Inner Rind Road, approach over 50% support at the level of charge of £1 per day. In conclusions, the study shows that the acceptability of road pricing can vary immensely across different situations. This is an important issue, which should be concerned on studies of the acceptability.

The results also demonstrate that acceptability depend highly on the individual's perceptions of the overall benefits of scheme to themselves and society as a whole. A road-pricing scheme would be acceptable when car users are convinced that the scheme benefits themselves and society.

Further study will focus on whether the high acceptable systems are effective in reducing car use. The study will also investigate the effects of road-pricing systems on non-car users in focus of whether they perceive the benefits and accept the system, and whether they would be influenced to use cars by reduction of car travel time.

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