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AN ANALYSIS OF ROAD USER CHARGING AND ROAD PRICING AT THE UPPER DERWENT VALLEY, UK

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This paper discusses the effect of the road user charging scheme at the Peak District National Park, UK. The analysis was carried out with stated preference survey techniques and using a multinomial mixed logit model as well as conventional statistic and regression models. The analysis focused on not only the congestion level and environmental impact, but also equity issues associated with the road user charging scheme. From the estimation results, the scheme has great potential to reduce congestion in this area of natural beauty. However, the potential monetary policy tool also presents an equity problem, because elderly visitors will be more willing to pay the toll and the fee to park at the Information Centre. In other words, elderly visitors are more disadvantaged than other visitors. This example shows how a monetary policy tool causes an uneven effect.

Key Words: road user charging, road pricing, mixed logit, stated preference, discrete choice

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INTRODUCTION

Private car use is a key component in areas of outstanding natural beauty because these locations attract many visitors from local and urban areas who arrive by car. Traffic congestion and associated air pollution due to excessive private car use are considered the most significant threat to the UK tourism industry, and eventually leave a negative impression on visitors. In order to reduce traffic congestion and improve the value of the natural beauty by reducing visual intrusion and traffic noise, transport policies such as private car access regulation, road user charging, and road pricing schemes are usually considered by policy makers. According to underlying economic theory, Road Pricing or Road User Charging is a suitable tool to ensure that road users pay for the external costs generated by their travel (Hensher, et al., 2005; Higgins, 1979; Steiner and Bristow, 2000). Currently, one of the major objectives of road user charging is to reduce traffic congestion levels. The Upper Derwent Valley in the Peak District National Park is one of the proposed areas for implementation of this new policy tool. It is likely that a road user charging scheme around the Upper Derwent Valley will be considered a viable option for reducing traffic levels. At the same time, it is important to examine to the extent to which visitors feel uncomfortable about the scheme.

This paper analyses the scheme with econometric tools including a multinomial discrete choice model using the Upper Derwent Valley in the Peak District

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national Park (the Valley) as a case study. In this paper, the demand of the one-day visitor is focused on because it is the major component of traffic in the Valley. First, this paper analyzes visitor characteristics and the willingness of visitors to pay fees such as a road toll and an associated park and ride charge. Then, the proposed transport policies are analyzed by a multinomial mixed logit model with stated preference data. A special focus is given to the equity impact of the road user charging scheme, as this matter is an interesting research topic these days and highly relevant to the research area (Bureau and Glachant, 2008;. Hensher and Puckett, 2005; Ison and Rye, 2005; Maruyama and Sumalee, 2007; Mitchell, 2005). The objectives of this paper are to analyze both the effects of the new schemes on congestion levels and an equity problem presented by the potential monetary policy tool.

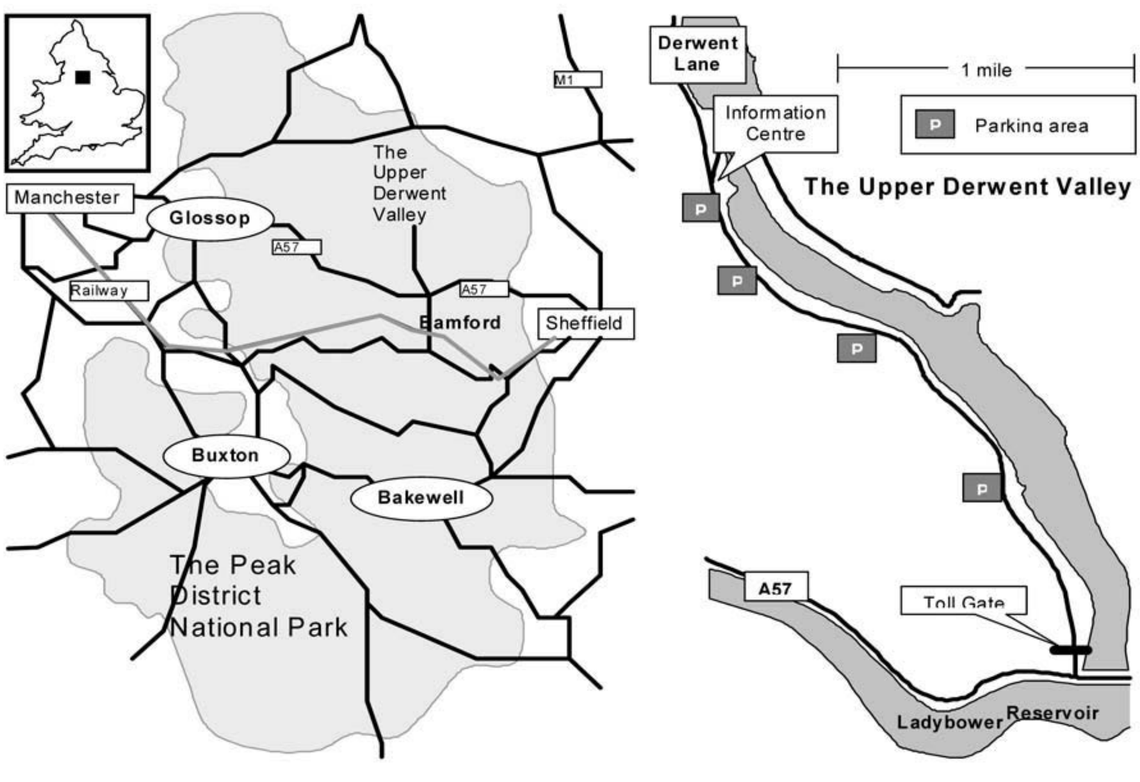
The rest of this paper is organized as follows. Section one explains some key background information, namely a case study site description and discrete choice analysis. Section two outlines the data collection processes and the stated preference questionnaire design. Section three describes individual characteristics of visitors, the distribution of willingness to pay the road user fee, and individual differences in behavior in response to parking costs. Section four analyzes the relationship between parking location and willingness to pay the road user fee, and the potential effects of the road user fee and the park and ride scheme on the basis of the estimation results from a discrete choice model. Finally, section five discusses the important findings and highlights some policy implications.

BACKGROUND

Case Study Site Description

The Upper Derwent Valley is located between two large cities, Manchester and Sheffield, as shown in Figure 1. Access to the Valley by private car is easy, not only from local towns, but also from nearby cities via the A57. Entrance to the Valley by car is only from the A57 and only through Derwent Lane, which comes to a

Figure 1. Map of the Upper Derwent Valley



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dead-end. There are four parking areas on Derwent Lane. The approximate capacity of each parking area is 134, 77, 58, and 18 vehicles respectively, in order by distance from the Upper Derwent Information Centre. Only the first parking area requires a ticket, which costs ￡2.50 for one-day parking or 50 pence per hour. Tourists try to park as close as possible to the Information Centre since the Information Centre is at the entrance to the scenic area of the Valley. However, the Information Centre charges parking fees, so visitors who are not willing to pay a parking fee will instead choose the Derwent Overlook (the second parking area). It is important to note that even on the busiest days congestion on the A57 and Derwent Lane is minimal, but severe congestion occurs around the Information Centre and the second parking area.

Discrete Choice Analysis

This study is particularly interested in the multinomial discrete choice model, which has been widely practiced in transport modeling. One of the state-of-the-art econometric models, discrete choice analysis produces a choice from a discrete set by treating unknown factors as random components of utilities (Ben-Akiva and Lerman, 1985).

The random utility theory was formulated in the late 1950s by Luce (1959) and implemented statistically in 1970s (Manski, 1977; McFadden, 1981). Today, it is adopted in many behavioral models including biodiversity, location choice, energy demand, etc. (Kim, Pagliara and Preston, 2005; Do and Bennett, 2006; Provencher and Moore, 2006; Rigby, Balcombe and Burton, 2009; Takama, et al., 2008); however, transport demand assessment remains the main field of this methodological development. While individuals tend to select the alternative that maximizes their utilities, the decision is still bounded to random components coming from the uncertainty in utility functions (Ben-Akiva and Lerman, 1985). In 1944, von Neumann (1953) developed the formal theory of risk and uncertainty, which was applied to the random utility theory. Although the two concepts cause individuals' expected decisions to differ, individuals try to maximize their utilities (Sandholm, 1999:214). For example, although one individual may visit a national park at a 50% congestion level, another individual may prefer to stay at home. This is because of risk, which individuals perceive differently. On the other hand, one individual may make different decisions given the same conditions, due to uncertainty in the utility functions. The utility of a decision maker can be estimated either by assuming mathematical functions or by fitting a curve empirically among a set of a discrete utility distribution. No matter what the utility function is, there is always an estimation problem, and the functions above are likely to be theoretical idealizations, but not reality. Therefore, the unobserved disturbance term, ε_i, should be associated on the right-hand side of the equations, i.e., $Ui = V_i + \varepsilon_i$. The disturbance term is a random variable that is usually distributed with mean zero and some form of variance, which is an important baseline of econometric discrete choice analysis.

Random utility models have been extensively used in the field of transportation research since the emergence of the model in the last thirty years. All applications were likely to be based on the multinomial logit model for discrete choice analysis (McFadden, 1974). Discrete choice analysis examines individual choice between discrete alternatives, such as the choice of travel mode based on individual behavioral data, including travel origin and frequency of trips (Spear, 1977). Therefore, its models are often called disaggregate travel demand models. In this paper, the mixed logit model is used, which solves the assumption of fixed tastes in discrete choice analysis.

Traditional discrete choice analysis has the underlying assumption of fixed tastes (Ben-Akiva and Bierlaire, 2003). This is problematic if people have heterogeneous characteristics. Transport and tourism economics involves heterogeneous individuals since visitor behavior often reflects choices made between discrete alternatives. In other words, visitors and commuters cannot select a part of one mode while using a different mode (McCarthy, 2001:93). More than one mode exists in the real transport system so the underlying assumption of identical preference for all individuals is implausible. The problem of homogeneous taste is solved in multinomial mixed logit models by taking the covariance between choices into account and, consequently, overcoming the problem of independence of irrelevant alternatives (IIA) (Revelt and Train, 1998; Train, 1998).

A mixed logit model and other discrete choice models cannot be calibrated by using standard curve-fitting techniques, such as least squares estimation, because their dependent variable is an unobserved probability (between 0 and 1) and the observations are

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the individual choices, which are either 0 or 1 (Train, 2003). Therefore, the mathematical transformation of the utility values is required to obtain probability values between 0 and 1. For example, the logistic form of the fitted model for choosing an automobile as a transportation mode among three options is:

$$P(Auto) = \frac{\exp(U_i^A)}{exp(U_i^A) + exp(U_i^A) + exp(U_i^A)}$$

The logistic forms for the other two options are similar to the one above. U_i^* is an unobserved utility including an error term, i.e., $U_i = V_i + \boldsymbol{\varepsilon}_i$ and *P*(Auto) is an unobserved probability of choosing the automobile option, and the parameters of the utility function are not fixed in the mixed logit model due to taste variation.

DATA COLLECTION

The road user charging scheme in the Upper Derwent Valley is still under consideration, and there is no implemented road user fee in a similar situation yet (Eckton, 2003:310; Steiner and Bristow, 2000:96), so a revealed preference survey was impossible. Therefore, a stated preference survey was used for the question about the mode choice from among Auto (toll and drive), Bus (park and ride), and Cancel (do not visit) options. Additionally, visitor characteristics and past trip experience were collected. Although the main concepts and methods used in this project are applicable in order to forecast entire travel demand (Anabel, 2002), due to the results from a pilot survey, this study focuses on day trip travel to the Valley. The pilot survey showed that the main components of travel demand during the busy period were the day trip visitors from local towns and neighboring cities, namely Manchester and Sheffield.

Pilot and Main Surveys

The pilot survey was conducted between 1st and 3rd August 2003. The main survey was carried out for nine days from 23rd to 31st August 2003 including the bank holiday Monday on 27th August. Survey locations were extended to the third parking area when the first two parking areas were extremely busy. Additionally, a small survey was conducted in public buses and at bus stops in the Valley. Overall, 700 questionnaires were distributed and 323 of them were returned (i.e., a return rate of 46.1%) to collect information about decision making processes of agents using the stated preference approach and the arrival rates of vehicles. Besides the hypothetical stated preference questions, revealed data was collected in the same questionnaire. Several interviews with key persons including parking officers and local authorities were also carried out.

Stated Preference Questionnaire Design

During weekends and holiday periods, Derwent Lane beyond the Information Centre is closed to private cars because of potential severe congestion. Visitors' destinations are usually beyond the Information Centre, otherwise, visitors relax in the area around the Centre. Therefore, respondents were asked how they would travel to the Information Centre if the road user fee and park and ride schemes were put into effect in the Valley in *ceteris paribus* conditions. In addition, visitors to the Upper Derwent Valley were expected to respond to the schemes in one of three ways:

"Auto" option:
Pay a toll for road use and drive into Derwent Lane to get to the Information Centre.

"Bus" option:
Come near the Valley via any travel mode, and then use the complimentary park and ride service to get to the Upper Derwent Information Centre.

"Cancel" option:
Cancel the trip to the Valley and instead go somewhere else or stay at home.

Terms used in the questions and brief explanations of the road user fee and park and ride schemes were given before the hypothetical questions relating to mode choices. After reviewing previous research (Fowkes, 2000; Ortuzar, et al., 2001:283; Steiner and Bristow, 2000) and revising the results of the pilot survey, four attributes of the mode choices of travel time and costs were chosen, and four levels were selected for each attribute:

Road user fee (£):
a toll to enter Derwent Lane from the A57

Park and Ride fare (£):

a fare for bus service, which links local parking areas, Bamford train station, and the Upper Derwent Information Centre

Frequency of bus service (minutes):

the period between departure times of the shuttle buses

Searching and walking time (minutes):

the combination of time spent searching for a parking space and walking time from the parking area to the Information Centre

Parking fee difference (£):

the difference between parking fees for the Auto and the Bus. The parking fee for the park and ride service is the fee visitors pay when they park their car before getting on a bus. The parking fee for toll and ride is the fee visitors pay when they park their car at one of the four parking areas along Derwent Lane

The four levels were determined by using the boundary value evaluation technique (Fowkes, 2000). For the question about "parking fee difference," two sub-attributes were used, i.e., parking fees for the Bus

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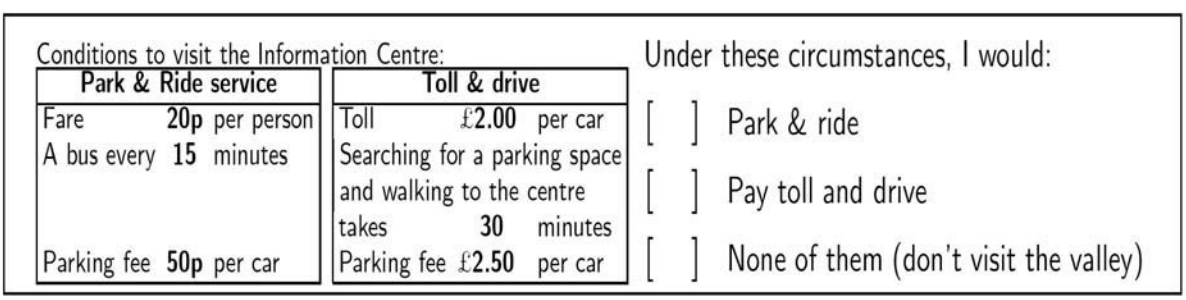
Table 1. 16 hypothetical questions and attributes

Q.	Toll fee (£)	Bus fare (£)	Headway (min)	Search and Walk (min)	Parking fee (£)		
					Auto	Bus	Difference
1	20p	£1.00	5	1	50p	10p	40p
2	20p	£2.00	15	30	£2.50	50p	£2.00
3	20p	£3.00	30	50	£1.00	50p	50p
4	20p	£5.00	45	15	£2.00	50p	£1.50
5	50p	£1.00	15	15	£1.00	50p	50p
6	50p	£2.00	5	50	£2.00	50p	£1.50
7	50p	£3.00	45	30	50p	10p	40p
8	50p	£5.00	30	1	£2.50	50p	£2.00
9	80p	£1.00	30	30	£2.00	50p	£1.50
10	80p	£2.00	45	1	£1.00	50p	50p
11	80p	£3.00	5	15	£2.50	50p	£2.00
12	80p	£5.00	15	50	50p	10p	40p
13	£1.00	£1.00	45	50	£2.50	50p	£2.00
14	£1.00	£2.00	30	15	50p	10p	40p
15	£1.00	£3.00	15	1	£2.00	50p	£1.50
16	£1.00	£5.00	5	30	£1.00	50p	50p

Figure 2. Example of stated preference question


Conditions to visit the Information Centre:

Park & Ride service	Toll & drive
Fare **20p** per person A bus every **15** minutes Parking fee **50p** per car	Toll **£2.00** per car Searching for a parking space and walking to the centre takes **30** minutes Parking fee **£2.50** per car

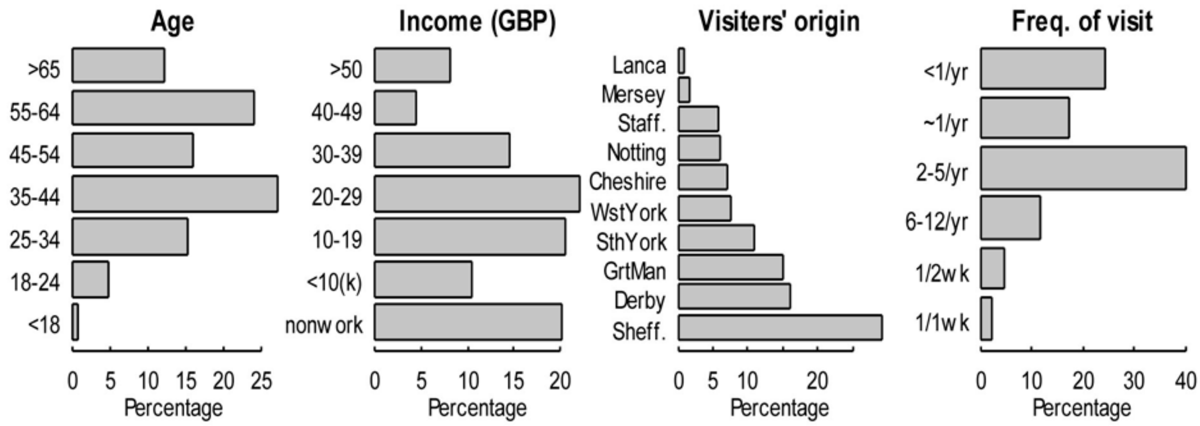
Under these circumstances, I would:

[ ] Park & ride

[ ] Pay toll and drive

[ ] None of them (don't visit the valley)

Figure 3. Proportions of visitors' characteristics



and the Auto. The four values of all attributes were equally distributed in the 16-fractional factorial experiment. The design of sixteen questions is known as a lattice square, as shown in Table 1.

Table 1. These four alternative specific variables were converted into generic variables comprising travel time and costs using the insignificant log-likelihood test (McFadden, 1974). Combined attributes were presented in Figure 2, and respondents were asked to choose their preferences from among the three stated options 1) Auto, 2) Bus, and 3) Cancel.

DATA DESCRIPTION AND BASIC STATISTICS

Characteristics of Visitors

Only 16% of visitors came from the local council area, Derbyshire. This survey was carried out during the busiest time of the year, and local visitors might have avoided visiting the Valley during the busiest period ("Visitors' origin" in Figure 3). However, most visitors (60%) to the Valley came from local towns and the neighboring cities of Manchester and Sheffield. The Upper Derwent Valley is easily accessible for the residents of these two cities via the A57. For example, an elderly visitor from Sheffield said that he drove 20 minutes to the Valley about three times a week just to take a walk with his dog. Therefore, for these visitors, the Upper Derwent Valley is like a large backyard where they relax and take a walk.

The age distribution of visitors is highly skewed, and two modes at 35 – 44 and 55 – 64 are present in the distribution ("Age"). This age distribution matches the observations made during the survey. Most visitors observed during the survey were either families or elderly, and they could represent the two most populous age groups in the distribution, i.e., families for 35 – 44, and elderly visitors for 55 – 64. In addition, income distribution ("Income") also supports this trend. Some 20% of visitors to the Valley are non-workers, and most of these visitors are elderly people, since the proportion of students is nominal (5%).

Distribution of Willingness to Pay to the Road User Charge

How much visitors were willing to pay for a road user fee was asked directly after the stated preference section of the questionnaire. The average WTP is £2.373 with a standard deviation of £1.75. However, the median of £2 seems to be a better representation of the central value. The distribution of the WTP is fairly normal with m=2 and σ=1 except for the small peak at £5 marked with an arrow in Figure 4. Also, the distribution is even closer to the normal distribution after omitting the observations of WTP = £5 (WTP[!=5]) in Figure 4.

No clear reason for the small peak was found except for possible questionnaire bias. The section preceding this open-ended WTP question was the stated preference questions, and the highest value of the road user fee stated in the questions was £5. Thus, although no upper boundary was set for the question of the WTP,

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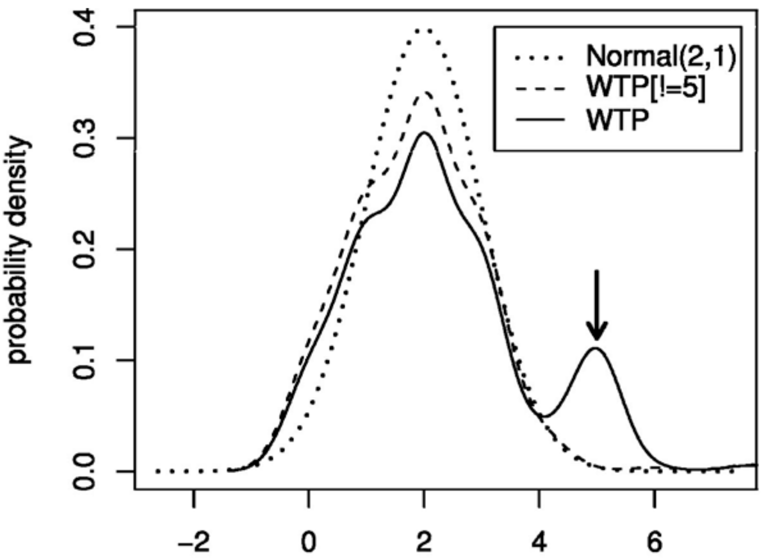
Figure 4. Density of the WTP



some respondents probably had assumed the upper boundary of £5 from the stated preference questions. The same questionnaire bias of an assumed WTP upper boundary influenced by preceding questions was also observed in previous studies (Eckton, 2003). As a result, the upper tail of the WTP distribution would be elongated if respondents did not assume that the upper boundary was £5, and this meant that the sampled distribution of the WTP was possibly underestimated.

Therefore, from the observations above, the majority of visitors to the Upper Derwent Valley are families and elderly people from the local area, Manchester, and Sheffield. Moreover, the central WTP value for the road user charging scheme is approximately £2.

Individual Differences in the Behavioral Responses to Parking Costs

In this section, parking behavior is analyzed with respect to travel frequencies and parking costs. The only current policy tool to suppress private car use in the Upper Derwent Valley is a parking fee charged at the Information Centre. It is wise to buy a day ticket rather than pay per hour if parked at the Information Centre for more than five hours, due to the fee system. The average time a visitor spends in the Valley is 4.1 hours. Consequently, most visitors either buy a day ticket or go to the other the parking areas where they are not charged for parking. Therefore, the distribution of parking costs is likely to be the bimodal of “0 pounds” and “2.5 pounds” as shown in Table 2.

Furthermore, the distributions of parking cost are different among age categories as shown in Figure 5, and among the categories of frequency of visits to the Valley as shown in Figure 6. Between the ages of 18 and 24 and under the age of 18, approximately half of visitors parked at the Information Centre with a day ticket and the other half parked at the other parking areas. In contrast, no more than 30% of visitors older than 25 and only 18% of visitors older than 65 did not park at the Information Centre. This difference among age categories may be partially due to an income effect.

Table 2. Parking costs at the Information Centre

Park fee (£)	0	0.5	1	1.5	2	2.5
Parking time up to	-	1hour	2hours	3hours	4hours	1day
Park at Information Centre?	No	Yes	Yes	Yes	Yes	Yes
% of visitor	26.8	5.1	2.9	1.0	6.4	58.0

Figure 5. Parking cost by visitors' age

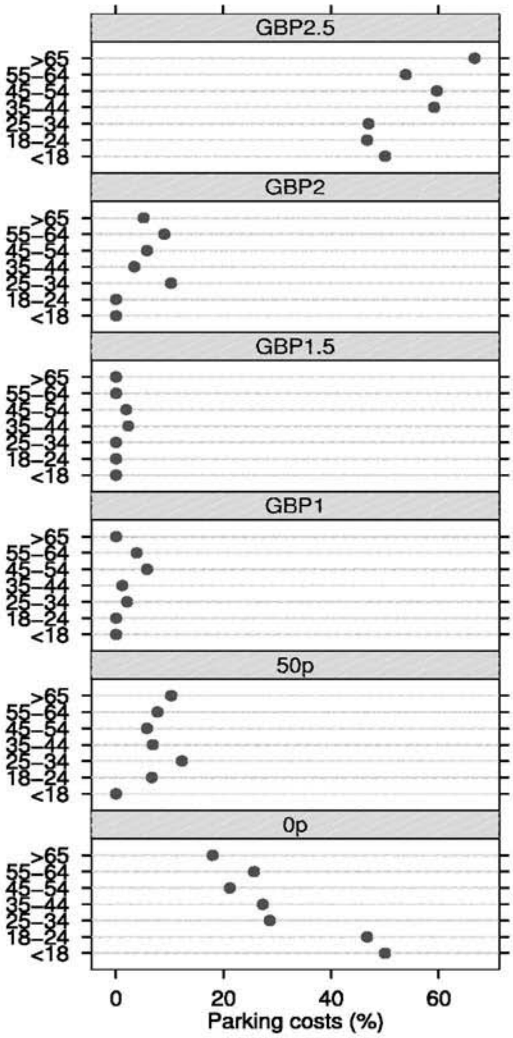
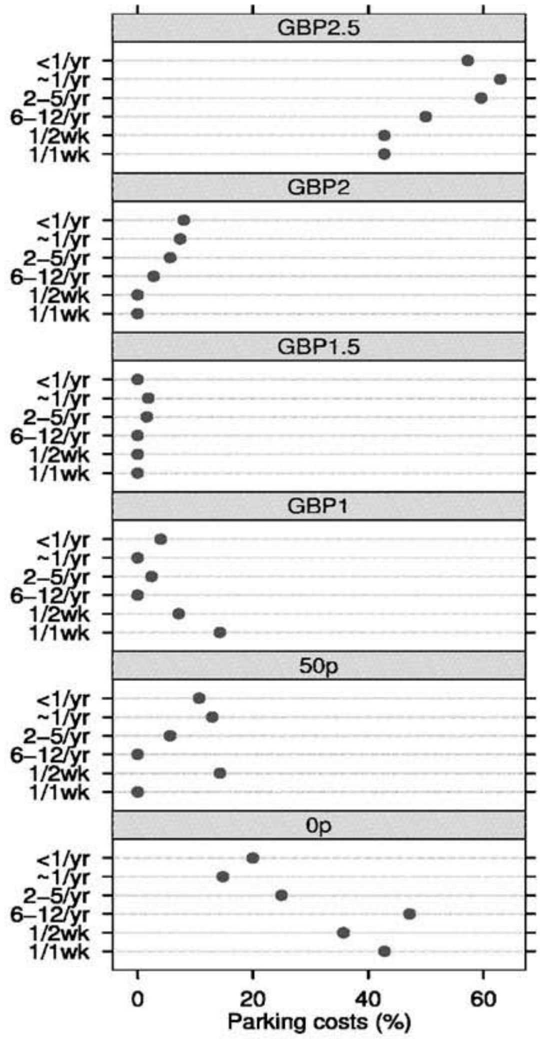


Figure 6. Parking cost by frequency of visits



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However, the distribution of parking costs by income categories does not show as clearly differentiated a pattern as that of age. Therefore, not only income but also other effects, such as distance from the Information Centre, contribute to the difference in the age categories. Even though the nearest free parking area (Derwent Overlook) is only 557 yards (~510 meters) from the Information Centre, the distance could be too long for babies in young families and elderly people. Moreover, many families and elderly people brought chairs and other large equipment with their cars to relax in the area around the Information Centre. It is difficult to carry such equipment by hand even for a few hundred yards.

The distributions of the parking cost by frequency of visits are different. As shown in the figure, frequent visitors are less likely to park their car at the Information Centre, thereby avoiding the parking fee. In contrast, infrequent visitors do not mind paying £2.50 for a day ticket as much as frequent visitors do. This trend is easily predictable, i.e., you may not go to the Valley every week if you pay a parking fee every time you visit, so you park somewhere else to visit the Valley more frequently.

ESTIMATION RESULTS OF PARKING AND MODE CHOICE

Parking Locations with Willingness to Pay Road User Fee

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The decision whether or not to park at the Information Centre shows the positive relationship between the WTP and the road user fee. Income level, which is commonly chosen as an explanatory variable, shows a positive relationship with the WTP (Jacobsen and Hanley). The fitted linear functions from the regression model are below:

Not park at the Centre: $WTP = 1.269 + 0.03(\text{Income})$
Park at the Centre: $WTP = 1.911 + 0.03(\text{Income})$

This means that visitors who park their car at the Information Centre pay 64.2 pence (£1.911 minus £1.269) more than others pay for the road user fee (Table 3). This looks like a small amount; however this is not negligible since the planned road user fee (toll) will be no more than £3 (Derbyshire County Council, 2003 per. com.), i.e., the effect of parking location is at least a quarter of the toll. The positive coefficient of income is a standard effect for any WTP analysis. If visitors earn more income, they do not mind paying a few extra pounds to visit where they want.

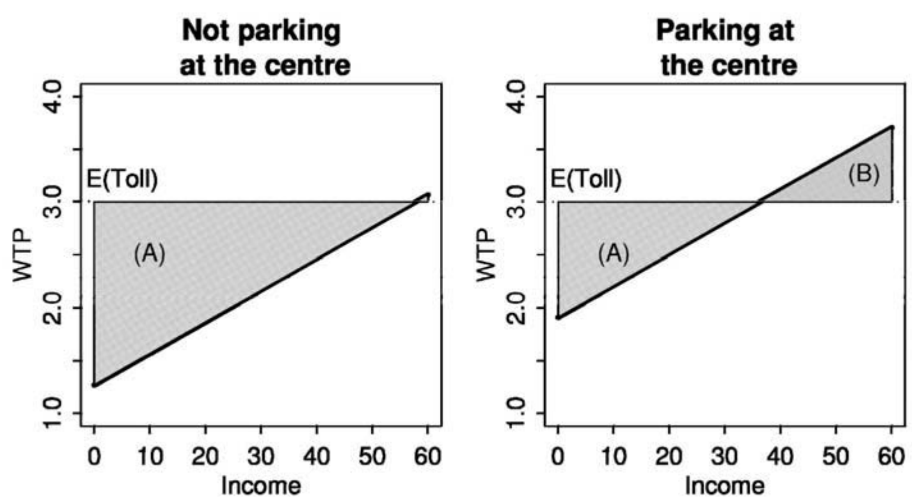
The difference between the two groups is more remarkable in Figure 7. For example, if the local authority charges toll fare at the maximum planned amount (£3), the user deficit of visitors will be generated as shown in the triangular zones (A) of Figure 7. The WTP the road user fee is lower than the toll fare at any given income level in the triangular zones. Similarly, the other triangular zone marked (B) is user surplus since users pay less than they are actually willing to pay. The user deficit is much larger in the group "Not parking at the Information Centre." The user surplus (left side of Figure 7) is almost invisible in this scenario, suggesting that the £3 fee is too expensive for this group. Consequently, the effects of the road user charging scheme will not be the same for all visitors to the Upper Derwent Valley. Some visitors avoid paying a parking fee and so they will be more reluctant to return to the Valley after the implementation of the scheme.

Table 3. Regression analysis for the WTP

Coefficients:	Estimate	Std. Error	t-value	Pr(< t)
(Intercept)	1.269	0.340	3.730	0.0002
Income (× £k/yr)	0.030	0.009	3.187	0.0017
Park location	0.642	0.293	2.190	0.0297

R^2: 0.0747

Figure 7. Difference between the WTP and maximum toll fee (unit: GBP)



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This is a problem with the road user fee, i.e., everyone pays the fixed fee no matter the WTP (Eckton, 2003).

Estimation Results of a Discrete Choice Model

This section analyzes potential mode choice of visitors after implementation of the road user fee and park and ride schemes. Overall, 48 respondents did not answer the section of stated preference questions properly; so 275 questionnaires were used for this analysis. All possible combinations of models with several input variables and alternative-specific constants (ASCs) were tested. The correlations among three alternatives were insignificant, so that both the nested logit model and the error component model of the mixed logit model were also insignificant. Such insignificant correlations among alternatives could be due to a simultaneous decision-making process since destination (Trip | Cancel) and mode (Bus | Auto) are likely to affect the processes simultaneously in this situation (Steiner and Bristow, 2000).

The heteroscedastic taste of time and cost with the multinomial mixed logit model are significant, but no socio-economic factors are significant. Possibly, socio-economic factors are efficiently captured by the taste variation of the mixed logit model. The insignificant group size can be explained by the discussion on the marginal or average road pricing principle (Nash, 2003; Rothengatter, 2003). In this case, a road user fee seems to be as effective as the marginal pricing principle, so that the additional trip members are not as important as the first member to calculate the travel cost, i.e., the toll is not simply divided by the number of trip members.

The multinomial mixed logit model with the normal distribution was selected for analysis. Moreover, the lagged dependency from former to successive questions was inevitable in this situation since the data were collected by a stated preference survey, so that a panel data structure was also applied (Honore and Kyriazidou, 2000). The best-fitted utility functions with the multinomial mixed logit model are:

$$
\begin{aligned}
\text{Auto: } V_i^A &= \alpha^{\text{Auto}} + \beta^{\text{time}}(\text{Toll + Parking fee}) \\
&\quad + \beta^{\text{time}}(\text{Search and walk}) \\
\text{Bus: } V_i^B &= \beta^{cost}(\text{Bus fare + Parking fee}) \\
&\quad + \beta^{time}(\text{Headway}) \\
\text{Cancel: } V_i^C &= \text{?cancel}
\end{aligned}
$$

The log-likelihood ratio test showed that the parameters for costs and time are generic. Thus, no alternative specific coefficient is present in these utility functions. Also, the test showed that the multinomial mixed logit model significantly improves the model fitness compared with the conventional multinomial logit model. These functions do not show a mean and standard error for the coefficients of cost, time, and lagged dependent variable, but these are expressed in the summary statistics for the estimates of the utility

Table 4. Estimation Result of a Multinomial Mixed Logit Model

Coefficient		Estimate	Robust Std. Error	Robust t-value	
α^{Cancel}		-4.627	0.299	-15.497	
α^{Auto}			1.873	0.141	13.277
β^{cost}	m	-0.704	0.040	-17.463	
	σ		0.089	0.043	2.058
β^{ime}	m	-0.051	0.003	-15.019	
	σ		0.025	0.004	7.120
lagged	m	[fixed]	-	-	
	σ		3.070	0.222	13.819

Note: m and σ represent means and standard errors of coefficients respectively.

Number of observations = 3,840

L(0) = -4218.67

L(β) = -2730.05

$\bar{\rho}$ = 0.351

functions as shown in Table 4. The cost and time attributes are presented in pounds and minutes, respectively.

The base unit of this model is a visitor group with an average membership of 2.99 people, but not an individual. Modeling based on individuals could be preferable. However, each visitor group traveled together by the same mode, and the purpose of the road user charging scheme is to reduce the number of cars going to the Valley. Therefore, the model based on visitor groups is sensible for the purpose of this scheme. All six coefficients have no significant correlation with one another as calculated by the robust t-test.

Parameter Explanations of a Discrete Choice Model

As shown in Table 4, the positive α^{Auto} shows a preference of Auto when the remaining variables are constant. Similarly, the strong negative α^{Cancel} shows that the trip to the Valley is of great value to visitors. α^{Auto} is different from the average WTP for toll fee. This means that the decision-making process of visitors is rather complex and involves many factors including travel time and cost. As expected, the trip-related time β^{time} and cost β^{cost} coefficient have negative signs. The higher the cost or time of an option, the lower the utility. Consequently, an option with strong negative coefficients is less likely to be chosen. The standard errors express that the probabilities of negative coefficients are >99.99% for β^{time} and 97.93% for β^{cost}. Therefore, the problem of positive coefficients is negligible. The positive coefficients are irrational, but the probability of irrationality is small enough to be expressed by misperception and miscalculation. In addition, the positive time coefficient can be explained by the pleasure of walking or driving (Mokhtarian and Salomon, 2001; Redmond and Mokhtarian, 2001). For example, some visitors may enjoy the time spent walking from the third parking area to the Information

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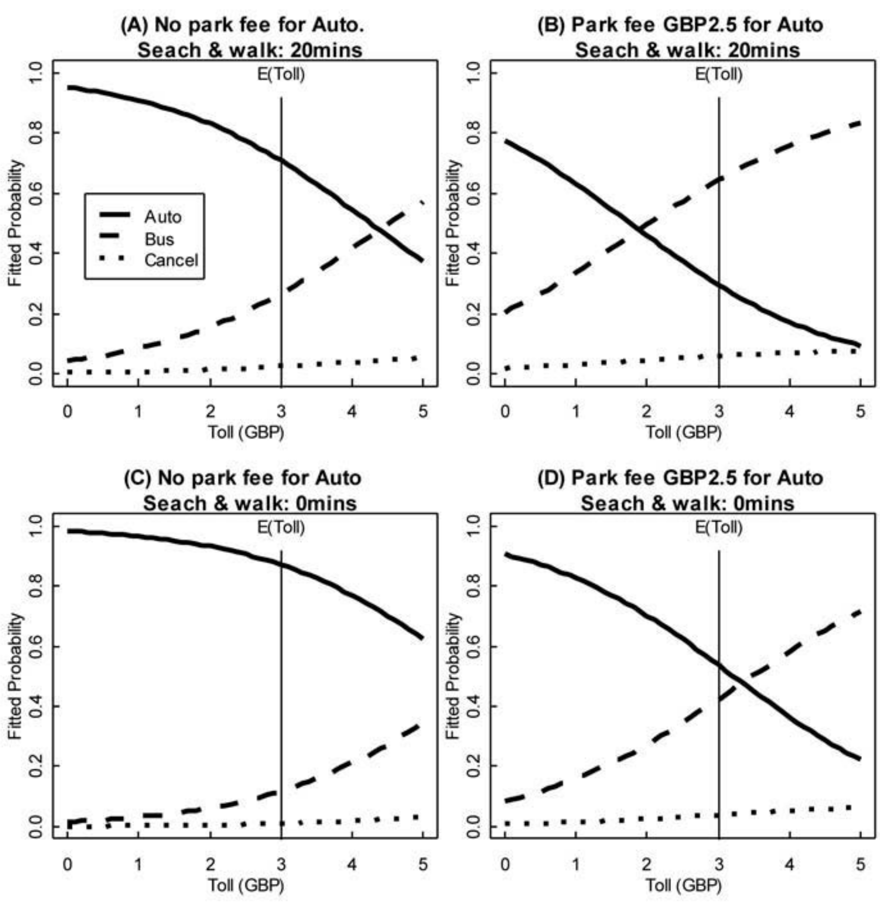
Figure 8. Visualization of the Model Estimation Results



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Centre. A lagged dependent variable is fixed to zero so only the standard error is estimated. The purpose of including a lagged dependent variable as an independent variable is to control the variation from one question to another within an individual. Therefore, this should not affect the result between individuals. Hence, the mean value is fixed to zero.

In this case, the value of time was 7.24 pence per minute, which was calculated from [Value of time = $\beta_{time}/\beta_{cost}$]; so, -0.051/-0.704 = 0.0724 pounds per minute = 7.24 pence per minute. This is close to the non-commuting values of time in the report from the Department for Transport, i.e., 7.55 pence per minute (Department for Transport, 2004).

Figure 8 visualizes the results from the multinomial mixed logit model. Toll price and searching and walking times are the concerns of this project, so the figure shows the probability of each chosen mode according to the change in these two variables. The parking fee for the Bus option is 50 pence, bus fare is 50 pence, and headway is 30 minutes, according to the interview with the local authority. The Auto option has a negative trend, and the Bus and Cancel options have a positive trend against the toll fee. As the toll rises, visitors are likely to stop using their private cars and start using public buses to get to the Valley. Simultaneously, some visitors decide not to go to the Valley and instead go somewhere else or stay at home.

However, this trend is not as strong as that of a mode-shift from Auto to Bus. Additionally, when the two left-hand graphs in Figure 8 (A, C) and the two right-hand graphs (B, D) are compared, the strong effect of the parking fee is recognizable, which favors the Bus option. The effect of "time searching for a parking space and time walking to the Information Centre" works in a similar way to the effect of parking cost. Therefore, visitors in the top right graph (B in Figure 8) use the Bus option relatively more than the visitors in the bottom left graph (C in Figure 8) at any given toll level. All three effects seem to show sensible results in the situation of the Upper Derwent Valley.

The road user fee and the supplemental park and ride schemes have not yet been put into effect, so strictly we cannot assume "Travel by car = Auto option." Therefore, the results may not be able to describe the current situation of travel behavior around the Valley. Nevertheless, the travel behavior at the Information Centre should be similar to the bottom right graph of Figure 8 (D). The behavior of avoiding a parking fee by using other parking areas should be similar to the top left graph of Figure 8 (A). A visitor who parks at the Information Centre pays a parking fee and spends nominal time on searching and walking. Therefore, the visitor is more likely to change his or her travel mode from Auto to Bus compared to other visitors arriving directly at the other parking areas. After the implementation of the £3 toll fee, the probabilities of travel mode are the ones shown in Table 5.

DISCUSSION AND CONCLUSION

For the parking fee policy, the scheme at the Information Centre had an uneven effect on visitors by age, visiting frequency, and the origin of travel. Similarly, the WTP effect differed between visitors parking at the Information Centre and those using the other parking areas. The income effect of the potential new policy, namely the road user charging scheme, was not observed. Therefore, this policy has a potential equity issue. Moreover, the results of the parking fee analysis showed that the strong positive relationship between the WTP and the road user fee and parking locations was also influenced by the parking costs. Therefore, these two policy tools have the problem of double charging, i.e., visitors who are willing to pay a

Table 5. Expected probabilities of each mode choice between parking locations

Park at	Toll (pounds)	W + S (mins)	Parking (pounds)	Probability Auto	Bus	Cancel
Centre	3	0	2.5	0.54	0.42	0.04
Other	3	20	0.0	0.71	0.27	0.02

Note: W + S stands for searching and walking minutes, and Parking means parking fee for the Auto option.

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toll are likely to pay a parking fee.

The road user fee analysis with stated preference data showed more behavioral differences amongst visitors. More than half of visitors who used to park at the Information Centre are likely to keep using their own cars to visit the Valley. More than two-thirds of the visitors who used to park at the other parking areas, in contrast, are likely to keep using their own cars to visit the Valley. This result shows that the effect from the road user charging scheme is not equal for all types of visitors. Elderly and infrequent visitors are more likely to be affected by the road user fee. They are the most likely to park at the Information Centre, so they are more likely to change their travel mode from private car to public bus than the other types of visitors are. Therefore, the road user charging scheme is confirmed to have a possible equity problem as Eckton (2003) suggested.

On the other hand, the purpose of the road user fee is to reduce the congestion level around Derwent Lane, and it is, consequently, effective in achieving this policy aim. As confirmed in previous research, road user charging schemes will reduce environmental impact by lowering congestion levels (Beevers and Carslaw, 2005; Glaister and Graham, 2006; Newbery, 2005). This is the case in the Upper Derwent Valley. The parking areas are located in the natural scenic area and close to one of the most beautiful areas of the National Park and some visitors even enjoy picnics around the parking areas. As congestion is reduced, the value of the natural environment increases because air pollution, traffic noise, and visual intrusion are reduced; therefore, this transport mode policy should also focus on the environmental issues (Hensher, 2002). This will consequently increase the economic value of the Valley and will match the WTP for the toll fee, £3, which is considered expensive based on this analysis. Although a toll is a policy tool and not a payment to use the Valley, strictly speaking, it is important to consider this aspect as well when policy makers consider the equity issues mentioned above. Anyone has a right to consume the value of the Valley as an environmental public good.

This is the beyond the scope of this paper, but if the elderly do not have an alternative to visit the Valley due to its easy private car access and relatively short distance from their residence, they are more likely to be affected by this new monetary tool. Younger visitors may travel easily using the associated park and ride scheme, even with picnic equipment. In contrast, the park and ride scheme may not be a useable support for the elderly if they need to carry a chair to enjoy a picnic in the Valley. This paper still recommends implementing the road user fee in the Valley to reduce the environmental impact of visitors and to maintain its natural beauty; however, some exemption for the elderly to visit the Valley will be an appropriate consideration to reduce the equity issues associated with the scheme. The previous study also confirmed that the equity issues of road user charging are eased by appropriate scheme design, and exemptions will improve the political acceptability of the charge (Bureau and Glachant, 2008) and the social cost and profit of the scheme.

Moreover, this econometric analysis has some shortcomings. The multinomial mixed logit model for mode choice could not utilize the socio-economic characteristics of visitors in this case study, although this analysis briefly discussed equity issues among different socio-economic groups. In addition, since a model addressing the parking network in the Upper Derwent Valley is absent from this analysis, the congestion level at each parking area is unclear. For example, in using the parking location model we assume that a visitor can definitely park at the Information Centre if the visitor decides to park there. This is because these models cannot formulate the concept of congestion, which requires dynamic interaction among visitors (Stopher, 2004). Future research is recommended to consider these problems to improve the modeling quality.

This economic analysis of a road user fee first identified the characteristics of one-day visitors to the Upper Derwent Valley. Most visitors come from local areas and two neighboring cities and a large number of visitors are families and elderly people. Then, the characteristics of visitors differed according to parking area. The parking locations were strongly correlated with the current policy tool, a parking fee, so the policy tool affects visitors differently. Finally, the analysis using the stated preference data and the WTP a road user fee showed that the proposed road user fee and the park and ride schemes had equity problems. On the other hand, this paper confirmed that the policy tool would significantly reduce congestion and consequently the environmental impact of visitors to the Upper Derwent Valley.

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