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Benefits and Costs of Resource Policies Affecting Public and Private Land

Thirteenth Interim Report

June 2000

Introduction

This volume contains the proceedings of the 2000 W-133 Western Regional Project Technical Meeting on "Benefits and Costs of Resources Policies Affecting Public and Private Land." The meeting was held in conjunction with the 2000 Western Regional Science Association Meeting at the Sheraton Kauai Resort, Kauai, Hawaii, February 28 – March 1, 2000. The meeting included a joint WRSA-W-133 session that was attended by many WRSA participants.

The Kauai meeting was attended by academic faculty from many W-133 member universities in addition to researchers from non-land grant universities, federal agencies and private consulting firms. A list of those who attended the meeting follows.

The papers included in this volume represent a wide-range of current research addressing the W-133 project objectives, which are: 1) benefits and costs of agro-economic policies, 2) benefits transfer for groundwater quality programs, 3) valuing ecosystem management of forests and watersheds, and 4) valuing changes in recreational access. The complete program for the meeting follows the list of participants.

The trip to Kauai was a long one for most and made the meetings this year smaller than those in recent years. The overwhelming opinion of those who made the trip was that it was well worth it. The sessions were stimulating and the scenery and weather were superb. I'd like to thank Jerry Fletcher, John Loomis, Frank Lupi, Douglass Shaw for their help with this year's meeting and special thanks to David Plane of WRSA for taking care of so many of the logistics of the meeting.

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A New Approach to Random Utility Modeling with Application to Evaluating Rock Climbing in Scotland

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A New Approach to Random Utility Modeling with Application to Evaluating Rock Climbing in Scotland

ABSTRACT

We introduce a new econometric approach to the analysis of site choice data, the Dirichlet multinomial model, which has a number of advantages over the standard conditional multinomial logit model. We use this model to estimate the impacts on per-trip consumers surplus of alternative management strategies for popular rock climbing sites in Scotland. The management alternatives are increasing access time to the crags and charging a car parking fee. Results show that the Dirichlet approach gives more precise coefficient and welfare estimates in this case. We also compare classical welfare measures with their posterior equivalents.

INTRODUCTION AND POLICY CONTEXT

A. Rock-climbing in Scotland

This paper is concerned with the estimation of the impacts on per-trip consumers surplus of management alternatives for a recreational resource. We use the example of popular rock-climbing areas in Scotland and model the impacts of a range of increases in both the time necessary to access crags on foot from parking areas and the direct money cost of access. In order to produce welfare estimates, we introduce a new way of modeling site choice data, the Dirichlet multinomial model, which turns out to have some advantages over the standard approach found in the literature. We do not attempt to represent changes in participation following the introduction of time or direct money charges; for a paper which attempts to do this using a conventional repeated nested logit model, see Hanley, Alvarez-Farizo and Shaw [7].

Rock climbing is one of the fastest-growing leisure activities in the United Kingdom, and shows a rising trend for Scotland over the period 1945-95 according to a variety of indicators (Wightman, [21]). Around 767,000 mountaineers from the UK visited the Highlands and Islands of Scotland for hillwalking (hiking on hills >2500 ft), technical climbing, ski mountaineering or high level cross-country skiing in 1995, the most recent year for which data is available (Highlands and Islands Enterprise [8]). This gave an estimated total number of rock climbers of between 82,836 - 153,400, spending a predicted total of 1,159,704 - 2,147,600 total climbing days in the area. Although almost all rock-climbing areas are located on private land, access is free in the sense that no monetary access fee is charged. A strong cultural resistance to charging for access to the hills has developed since mountaineering became established in Scotland at the end of the 19th century. However, the growth in participation in mountaineering of all types has led to an increasing number of problems in popular areas, including footpath erosion, the disruption of wildlife, and congestion. This has led a number of bodies, such as the National Trust for Scotland (which owns several mountain areas) and private landowners, to look at alternative means of restricting access. In the Cairngorms (the most visited mountain area in our survey), a "long walk in" policy has been introduced at some sites, whereby car and bicycle access to crags has been banned, thus increasing the time it takes to walk to the crags from parking areas. In other areas, parking charges have been proposed as a feasible and effective means of restricting access (most climbing sites have very few access points where cars may be left).

In the random utility travel cost model, recreationists make probabilistic choices over where to visit from amongst a set of choice alternatives, based on the attributes of these alternatives. Travel cost has always been viewed as a very important attribute, as it provides the key to obtaining consumer surplus estimates for changes in recreation site quality and/or availability. Many researchers include travel time along with petrol costs as one element of travel costs. This follows from a household production view of demand which recognizes that recreational time has a positive opportunity cost. More recently, Shaw and Feather [18] have argued that time should be included separately to travel costs. Whichever view is correct, travel time is a potentially relevant attribute in terms of demand. For rock climbers, travel time is composed of two elements: the time taken to drive to the nearest point of access to their target crag from their home; but also the time it takes to walk to the foot of the crag. This can be anything up to four hours for some popular crags in Scotland. We anticipate that, other things being equal, climbers will prefer sites with lower access times. Since income possesses a positive marginal utility in the random utility model, we also anticipate that charging a car parking fee where none currently exists will lower utility.

B. Literature review

An interesting paper by Louwenstein [13] sets out reasons why the actual behaviour of climbers may lie outside the explanatory power of utility theory. Despite this allegation, several papers have applied random utility demand models to climbing. Shaw and Jakus [19] estimate demand models based on a survey of members of the Mohonk Preserve in New York State in 1993. A site choice model based on choices between four sites (Mohonk, Ragged Mountain, the Adirondacks and the White Mountains) was estimated, using two site attributes: (i) travel costs (from respondent's home); and (ii) the number of routes within each area which the respondent was technically able to climb. This was estimated jointly with a double-hurdle count model which controlled for the participation decision (whether to go climbing at all), in addition to the decision as to how many trips to make to Mohonk, given a decision to climb. Estimates from these models were then used to produce consumer surplus figures for changes in climbing opportunities at Mohonk. Hanley et al [6] use a standard multinomial logit model of rock-climbers in Scotland combined with a count model, to look at the determinants of both site choice and participation. Hanley, Alvarez-Farizo and Shaw [7] use a similar data set to estimate a repeated nested logit model of site choice and participation.

In the US, Cavlovic et al [2] report results from a national repeated nested random utility model of climbers, which estimates the welfare losses associated with closing access to certain sites on Forest Service lands. Principal attributes governing site choice were the number of rock climbing areas in a region and climate. Results showed that proposed changes had welfare losses in excess of $100million per annum. In a similar context, Cavlovic and Berrens [1] carried out a climbing participation study of 1,084 members of the general public. They found that gender, education and membership in environmental organizations were all significantly related to participation in 1998, although income was not. Finally, in a somewhat different vein, Jakus and Shaw [9] analyzed the response of climbers to hazard warnings relating to the degree of protection on routes. They found that more skillful climbers were more likely to undertake hazardous climbs than less-skillful climbers, but that they "mitigate the likelihood of a hazardous outcome by reducing the technical difficulty of the hazardous route chosen" (page 581). Their empirical results add to the support for an underlying economic rationale behind climber decision-making.

This paper contributes to this literature by using a new econometric approach to estimate changes in per-trip welfare for a range of management alternatives at popular climbing sites in Scotland. In what follows, section 2 outlines the econometric approach taken and the reasons for choosing it. Section 3 describes the sample collection procedures and sample characteristics. Results are presented in section 4 and then some conclusions close the paper.

ECONOMETRIC APPROACH

A. Background

A conventional recreation site choice model is the random utility model (RUM) of McFadden [16]. This model possesses useful properties for analyzing the site allocation problem because visitation data are discrete and the model can be used to estimate exact per-trip welfare measures for site quality changes. Here we consider that the i^{th} ($i=1, 2, \ldots, N$) individual's indirect utility for the j^{th} ($j=1, 2, \ldots, J$) site takes the linear form

$$U_{ij} = v_{ij} + \varepsilon_{ij} \qquad (1)$$

where v_{ij} is parameterized to depend upon observed conditioning variables and ε_{ij} is an idiosyncratic term unknown to the observer. When the ε_{ij} are assumed independently and identically distributed as generalized extreme value variates, the probability of selecting site j is generated as

$$\pi_{ij} = \exp(v_{ij}) / \sum_{k=1}^{J} \exp(v_{ik}) . \qquad (2)$$

Further, expected maximum utility, $E\{\max[v_{i1} + \varepsilon_{i1}, v_{i2} + \varepsilon_{i2}, \ldots, v_{iJ} + \varepsilon_{iJ}]\}$, has a simple closed form expression which may be evaluated if the v_{ij} terms are known or estimated.

The multinomial or, perhaps more precisely, the conditional logit model (see Greene [4] for the somewhat arbitrary distinction) is customarily used to estimate the parameters of v_{ij}. Specifically let y_{nj} denote the number of trips for the i^{th} ($i=1, 2, \ldots, N$) individual to the j^{th} unique site. Let $Y_i = \sum_{j=1}^{J} y_{ij}$ denote aggregate trips for the i^{th} individual to all the sites of interest. Now suppressing the i^{th} individual's index, if the $y_1, y_2, \ldots, y_J$ are independently distributed as Poisson, i.e. $y_j \sim Po(\mu_j)$, then these results follow:

i) Y is distributed $Po(\mu = \Sigma\mu_j)$

ii) $$P(Y_1 = y_1, Y_2 = y_2, \ldots, Y_J = y_J | Y) = \prod_{j=1}^{J} \mu_j^{y_j} e^{-\mu_j} (y_j!)^{-1} \Big/ \mu^Y e^{-\mu} (Y!)^{-1}$$

$$= \frac{Y!}{y_1!y_2!\ldots y_J!}\left(\frac{\mu_1}{\mu}\right)^{y_1}\left(\frac{\mu_2}{\mu}\right)^{y_2}\ldots\left(\frac{\mu_J}{\mu}\right)^{y_J}$$

$$Mn(\mathbf{y}|\pi, Y) = \frac{Y!}{y_1!y_2!\ldots y_J!}\pi_1^{y_1}\pi_2^{y_2}\ldots\pi_J^{y_J}; \quad \text{where } \pi_j = \mu_j/\mu$$

iii) The independent, non-negative, integer valued variables $y_1, y_2, \ldots, y_J$ have Poisson distributions if and only if the conditional distribution of these variables for the fixed sum $\sum y_j = Y$ is a multinomial distribution (Johnson et al., [11]).

Result i) follows from the reproductive property of the Poisson distribution (Johnson et al., [10]). Result ii) explicitly links the multinomial distribution, denoted as Mn(.), to a conditional multivariate distribution of independent Poisson variates. Result iii) provides the converse of the result in ii), namely that a multinomial distribution implies Poisson distributions for the components of Y. Yet if the $P(Y_j)$ are not exactly distributed as $Po(\mu_j)$, then there can be no claim that the conditional distribution is indeed multinomial. In other words, the multinomial specification imposes stringent requirements on the underlying data. While travel cost modelers of recreation demand who attempt to model either the number of visits to a single site, y_j, or aggregate visits to closely related sites, Y, routinely consider alternatives to the Poisson distribution in the event of over-dispersion or excess zeros, random utility modelers rarely concern themselves with such possible distributional misspecifications.

Pearson's χ^2 statistic (McCullagh and Nelder, [15]) can be used to assess the presence of distributional misspecification. The test statistic has the form

$$X^2 = \sum_{ij} (y_{ij} - E(y_{ij}))^2 / V(y_{ij}). \qquad (3)$$

For the multinomial model the summation is over all individuals and all alternatives, where $E(y_{ij} \mid Y_i) = Y_i \hat{\pi}_{ij}$ and $V(y_{ij} \mid Y_i) = Y_i (\hat{\pi}_{ij} - \hat{\pi}_{ij}^2)$. Under the null hypothesis of proper specification, the test statistic is asymptotically distributed as χ^2 with $N(J-1) - K$ degrees of freedom. Here K represents the number of estimated parameters. Unfortunately, rejection of the null may leave the random utility modeler with no known alternatives to the multinomial model.

Fortunately the multinomial distribution is a member of the linear exponential family of probability density functions and as such can provide consistent estimators of the conditional means of the y_j even though the true distribution of the data is not multinomial (Gourieroux et al.,[3]). Under this misspecified maximum likelihood approach, termed pseudo- or quasi-maximum likelihood, standard errors of estimated parameters may be consistently estimated using the robust or sandwich method (White [20]; Gourieroux et al.[3]). So in lieu of having the estimated multinomial logit model pass a specification test, random utility modelers can be assured of conducting proper inference if robust standard errors are calculated for the estimated parameters. A drawback to this procedure is that the modeler sacrifices efficiency by not addressing the distributional misspecification. In general this will result in less precisely estimated parameters and may potentially affect the statistical significance of calculated welfare measures.

B. The Dirichlet Multinomial Distribution

Random utility modelers may be unaware that there are alternatives to the multinomial logit model which can accommodate distributional violations such as over-dispersion of the visitation data. Recall this may be a problem if the units of observation (individuals or zones of origin) display multiple trips to one or more sites since these trip counts are required to be Poisson distributed under the multinomial distribution. We consider the Dirichlet multinomial (Dm) model which was first derived by Mosimann [17], although in a somewhat restrictive form. More recently the distribution has been presented in an empirical Bayes framework (Leonard and Hsu [12] ; Lwin and Maritz [14]). Below we outline its derivation and comment on several of its interesting properties. In the subsequent development note that the observational index, i, has been suppressed.

Let $y_1, y_2, \ldots, y_J$ possess a multinomial distribution ($\Sigma y_j = Y$) with corresponding cell probabilities $\pi_1, \pi_2, \ldots, \pi_J$ and define the J-1 dimensional unit simplex $S_U = \{(\pi_1, \pi_2, \ldots, \pi_J): \pi_j > 0, \Sigma\pi_j = 1\}$. Now assume that the prior distribution of $\pi_1, \pi_2, \ldots, \pi_J$ is Dirichlet with parameters $\alpha\theta_1, \alpha\theta_2, \ldots, \alpha\theta_J$ ($\theta \in S_U$, $\alpha > 0$). This prior distribution is chosen since it is a conjugate prior for the multinomial distribution and is written as:

$$f(\pi|\alpha, \theta) = \frac{\Gamma(\alpha)}{\prod_{j=1}^{J} \Gamma(\alpha\theta_j)} \prod_{j=1}^{J} \pi_j^{\alpha\theta_j - 1} .$$

Now the joint distribution of $y_1, y_2, \ldots, y_J$ is obtained by integrating out the π_j. That is we wish to evaluate

$$\int\int\ldots\int_{S_U} \frac{Y!}{\prod y_j!} \prod \pi_j^{y_j} \frac{\Gamma(\alpha)}{\prod_{j=1}^{J} \Gamma(\alpha\theta_j)} \prod_{j=1}^{J} \pi_j^{\alpha\theta_j - 1} d\pi .$$

This results in the Dirichlet multinomial distribution which has probability mass function

$$p(\mathbf{y}|\alpha, \theta, Y) = \frac{Y!\,\Gamma(\alpha)/\Gamma(Y+\alpha)}{\prod\{y_j!\Gamma(\alpha\theta_j)\}} \prod \Gamma(y_j + \alpha\theta_j)\,; \quad \text{such that } \theta \in S_U,\ \alpha > 0. \qquad (4)$$

By specifying a Dirichlet prior for the multinomial probabilities an additional parameter, α, has been introduced. The θ_j, like the multinomial π_j, may be interpreted as probabilities. The relationship between the first two central moments of the two multivariate discrete distributions makes this evident.

Moment	Multinomial	Dirichlet Multinomial
$E(y_j \mid Y)$	$Y\pi_j$	$Y\theta_j$
$Var(y_j \mid Y)$	$Y(\pi_j - \pi_j^2)$	$\rho Y(\theta_j - \theta_j^2)$
$Cov(y_j y_k \mid Y)$	$-Y\pi_j\pi_k$	$-\rho Y\theta_j\theta_k$

Here $\rho=(Y + \alpha)/(1 + \alpha)$ and, since it is strictly greater than zero, this factor provides for over dispersion of the conditional variances and covariances of the y_j. Thus the larger the value of ρ (or the smaller the value of α), the more diverse is the sample from what would be expected under multinomial sampling (Wilson, [22]). Note that as $\alpha \to \infty$, $\rho \to 1$ and consequently the moments converge in this case. In fact it can be shown that as $\alpha \to \infty$, then $p(y \mid \alpha, \theta, Y) \to \frac{Y!}{\prod y_j!} \prod \theta_j^{y_j}$, that is the Dm distribution converges to the multinomial distribution as the α parameter goes to positive infinity.

This result can be exploited to construct a test of the multinomial versus the Dm distribution. Simply define $\gamma = 1/\alpha$ and maximize the log likelihood over the N observation sample. For the ith individual the log likelihood is

$$\ell_i = \ln(Y_i!) + \ln\Gamma(\gamma^{-1}) - \ln\Gamma(Y_i + \gamma^{-1}) + \sum_{j=1}^{J}\{\ln\Gamma(y_{ij} + \gamma^{-1}\theta_{ij}) - \ln\Gamma(\gamma^{-1}\theta_{ij}) - \ln(y_{ij}!)\}. \quad (5)$$

Maximizing $\sum \ell_i$ should in principle be no more computationally demanding than estimating a negative binomial regression model. Upon convergence, a test of $\gamma = 0$ can then be conducted. Failure to reject this hypothesis would suggest that the underlying data generating mechanism was the multinomial distribution.

Finally the empirical Bayes derivation of the Dm distribution permits a posterior analysis. Given the prior density of π, $f(\pi \mid \alpha, \theta)$, and the Dirichlet-multinomial distribution of **y**, $p(\mathbf{y} \mid \alpha, \theta, Y)$, which can be used to identify θ, then the posterior density of π is $Mn(\mathbf{y} \mid \pi, Y)f(\pi \mid \alpha, \theta)/p(\mathbf{y} \mid \alpha, \theta, Y)$ or specifically

$$f^*(\pi|\alpha, \theta, \mathbf{y}) = \frac{\Gamma(\alpha+Y)}{\prod_{j=1}^{J}\Gamma(\alpha\theta_j + y_j)} \prod_{j=1}^{J} \pi_j^{\alpha\theta_j + y_j - 1} .$$

The posterior mean of π_j is $$\pi_j^* = \frac{y_j + \alpha\theta_j}{Y+\alpha} . \tag{6}$$

This expression makes explicit how observed behavior and estimators determined by the data affect the magnitude of the posterior probabilities. Also note that as $\alpha \rightarrow \infty$ the posterior mean, π_j^*, converges to the probability θ_j, showing that the information incorporated in the prior distribution is uninformative. We now outline the procedure by which data were collected to estimate the Dirichlet multinomial model.

SAMPLE COLLECTION PROCEDURE AND SAMPLE CHARACTERISTICS

A. Sample collection procedure

The initial steps in the empirical part of this study were to identify the appropriate choice set for Scottish climbers and to check on relevant attributes to describe these choices. To accomplish this, focus groups were conducted with climbers from university mountaineering clubs in Edinburgh and Stirling. In terms of the choice set, eight principal climbing areas were identified. These were the Northern Highlands, Creag Meagaidh, Ben Nevis (including Glen Nevis), Glen Coe (including Glen Etive), the Isle of Arran, Arrochar, the Cullins of Skye and the Cairngorms. This meant we excluded some more minor climbing locations such as sea cliffs and lowland quarries and outcrops. The focus groups identified travelling costs and approach time to the crags from the road as relevant attributes in deciding where to visit on any given occasion.

The sampling frame was provided by the Mountaineering Council of Scotland through a list of climbing club members in Scotland. A random sample of addresses was selected and questionnaires mailed to these individuals, who were asked to complete and return the questionnaire. A donation of £2 was promised to the John Muir Trust (a charity which exists to conserve wilderness areas in Scotland) for every questionnaire returned as an incentive. To widen the sample in terms of representativeness, questionnaires were also administered at indoor climbing walls in Edinburgh, Glasgow and Falkirk (many climbers do not belong to official mountaineering clubs). One major problem which became apparent with the sampling frame was that we had no way of identifying which members of a given mountaineering club were actually rock climbers and which were just hill walkers. This resulted in a very large number of questionnaires being returned by hill-walkers. Since many of the questions did not apply to them, thus a number of additional mail-outs became necessary. Nevertheless, a sample of 267 useable responses from climbers was eventually acquired of which 245 surveys had sufficient detail to permit estimation.

Climbers were asked questions relating to their total trips in the last twelve months (both summer and winter) to each of the 8 climbing areas noted above; to evaluate each area in terms of the access time attribute; to provide us with their post code (zip code) so that distance from home to sites could be computed; to provide information on spending related to rock-climbing; to provide information on their climbing abilities and experience; and finally, to provide us with standard socio-economic information. Trip lengths to the sites were computed by the authors using Autoroute (travel distance from home). Travel distance was converted into travel costs using a per-mile cost of 10 pence, which reflects the marginal (petrol) cost of motoring. For the two sites that can only be accessed by ferry (Arran and the Cullins), round trip travel costs were augmented by the appropriate fares.

B. Descriptive statistics for the sample

Some 55% of all climbers questioned were in the 25-40 years age bracket, which exhibited twice as many climbers as in any other age group. 19% and 24% of climbers were in the age brackets under 25 years and 41-55 years respectively. Only 2% of climbers were aged over 55 years. The majority of those responding were male (79%). 55% of the sample were single, whilst 29% of those interviewed had children. The majority of climbers (71%) were university degree holders with a further 16% having completed a certificate or diploma. The mean household income before tax was £27,111, which is considerably in excess of the Scottish mean. Climbers in the sample were thus high income and highly-educated on average.

Over 58% of climbers had been climbing for 10 years or less, with another 28% stating that they had been climbing for between 10 and 20 years. In terms of participation, 36% of all respondents completed 25 climbs or less in a year, with the next largest group of 31% of respondents completing from 26 to 50 climbs. Overall the mean number of climbs completed per year (any given year) was 57, with the median at 40 and mode at 100 climbs. Since more than one route is typically climbed per trip, mean trips were much lower at 14.2 per year, with the average length of trip being just over one day in duration. Climbers claiming more than 99 trips per annum were dropped from the data set prior to estimation as there was concern that their activities were business related rather than recreational.

RESULTS

A. Estimation

Table I presents the estimation results for the conditional logit model fit to the data on eight sites and representing 245 individuals. Travel cost and access times both have the expected negative coefficients. Additionally site specific dummy variables were added to account for unobserved differences between the sites. Evidence of misspecification is manifested both by the substantial differences in the robust and conventional standard errors for the cost coefficient and by Pearson's specification test (p=.0000). As a consequence the Dm distribution was adopted and these estimation results appear in Table II.

Here we see that now conventional and robust standard errors correspond more closely and that the payoff to the more efficient estimator is smaller robust standard errors for the parameters of interest. Pearson's test does not reject the null of proper specification at standard levels of statistical significance (p=.2534). A robust Wald test of the null hypothesis that $1/\alpha=0$ (implicitly that $\alpha=\infty$) yields a test statistic of 73.6 (p=.0000). Further investigation of the precision of the robust standard errors in both models was performed by comparing them to those obtained by bootstrap methods. Results (available from the authors) indicated a very close correspondence. Thus we conclude that there is significant over-dispersion (relative to the multinomial) and that the Dm probability mass function is appropriate for these data.

B. Welfare Analysis

Following the approach of Hanemann [5], write the systematic component of indirect utility for site j when the individual specific index is suppressed as

$v_j = \beta p_j + h(\mathbf{q}_j)$

where p_j is travel cost and $\mathbf{q}_j$ is a vector of site-specific attributes. In this no income effects model consumers surplus is

$C = -1/\beta[V(\mathbf{p}^1, \mathbf{q}^1) - V(\mathbf{p}^0, \mathbf{q}^0)]$; where $V = E\{\max[v_1 + \varepsilon_1, v_2 + \varepsilon_2, \ldots, v_J + \varepsilon_J]\}$.

For the Dirichlet multinomial model when the θ_j are expressly parameterized as

$\theta_j = \exp(v_j) / \sum_{k=1}^{J} \exp(v_k)$, then $V = \ln \sum_{k=1}^{J} \exp(v_k) + .577215665$.

Thus welfare analysis follows the same methodology as for the conditional logit model. Welfare measures for a number of changes in entry fees and approach times are presented in Table III. The welfare measures from the Dirichlet multinomial model are generally about five to fifteen percent larger than their conditional logit counterparts. Also the bootstrapped standard errors and confidence intervals almost uniformly show that the Dm based welfare measures are estimated as precisely or more precisely than those from the conditional logit approach.

The results in Table III stem from considering possible strategies for limiting access at three of the four most popular climbing sites in Scotland. Site 3 (Ben Nevis) accounts for 11% of the trips in our sample. Here parking/entry fees are being considered as a means for reducing visitation rates and providing improved parking facilities. We see that the introduction of £3 and £5 fees reduces per trip surplus by £0.37 and £0.59, respectively. This is about half the impact such fees generate at site 4 (Glencoe) due to the fact that it is a more popular destination accounting for about 22% of all trips. Also being considered at site 4 is the re-routing of paths to the crags in order to reduce erosion and wildlife disruption. An hour increase in approach time is revealed to be an important disamenity. A further increase of approach time to two hours at the most popular site,

site 8 (Cairngorms) with 25% of all trips, reveals a per trip reduction in consumer surplus of over £4. Such large reductions in welfare document rock climbers' aversion to long access routes and suggest a strategy for reducing congestion at popular areas.

An additional welfare measure is also available under the empirical Bayes derivation of the Dm model. That is, welfare analysis can be based on both the estimated parameters (using the behavior of all individuals) and each individual's observed behavior. This we term a posteriori welfare analysis, and its derivation obviously differs from the classical approach above since it is conditioned by individual-specific outcomes. Again following Hanemann's no income effects case, the surplus from a change in a single site, v_j, has the form

$$C^* = -1/\gamma \int_{v_j^0}^{v_j^1} \pi_j(v_1,\ldots,v_J)dv_j = -1/\gamma \int_{v_j^0}^{v_j^1} \int \ldots \int_{S_U} \pi_j f^*(\pi \mid \alpha,\theta,y)d\pi dv_j$$

In this case $C^* = \dfrac{1}{Y+\alpha}\left\{-\beta^{-1}y_j v_j]_{v_j^0}^{v_j^1} + \alpha C\right\}$; where $C = -1/\beta[V(\mathbf{p}^1, \mathbf{q}^1) - V(\mathbf{p}^0, \mathbf{q}^0)]$ as before. Notice that C^* explicitly depends on both the individual's trips to site j as well as total trips to all sites—this is a consequence of the posterior analysis. Additionally note that as $\alpha \to \infty$, then $C^* \to C$ as would be expected.

To illustrate the consequences of using the posterior distribution to perform welfare analysis, we consider the implications of (arbitrary) price changes at the least visited site (Arran) and the most visited site (Cairngorms). The first part of Table IV provides descriptive statistics for these two sites. Next, consumers' surplus measures are given for large price changes. Note that the classical welfare measures indicate that for large enough price changes visitation is forced to zero so that further price increases do not affect the subsequent welfare values: for example, for Cairngorms, the fact that visits fall to zero beyond an entry fee of £200 means that increasing it further has no welfare cost. On the other hand, since the posterior welfare measures take into account observed levels of visitation, welfare losses increase without bound. The feature that past behavior is invariant to amenity or price changes is not necessarily attractive or even defensible.

However, for traditional surplus measures the feature that relative modest price changes can drive visitation at a site to zero may not be very realistic, since many committed and wealthy climbers may continue to climb at good sites even if costs increase substantially.

CONCLUSIONS

This paper has applied a new method of analyzing site choice data within a random utility framework to rock-climbing in Scotland. We find that increasing approach times to the crags by re-routing paths to reduce erosion and wildlife disruption may provide the additional benefit of reducing visitation. Apparently rock climbers view longer approaches as a substantial disamenity. The introduction of modest parking/entry fees does not appear to impact welfare nearly to the same extent if the results from site 4 are at all representative. Here the welfare loss from increasing the approach time by an hour is more than twice the loss from imposing a £5 entry fee.

The Dirichlet multinomial (Dm) approach proved to be a superior approach to standard conditional logit modeling in this case, in terms of potential misspecification, in the precision of parameter estimates, and in (generally) tighter confidence intervals for mean consumers' surplus. While the current application of the Dm distribution suggests its relative superiority to the customary conditional logit model, other potential uses may also prove its value. Certainly the over-dispersion parameter, α, could be parameterized to depend on a set of conditioning variables—the only constraint being that it be greater than zero. This might be useful if sampling variability can be linked to individual-specific traits. Another possible extension is in pooling random utility models. In this case the dispersion parameter might vary across data sets. Or if pooling revealed and stated preference data, it might be of interest to investigate whether the dispersion parameter varies between observed and hypothetical behavior.

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Table I.
Maximum Likelihood Results for Conditional Logit Model (N=245)

Variable	Coefficient	StdErr(R)[a]	t-value(R)	StdErr(H)[b]
Cost	-0.0578	0.0062	-9.3133	0.0025
Access	-0.0093	0.0016	-5.9682	0.0011
Site1	0.5585	0.1686	3.3134	0.0612
Site2	-1.4984	0.1197	-12.5152	0.0960
Site6	-1.7092	0.1526	-11.2024	0.0808
Site7	0.8518	0.2039	4.1783	0.0971
Site8	0.4912	0.0920	5.3397	0.0430

Log likelihood value: -6120.59

Pearsons χ^2 statistic: 4249.2 (1708 degrees of freedom)

[a]Robust standard errors calculated as per White
[b]Conventional standard errors calculated from estimate of the Hessian matrix

Table II
Maximum Likelihood Estimates of the Dirichlet Multinomial Model (N=245)

Variable	Coefficient	StdErr(W)[a]	t-value(W)	StdErr(H)[b]
Cost	-0.0484	0.0041	-11.8816	0.0035
Access	-0.0094	0.0014	-6.6758	0.0018
Site1	0.2263	0.1156	1.9582	0.0990
Site2	-1.3707	0.1126	-12.1782	0.1319
Site6	-1.7078	0.1304	-13.0990	0.1254
Site7	0.6396	0.1485	4.3064	0.1357
Site8	0.3897	0.0765	5.0915	0.0698
$1/\alpha$	0.1051	0.0122	8.5782	0.0086

Log likelihood value: -5717.33

Pearson's χ^2 statistic: 1745.4 (1707 degrees of freedom)

[a]Robust standard errors calculated as per White
[b]Conventional standard errors calculated from estimate of the Hessian matrix

Table III
Welfare Measures in £. 200 Bootstrap Replications.

Site	Change	Conditional Logit Mean[a]	Conditional Logit 95% C.I.	Dirichlet Multinomial Logit Mean[a]	Dirichlet Multinomial Logit 95%C.I.
3	+3 Entry	-0.34 (0.02)	-0.39 -0.30	-0.37 (0.02)	-0.40 -0.33
3	+5 Entry	-0.54 (0.03)	-0.61 -0.48	-0.59 (0.03)	-0.65 -0.53
4	+3 Entry	-0.70 (0.03)	-0.77 -0.63	-0.72 (0.03)	-0.79 -0.66
4	+5 Entry	-1.11 (0.05)	-1.23 -1.01	-1.16 (0.05)	-1.27 -1.07
4	60' Approach	-2.00 (0.44)	-2.98 -1.24	-2.47 (0.46)	-3.37 -1.62
8	120' Approach	-3.70 (0.69)	-4.96 -2.47	-4.24 (0.61)	-5.52 -3.04
3&4 **4** **8**	+3 Entry 60' Approach 120' Approach	-7.25 (1.23)	-9.65 -5.04	-8.40 (1.17)	-11.06 -6.23
3&4 **4** **8**	+5 Entry 60' Approach 120' Approach	-7.90 (1.23)	-10.31 -5.68	-9.09 (1.16)	-11.74 -6.92

[a]Bootstrap standard errors in parentheses

Table IV
Closing Sites. Prices and Welfare Measures in £ .

Sample Values	Site 5 (Arran)	Site 8 (Cairngorms)
Average Trips	0.322	4.02
Average Price	60.41	23.83
Price Range	(44.06,105.62)	(2.54,86.02)

Consumers Surplus per Trip

	Site 5			Site 8		
ΔPrice	CL	DM	DMP	CL	DM	DMP
50	-0.39	-0.62	-0.96	-5.44	-5.88	-9.68
100	-0.41	-0.68	-1.60	-5.81	-6.50	-16.58
200	-0.41	-0.68	-2.83	-5.83	-6.57	-29.75
400	-0.41	-0.68	-5.29	-5.83	-6.57	-56.03

CL: Conditional logit
DM: Dirichlet multinomial logit
DMP: Dirichlet multinomial posterior