Destination Choice Models for Rock Climbing in the Northeastern Alps: A Latent-Class Approach Based on Intensity of Preferences

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ABSTRACT. *Rock climbers are likely to exhibit preference heterogeneity dictating the way with which such sport is practiced. This has a reflection on the population's structure of recreational values of rock-climbing destinations, their attributes, and to land management policies. We test this hypothesis on a panel of destination choices by a sample of members of the Italian Alpine Club. Using a latent-class, random utility approach we find evidence in support of the hypothesis that there are at least four classes in the sample, thereby revealing a considerable richness in the structure of preference, which would otherwise be unobservable with more conventional approaches.* (JEL Q26, C25)

I. INTRODUCTION

The use of latent-class models has long been a well-established practice in other sciences (e.g., Langeheine and Rost 1988; Kamakura and Russell 1989; McLachlan and Peel 2000 for a review), and is gradually receiving more attention in environmental and resource economics. Since the seminal papers by Train (1998) and Chen and Cosslett (1998) investigations of unobserved taste heterogeneity in destination choice models of recreation have shown the presence of substantial taste variation among natural resource users, which can only be partially captured by means of the usual interactions with measurable socio-economic co-variates. The modelling of random taste distributions within the framework of site selection random utility logit models has relied on either continuous distributions (Train 1998; Chen and Cosslett 1998; Breffle and Morey 2000) or finite ones (Provencher, Barenklau, and Bishop 2002; Shonkwiler and Shaw 2003; Provencher and Bishop 2004; Scarpa and Thiene 2004). While using continuous-mixture distributions approaches is an undoubtedly elegant way to represent preference variation (Train 2003), it is not without shortcomings in terms of complexity of both modelling choices and estimation (see Hensher and Greene 2003 for a discussion of such shortcomings). For example, it is often difficult to identify an empirically tractable distribution of taste adequate for treating "lumpy" preferences. Such preferences manifest themselves via multi-modal empirical distributions of taste intensities. In this context, the finite-mixture (or latent-class) approach based on endogenous segmentation appears of simple implementation. And it is also appealing for both its ease of estimation via maximum likelihood and its intuitive interpretation and communication to policymakers. The finite mixing approach endogenously assigns individuals to "classes" with identical preferences and estimates the probability of membership to each class along with their respective class-specific preference parameters. The definition of the correct number of classes, how-

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ever, is somewhat arbitrary as there are no exact statistical tests capable of discriminating across competing hypotheses. The empirical evidence over continuous versus finite mixing distributions is still inconclusive, and the debate is still open (Andrews, Ansari, and Currim 2002), although it is likely to remain a sample-specific empirical issue. However, in this occasion we wish to deal with potentially "lumpy" preferences of a sample of rock-climbers, and we hence focus on finite mixing.

Other applications of finite-mixing/latent-class models (LCM) in environmental economics include a small number of papers in which authors report on the use of the technique with stated-preference and attitudinal data (Boxall and Adamovicz 2002; Scarpa, Willis, and Acutt 2003; Morey, Thacher, and Breffle 2004; Menzel and Scarpa 2004; Hu et al. 2004; Scarpa et al. 2005).

In this paper, we report on our use of the latent-class approach to identify the number of classes with homogeneous preference in a large sample of destination choices by rock climbers, and their relative probability of membership to each class. Rock climbing is a rapidly expanding outdoor activity and has recently been the focus of a number of recreation demand studies in the United States and the United Kingdom (Shaw and Jakus 1996; Hanley et al. 2001; Hanley, Alvarez-Farizo, and Shaw 2002; Grijalva et al. 2002a, 2002b; Hanley and Wright 2003). This is the first study, as far as we know, that uses finite-mixing approaches to model discrete choices of destination in mountain recreation. Because such an approach generates parameter estimates for the utility function of each latent class, we only present a selection of estimates, to avoid overwhelming the reader with too much information without an accompanying interpretation. We are careful, however, to describe the relevant details of our analytical approach on a panel of destination choices. More details on the broad strategy behind the results presented here are available from the authors.

In this study, we found some features of the distributions of the implied welfare measures of high policy interest. In the analysis, we have two objectives. First, we examine the richness in patterns of distributions of benefit estimates conditional on observed individual choices. These are derived for each attribute in the destination choice model. The incorporation of observed choices into welfare measure has recently encountered some attention (von Haefen 2003). The second objective is to illustrate the effects of our modelling this type of preference heterogeneity on the distribution of benefits and costs associated with a welfare-neutral user's fee. The associated revenues would be used to increase the number of climbs and the quality of access to them: a policy of potential interest to the local authorities in the Alps. The analysis illustrates how incorporating preference heterogeneity in the model allows a clear identification of losers and winners in the sample. In our application, it emerges that the policy is progressive, redistributing benefits from high-income to low-income members of the sample, which is drawn from the local chapter of the Italian Alpine Club (henceforth abbreviated as CAI). This also is a novel focus, since with few exceptions (e.g., Hutchinson et al. 2003), travel cost applications tend to ignore equity effects, and mainly concentrate on efficiency issues.

The remainder of the paper is divided as follows. In the next section we briefly review the use of finite-mixing, random utility models in environmental economics. Section 3 describes the data and the behavioral rationale for taste heterogeneity underpinning and motivating this study. Section 4 addresses some econometric issues, while the results of the analysis are discussed in Section 5. Section 6 concludes.

II. FINITE-MIXING IN RANDOM UTILITY MODELS

Travel Cost Applications

Recent applications of finite mixing include some travel cost studies of recreational site choice (Provencher, Barenklau, and Bishop 2002; Shonkwiler and Shaw 2003; Provencher and Bishop 2004). Provencher, Barenklau, and Bishop (2002) assumed class membership to be conditional on individual characteristics (age and experience) and captured the dynamic of choice by means of a serially correlated error structure across the sequence of one individual's choices. They concluded that there was some evidence of time dependence across choices and that finite mixing is a convenient and intuitive alternative to mixed logit, especially in terms of computational cost. They use selection criteria for the number of classes and evaluate these criteria for two, three, and four classes finding evidence for three classes with separate preferences. However, they did not find evidence of a group of "seasoned veterans" that behave differently from others, which had been their expectation at the outset.

Shonkwiler and Shaw (2003) also assumed class membership to be conditional on individual characteristics, and emphasized how the two-class models they estimated displayed different marginal utility of income, which is otherwise more cumbersome to account for. They suggested that this could be an elegant, yet uncomplicated way to allow for non-linear preferences for money. This has implications in the valuation of attributes, which differ across groups. They also discussed (as we do here) the potential use of probabilities conditional on observed choices, although they did not use them in the derivation of their welfare estimates.

Provencher and Bishop (2004) model anglers' decisions of recreation participation and evaluate the models' performance on the basis of out-of-sample forecast accuracy. They find evidence of dynamic behavior and that, in their sample, similar results are produced from finite and continuous mixing specifications.

None of the revealed preference studies above focussed on the derivation of individual welfare measures conditional on the observed pattern of choice, which is instead of some interest as documented in von Haefen (2003). This, we feel, is a useful feature to expand upon in this study because it further adds to the merits and additional insights that finite mixing can contribute to the treatment of taste heterogeneity.

Choice Experiment Applications

A number of recent stated-preference applications used LCMs. These, among others, include Boxall and Adamovicz (2002), who conducted a lucid investigation using factor analysis to determine the motivational determinants of trips to wilderness, and built individual-specific factor loadings that were then used as determinants in the class membership equation. Their analysis supported the existence of four classes with homogeneous preferences, and consequently affords a much richer interpretation than a conventional multinomial logit model.

Hensher and Greene (2003) used a dataset on choice of road types in New Zealand and systematically contrasted the merits of mixed logit with those of latent-class modelling. Comparisons were carried out in terms of choice elasticities, distributions of predicted choice probabilities and changes in absolute choice shares. Based on their results, they concluded that no unambiguous recommendation could be made as to the superiority of any of the two approaches, although they found strong statistical support for the LCM approach with three preference classes.

Scarpa et al. (2003) used LCM analysis as an accessory to a more conventional conditional heterogeneity multinomial logit analysis of the choice of piglet breeds, in an effort to value an indigenous pig breed in Yucatan on a sample of households. They found evidence for two distinct preference classes, using membership probability equations including various individual specific co-variates.

In the context of public good provision from water supply Scarpa et al. (2005) derive individual-specific conditional welfare measures from responses to choice experiments for factor services of a water company. They contrast the implied sample distributions from continuous mixing with those from two, three, and four class finite mixing. They find that for some attributes the implied distributions from the four class estimates approximate well that implied by continuous-mixing estimates.

Applications Based on Attitudinal Questions

Morey, Thacher, and Breffle (2005) employ an Expectation-Maximization estimator on responses to Likert-scaled attitudinal questions to segregate a sample of Great Lakes anglers into two to four attitudinal classes. They also illustrate how membership probabilities so obtained can be used to inform estimation of structural random utility models.

In the context of a referendum CVM study for the value of biodiversity conservation Menzel and Scarpa (2004) built on this approach and apply the same membership probabilities estimator. They use responses to Likert-scaled questions developed to measure psychological constructs proper of Protection Motivation Theory (Rogers 1983). They find that the estimated membership probabilities for the four classes predicted by such theory significantly improve the log-likelihood of a RUM logit model explaining the response to referendum CVM questions.

III. ALPINE ROCK CLIMBING: THE DATA AND RATIONALE FOR TASTE HETEROGENEITY

The Northeasten Alps

We investigate the preferences behind a panel of destination choices of one-day rock-climbing trips across eighteen mountain groups in the Northeastern Alps (Figure 1), which are quite diverse from both a morphological and rock-climbing perspective.

The destinations include the following:

1. Vette Feltrine, M. Sole
2. P. Dolomiti Pasubio
3. Consiglio-Alpago
4. Altipiano Asiago
5. M.Grappa
6. Lessini-M.Baldo
7. Antelio
8. Pelmo
9. Tofane-Cristallo
10. Duranno-Cima Preti
11. Sorapiss
12. Agner-Pale San Lucano
13. Tamer-S. Sebastiano
14. Marmarole
15. Tre Cime-Cadini
16. Civetta-Moiazza
17. Pale di S. Martino
18. Marmolada

Within this list two broad geographically determined groups have been generally distinguished. Destinations 1–6 belong to the pre-Alps, which are mountains with gentler slopes and lower peaks separating the plane from the proper Alps. Because of their closeness to the main urban centers, and the presence of relatively difficult hiking routes—even though the length of the access paths is limited—the pre-Alps are the final destination of many local day trips.

Destinations 7–18 are in the Northeastern Alps, in the mountain chain of the Dolomites, which is an extended rocky area mostly made of dolomite rocks. This rare and distinguished rock type is geologically well-defined as it originates from coral reefs. Mountains made of this rock are scenically attractive, as they tend to show orange-pink reflections at sunset and under cloudy skies. These create those dramatic scenes for which the Dolomites are well-known the world over.

Sample and Its Characteristics.

Because a great fraction of the Italian rock climbers belong to the CAI[1], and our interest was to characterize preferences of local users able to take day trips, rather than longer holidays, the sampling frame was based on the Veneto chapter of CAI members.[2] This type of membership is very popular across regular mountain users, such as the like of rock climbers, as the club

[1] Some previous studies highlighted that about 25% of the day trips in the studied area were completed by CAI members.

[2] It can be argued that sampling from a club of specialized users can produce a biased sample, and—despite the broad membership base of CAI—this is probably true in our case. However, it remains unclear how to correct for this. For this reason, inference of our results to the general population should, of course, be conducted with much caution.

FIGURE 1
The Northeastern Alps

provides a great deal of locally relevant services, such as training courses, activity maps, regularly updated guides, and rescue services.

The data for the study was collected with a survey from a sample of 528 members who reported on their mountain visits for the year 1999. The total number of climbing day trips the sample reported upon is 8,787. Figure 2 reports a histogram of trip distribution in the sample. The destination choices constitute a panel as for each individual n we know the number of trips $T(n)$ that were taken to each of the 18 destinations. We do not know, however, the sequence with which these trips were taken, and this obviously limits our ability to capture the dynamic of decision making.

Data were collected using a questionnaire. Typically, a group of respondents were handed the questionnaire during a debriefing session in which they were given an explanation of how to interpret several questions. Then, each member of the group would fill in the questionnaire on their own. Respondents were asked questions about their mountaineering abilities and experience, whether they attended mountaineering training courses; regularly trained in cliffs and indoor climbing walls; inception of their hiking activities in the Alps; other activities practised such as ski-mountaineering.

They were also asked the total number of day trips made in the last twelve months to each of the abovementioned 18 sites. Because of the high potential for recall errors, the notion of asking the sequence of choices was foregone. The information provided on the number of trips to destinations may be marred by recall bias, which tends to result in over-reporting, but we did not correct for it as it is unclear how corrections can be effectively implemented. Finally, they provided socio-economic information about the state of their households. Round-trip distances from place of residence to each of the destinations in the choice set were calculated using the software package "Strade d'Italia e d'Europa." This data was used to estimate the individual travel cost for each trip.

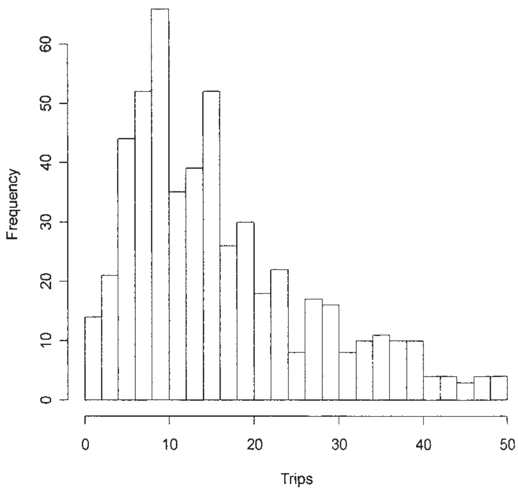

FIGURE 2
HISTOGRAM OF TRIPS

Distance costs were converted into monetary values in euros (€). Each reported visit was a "one-day trip," as customary for this form of local outdoor recreation. The opportunity cost of time is assumed to be zero. This may well be one of the main limitations of this study, which can be improved upon by using a framework similar to that developed by Shaw (1992), or by Feather and Shaw (1999).

The definition of a complete set of substitute destinations for this kind of recreation is a thorny issue to resolve. However, in this instance, because of the proximity of these sites to the place of residence of the interviewed sample, as well as the relatively similar nature of the climbs available at each site, we believe it is safe to assume that all the 18 destinations are substitutes. Although this choice set is certainly not exhaustive, experts estimate that less than five percent of climbing trips are taken to other non-listed destinations.

Only 13.41% of the respondents are women, the sample average of age is 37.63 (st. dev. 14), and that of years of experience in climbing is 10 (st. dev. 9.8). Most of respondents ended education at the high-school level (56%) and almost 13% graduated from university programs. The average of the reported income is in excess of €22,500. The average family size is 3.1 people.

Attributes Of Destinations

The attributes included in the estimation were mostly coded according to expert knowledge of the climbing features offered by the above destinations. These included:

Severity of the mountain environment. This is a three-level index representing the degree of severity of the alpine environment on the climbs of each mountain group. For example, different sites are exposed in varying degrees to sudden weather changes. The climbing viability conditions are variable over the year and such variability is larger for some sites than others. The score assigned to each destination was coded as two dummy variables representing high and intermediate severity, and using as a baseline low severity.

Difficulty of climbs and ability of climbers. This is an interaction variable between a site attribute and an individual characteristic. The attribute is the score assigned by experts on the basis of the average difficulty of the climbs at a destination ds (ranging from 1 to 4) and related to the technical difficulty of the climbs. By and large, each destination offers the opportunity to climb at various degrees of difficulty, this index reflects the prevalence of a particular degree over another. The individual characteristic is self-reported and relates to the degree of climbing difficulty normally sought by the climber, or d_i. The interaction variable is $D_i = 1/\text{abs}(ds\text{-}d_i)$ iff $ds \neq d_i$, 2 otherwise. It is constructed so as to have the highest value of 2 when there is a correct matching between difficulty sought and difficulty prevailing at the site, and to assign an increasing and symmetric penalty to mis-matching.

Number of equipped alpine shelters. This is the number of alpine shelters available at each destination. Alpine shelters are equipped to protect ramblers from the sudden changes in weather that are often experienced in the Alps and to allow them to sleep overnight when needed. They are also used as landmarks and reference points for rescue teams. The number of shelters varies from a minimum of two shelters (Site 10) and a maximum of 26 (Site 18).

Number of climbing routes. This is an index ranging from 1 to 5 and reflective of the relative density of viable climbing routes accessible at each destination. This variable was used numerically, which implies a linear effect of the estimated taste-parameter. We recognize that this is not ideal, but we wanted to obviate estimation problems caused by over-use of dummy variables.

Ease of access to the climbing site. This is a three-level index attempting to capture not only the time between parking places and the climbs at a given mountain destination, but also the difficulty in terms of the terrain over which climbers need to walk before reaching the climbs. The score was coded as two dummy variables representing intermediate and high ease of access, and using as a baseline poor accessibility.

Finally, estimated round-trip travel cost from place of residence to destination was also included in the indirect utility function.

Rationale for Taste Heterogeneity

It is worthwhile developing some rationale for the expected differences in taste amongst classes, at least for some features. Climbing methods can be categorized on the basis of whether and how the climber uses climbing equipment (bolts, hooks, ropes, etc.). *Free climbers* use equipment only during the descent or fall, but not during the ascent, while *aid climbers* use equipment during both.[3] Climbing categories can also be defined on the basis of how climbing aid equipment is put in place on the cliff. It can be put in place by the climber as she moves along and then removed (*traditional* climbers). Alternatively, *sport* climbers use equipment permanently placed on the cliffs. Free climbers may also help themselves with some gear in the ascent of particularly difficult tracts, but move up along mostly on their ability to take a grip on the rock.

Of course, each climber can practice various forms of climbing, according to his/her taste and purpose. Two extreme behaviors were identified in discussion with focus groups of climbers and with experts. It was agreed that in principle one can recognize many types along a continuum between two extreme types: the *alpine* climber and the *focussed* sport climber.

Alpine climbers are mostly traditional climbers. They tend to go climbing in classic routes and quite often at the end of a hiking trip, which in their view is an integral part of the alpine "experience." Such climbs are relatively more difficult from the technical perspective with few fixed bolts, in relatively unmarked climbs, and require good experience and intuition to guess the best way up. Independent of the destination of choice, alpine climbers also tend to choose longer climbs, which exposes them for longer periods to potential weather changes and overall represent higher risk ventures. They tend to regard climbing as an integral part of an old-fashioned trip to the Alps, which inevitably includes a long stroll to get away from the crowds, to submerge oneself in the beauty of the alpine experience, and to enjoy the pleasure that this affords.

However, it is well-known that other climbers see climbing quite differently. *Focussed* climbers are typically more inclined to develop a different category of techniques within free climbing. They have a higher risk aversion than alpine climbers and tend to choose much better marked and shorter climbs. These are, in some respect, analogous to indoor climbing gyms. This group tends to shun high-severity climbs and go for technically well-defined climbs.

Many focussed climbers, especially among keen sport and free climbers, may just want to reach a given climb and engage in climbing. To them, this activity is similar to going to the gym or the swimming pool: they want to reach the chosen destination, perform the climb, enjoy it, and then return, possibly avoiding congestion. For lack of a better term, we call this group *focussed*

[3] We are grateful to an anonymous reviewer for suggesting these categories.

climbers, because they focus on the climbing experience alone, with relative disregard of other alpine activities, and to the site attributes related to these.

In both groups, there are various degrees of experience, ranging from beginners to veterans, as well as different degrees of keenness and hence intensity of demand.

Taste Expectations on Attributes of Destinations

In what follows we outline our expectations on taste intensities for the recreational attributes of the destinations employed in the LCM as determinant of choice.

Severity of the environment. Generally speaking, this attribute should be perceived as undesirable. However, some taste variation would accommodate the adjustment to severity brought about by more frequent practice or idiosyncratic past experiences, as well as the propensity to increasingly—or occasionally—challenge oneself with unusually harsher environments. This is expected from specialized demand by members of the *focussed* group, such as free climbers or extreme sport climbers. This makes the development of a clearcut expectation on taste controversial, and reduces it to a matter of empirical investigation.

Difficulty of climbs and individual ability. We expect this attribute to show a positive effect in the probability of selection. In general, climbers of good ability tend to seek destinations where challenging climbs prevail. On the other hand, climbers with lower ability, such as beginners, will probably seek destinations where easy climbs prevail. However, most sites offering difficult climbs also offer low-ability climbers many opportunities adequate to their skill level.

Number of alpine shelters. Alpine shelters are important protection points and should generally be regarded as a desirable site attribute in the indirect utility from the choice of destination for climbing trips by all climbers, regardless of the activity they wish to undertake in the mountains. They are quite valuable to some traditional alpine climbers, who often need a good day's walk to get closer to classic climbing routes and sometime sleep in shelters overnight. However, for many focussed climbers the presence of shelters may be totally irrelevant, or even not appealing to those who want to escape crowds, as the presence of shelters inevitably attracts other alpine visitors apart from climbers.

Ease of access and number of climbs. These attributes are likely to be perceived differently by focussed and alpine climbers for a variety of reasons. To focussed climbers, ease of access, as well as the number of climbs accessible from a given destination are valuable features. However, alpine climbers may more frequently choose sites with difficult access to the climbs to get away from congestion, which unfortunately we could not measure from our data. To this type of climber, the experience of getting to the pinnacle of the climb is as enjoyable as the walk to the base of it, and ease of access may be perceived as a "bad" because of its association with potential congestion, or not of particular importance.

A Benefit-Neutral Policy

The Italian Alps have a long history of management, which results in a very high level of local knowledge for the traditional use of the land for recreation. Traditionally, the troop's recruitment of the Italian Alpine Corp was based on the national draft. Conscripts were recruited from alpine areas and during the draft period they had to maintain many of the Alpine roads, trails, and pathways, which determine the ease of access to most climbs at our destinations. Other local organizations, such as the Alpine Club (CAI), have been also in charge of maintenance of climbing routes and trails. With the recent abolition of the national military service, it is envisaged that the cost and logistics of maintenance will be shifted to local authorities that, in turn, will need extra revenue for the up-keep. For such a reason, it is of interest to obtain estimates of welfare change from recreationists of all types, including climbers. In this study, we focus on a policy proposal that would increase the number of climbing routes in those few destinations with very low current level of supply to an intermediate level of supply. We also focus on increasing the ease of access to such climbing routes, so as to bring all sites to a definition of "high ease of access."

Both actions are a realistic target for local authorities. The first policy component will provide more local supply of equipped climbs, or extend the existing ones, thereby diversifying the attraction of each destination; the second policy component will make it easier to reach currently less accessible climbing locations by providing closer parking sites and better mountain trails.

IV. ECONOMETRIC ISSUES

The derivation of the latent class logit model is based on a class membership probability equation, and on an alternative choice probability equation, both of which turn out to have a convenient logit formulation when two independent Gumbel-distributed error components are used.

The membership equation explains the probabilistic assignment into a number of C classes, where C is exogenously defined and outside the space of estimable parameters. In the results we choose to present here, we have adopted the approach documented in Hensher and Greene (2003) and Kamakura and Mazzon (1991).

Briefly, the specification we present does not include any socio-economic covariate as determinants of the membership probability. Indeed, during the specification search for the membership equation the whole range of socio-economic covariates available was used and none was found to be significant at the conventional values. The only variable that did play a statistically significant role was the number of trips taken, which also had a quadratic effect, but only in the two-class case, and hence this also was omitted as unsuitable under the assumption of a larger number of classes. So, for the C membership probabilities a semi-parametric logit format is assumed

$$\Pr(n \in c) = \begin{cases} Q_c = \dfrac{\exp(\alpha_c)}{1 + \sum_{c=2}^{C} \exp(\alpha_c)}, \ \forall c \neq 1 \\[2ex] Q_1 = \dfrac{1}{1 + \sum_{c=2}^{C} \exp(\alpha_c)}, \ c = 1, \end{cases} \qquad [1]$$

where α_c is a class-specific constant for classes 2, 3, …, C. To ease interpretation, in the estimation results we report directly the values for Q_c, rather than the individual α values.

Given membership to class c, the choice probability equation explaining the mechanics of probabilistic choice across alternatives in each choice occasion is based on a conventional random utility framework of the multinomial logit:

$$\Pr(i|c) = \frac{\exp(v_i)}{\sum_{j \in J} \exp(v_j)} = \frac{\exp(\mathbf{x}_i \boldsymbol{\beta}_c)}{\sum_{j \in J} \exp(\mathbf{x}_j \boldsymbol{\beta}_c)}, \qquad [2]$$

where the scale parameter of the Gumbel error distribution is normalized to 1, and omitted, and $\mathbf{x}_i$ and $\boldsymbol{\beta}_c$ are two conformable vectors of site attributes and taste-parameters respectively.

Number of Classes with Different Preference

The number of classes with different preferences is not part of the maximization process from which the parameter estimates are derived. In other words, it is outside the space of the estimable parameters. The conventional specification tests used for maximum likelihood estimates (likelihood ratio, Lagrange multipliers, and Wald tests) are not valid in this context because they do not satisfy the regularity conditions for a limiting chi-square distribution under the null. This because the parameter values under the null are at the boundary of the parameter space.

Resampling from the empirical distribution is feasible but very impractical because of the computational complexity it involves (Wedel and Kamakura 2000, 91). As a guidance, some authors have used a variety of information criteria $C = -2\ln L + J\kappa$ where $\ln L$ is the log-likelihood of the model at convergence, J is the number of estimated parameters in the model, and κ is a penalty constant.

For $\kappa = 2$ we obtain the Akaike Information Criteria (AIC); for $\kappa = \ln(N + 1)$, we obtain the *consistent* AIC (cnAIC); for $\kappa = \ln(N)$ we obtain the Bayesian Information

Criteria (BIC), which by construction is very similar to the cnAIC. Finally, for $\kappa = 2 + 2(J + 1)(J + 2)/(N - J - 2)$ we have the *corrected* AIC (crAIC) (Hurvich and Tsai 1989), which increases the penalty for the number of extra parameters estimated.

However, these criteria also fail some of the regularity conditions for a valid test under the null (Leroux 1992). Asymptotically, the AIC is reported to be biased towards an over-estimate of the number of preference classes, while the BIC is not, although in small sample sizes the BIC tends to favour too few classes (McLachlan and Peel 2000).

Furthermore, as the number of classes increases, the significance of parameter estimates in the utility function gradually decreases, especially in classes with low probability of membership. Therefore the chosen number of classes must also account for significance of parameter estimates and be tempered by the analyst's own judgment on the meaningfulness of the parameter signs.

Derivation of Conditional Estimates from LCM Models

Consider a population with C preference classes and a set of T observed choices per individual n over J destination alternatives. Given a set of choices by the same individual and conditional on belonging to a given preference class c the joint logit probability of a set of destination choices $T(n)$ is

$$P_{T(n)}|c = \prod_{t(n)=1}^{T(n)} \frac{\exp(\mathbf{x}_{t(n)}\boldsymbol{\beta}_c)}{\sum_{j=1}^{18}\exp(\mathbf{x}_j\boldsymbol{\beta}_c)}. \quad [3]$$

With the individual probability of membership to a class c defined as Q_c, one can derive the unconditional probability of the set of destination choices $T(n)$ for the individual n by taking the expectation over all the c classes:

$$\Pr(T(n)) = E[P_{T(n)}|c] = \sum_{c=1}^{C} Q_c P_{T(n)}|c = \sum_{c=1}^{C} Q_c \prod_{t(n)=1}^{T(n)} \frac{\exp(\mathbf{x}_{t(n)}\boldsymbol{\beta}_c)}{\sum_{j=1}^{18}\exp(\mathbf{x}_j\boldsymbol{\beta}_c)}. \quad [4]$$

Equation 4 represents the individual's contribution to the latent-class likelihood function of the sample that is maximized to obtain $\hat{Q}_c$ and $\hat{\beta}_c$.

After estimation, a conditional estimate of the individual-specific class probability can be obtained as a function of the parameter estimates and the set of observed $T(n)$ choices of destination by means of Bayes' formula using the "plug-in" estimator:[4]

$$\hat{Q}_{nc} = \Pr(n \in c)|\mathbf{y}_{T(n)}, \mathbf{x}_{T(n)} = \frac{\hat{Q}_c \prod_{t(n)=1}^{T(n)} \frac{\exp(\mathbf{x}_{t(n)}\hat{\boldsymbol{\beta}}_c)}{\sum_{j=1}^{18}\exp(\mathbf{x}_j\hat{\boldsymbol{\beta}}_c)}}{\sum_{c=1}^{C}\hat{Q}_c \prod_{t(n)=1}^{T(n)} \frac{\exp(\mathbf{x}_{t(n)}\hat{\boldsymbol{\beta}}_c)}{\sum_{j=1}^{18}\exp(\mathbf{x}_j\hat{\boldsymbol{\beta}}_c)}} \quad [5]$$

where $\mathbf{y}_{T(n)}$ and $\mathbf{x}_{T(n)}$ are, respectively, the observed choices and the attributes of the chosen climbing destinations.

Given this set of individual-specific probabilities of membership in each preference-class c, one can derive individual-specific conditional estimates of the marginal WTP for attribute k (Haab and McConnell 2000) as

$$\widehat{WTP}_n = \hat{E}\left(-\frac{\hat{\beta}_{nk}}{\hat{\beta}_n}\right) = \sum_{c=1}^{C}\hat{Q}_{nc}\left(-\frac{\hat{\beta}_{nck}}{\hat{\beta}_{nc€}}\right)_c, \quad [6]$$

where $\hat{\beta}_{n€}$ is the individual marginal utility of money, as measured by the travel cost parameter estimate computed conditionally on observed choices.

Similarly, we derive conditional estimates of welfare changes per choice occasion from policies aimed at improving some of the destination attributes from the status-quo $\mathbf{x}^0$ to some ex-post $\mathbf{x}^1$ condition as

$$\widehat{CS}_n = \hat{E}[CS_n] = \sum_{c=1}^{C}\hat{Q}_{nc}\frac{1}{\hat{\beta}_{nc€}}\left\{\ln\left[\sum_{j=1}^{18}\exp(\mathbf{x}_1\hat{\boldsymbol{\beta}}_{nc})\right] - \ln\left[\sum_{j=1}^{18}\exp(\mathbf{x}^0\hat{\boldsymbol{\beta}}_{nc})\right]\right\}. \quad [7]$$

In our case, we find it of interest to

[4] Kamakura and Wedel (2004) indicate that this approach provides a first-order approximation to the posterior mean of the individual level estimates, although they propose to improve it by integrating over the asymptotic posterior distribution. An approach we choose not to adopt here.

TABLE 1
CRITERIA FOR NUMBER OF CLASSES

N = 528 Number of Classes	ln$L$	Parameters	AIC	BIC	crAIC
1	−21,655	11	43,332	43,375	43,333
2	−21,130	23	42,306	42,397	42,309
3	−20,763	35	41,596	41,734	41,604
4	−20,644	47	41,382	41,567	41,396
5	−20,494	59	41,105	41,338	41,128

focus on the sample distribution of welfare changes for what we define a "sample-sustained" policy. This is a policy which brings about some improvement in terms of destination attributes, but is also paid for by a per-trip user fee h^*, such that the following condition is satisfied:

$$\sum_{n=1}^{N} \widehat{CS}_n = 0. \qquad [8]$$

This value is found by employing a root-searching algorithm exploring the positive space of h in the neighbourhood around zero. The solution to this search h^* represents the "optimal" entrance fee, in the sense that, given the target policy, this fee is the lowest at which—at the sample level—benefits are perfectly balanced by costs. A kernel plot of this distribution of estimates is then readily interpretable as a means to identify winners and losers in the policy in question, because it is centred on zero.

Reporting and Explaining Individual-Specific Welfare Estimates for the Sample

We illustrate the differences across the sample distribution of welfare estimates by means of kernel plots. The kernel smoothing techniques are often used for this purpose and provide a means to visually compare distributions. We use a normal kernel with optimal bandwidth using the SM routine in the free-source statistical software R, which is documented in Bowman and Azzalini (1997).

Further, we use a binary logit regression to explore how the probability of being predicted to benefit from the policy is related to socio-economic covariates. Note that the same covariates were used as determinants of probability of group memberships in the preliminary analysis and failed to show significance. We expected to find some effects that validate the approach, at least in terms of some important determinants of value, such as household income, household size and number of trips taken.

V. RESULTS AND DISCUSSION

The values for selected information criteria of different preference groups are reported in Table 1 and are consistent with the hypothesis that there are at least four classes with satisfactory parameter estimates, in both statistical and theoretical terms. The model with five classes is statistically preferred according to the various information criteria in either sub-group, but the pattern of estimates it produces is difficult to interpret, and it shows many statistically insignificant parameter estimates. We hence decide to present and discuss the models with four classes. Such estimates are presented in Table 2. Notice that because only difference matters in RUMs, in order to ease comparisons across preference classes, we report the marginal rates of substitution (part-worths), with respect to travel cost in brackets below the asymptotic z-value of each parameter estimate.

Among the various measures we chose to report for each class is

$$MRS(k, Cost) = \hat{\gamma} = -\frac{\hat{\beta}_k}{\hat{\beta}_{€}}, \qquad [9]$$

because in some cases (Haab and McConnell 2002) this is also a measure of WTP for a unit change in the attribute.

Further, as a measure of central tendency across class-specific estimates we

TABLE 2
LATENT CLASS MAXIMUM LIKELIHOOD ESTIMATES

Variables	$N = 528$; choices = 8,787; $\ln L = -20{,}644$; Adj. $R^2 = 0.193$					
	$\hat{\beta}_A$	$\hat{\beta}_B$	$\hat{\beta}_C$	$\hat{\beta}_D$	$\hat{\gamma}_w$	$\hat{\Omega}$
Travel cost	−0.675 (−35.08)	−2.092 (−74.16)	−1.332 (−43.67)	−3.227 (−0.01)		
Intermediate severity	−0.808 (−14.26) [1.198]	−0.723 (−11.91) [0.346]	−1.478 (−11.28) [1.110]	−0.255 (−0.91) [0.079]	1.303	2.27
High severity	−1.067 (−12.44) [1.581]	−1.721 (−18.94) [0.823]	−2.739 (−12.72) [2.057]	−2.296 (−5.42) [0.711]	2.583	1.51
Difficulty of climbs and climber's ability	0.013 (2.17) [−0.019]	0.071 (10.38) [−0.034]	0.181 (17.59) [−0.136]	0.023 (1.13) [−0.07]	−0.100	3.56
Shelters	0.005 (2.01) [−0.007]	0.036 (15.21) [−0.017]	0.002 (0.71) [−0.002]	− 0.069 (−7.81) [0.021]	−0.009	7.57
Number of climbs	0.440 (22.64) [−0.653]	0.270 (13.95) [−0.129]	0.625 (16.44) [−0.469]	1.397 (16.37) [−0.433]	−0.779	1.26
Intermediate access	0.758 (16.75) [−1.124]	0.946 (23.92) [−0.452]	0.064 (0.61) [−0.048]	1.397 (16.37) [−0.595]	−1.064	2.04
Good access	0.795 (16.14) [−1.178]	1.047 (20.19) [−0.500]	0.287 (2.64) [−0.216]	1.921 (8.32) [−0.958]	−1.277	1.89
ASC site 6	−0.178 (−3.13) [0.264]	−0.281 (−5.49) [0.134]	−0.206 (−1.48) [0.155]	−15.169 (−0.01) [4.701]	2.470	8.54
ASC site 12	−0.719 (−8.16) [1.065]	−0.206 (−1.88) [0.098]	0.004 (0.03) [−0.003]	−1.646 (−3.10) [0.510]	0.745	2.96
ASC site 13	−0.329 (−5.79) [0.488]	−1.606 (16.98) [0.768]	−1.324 (−7.36) [0.994]	−1.626 (−8.80) [0.505]	1.536	1.13
Group probability	0.398 (14.68)	0.282 (12.10)	0.223 (8.58)	0.097 (6.14)		

Notes: Asymptotic z-values in parentheses; marginal rates of substitution with money in brackets.

propose the weighted average of the *MRS*, defined as

$$\hat{\gamma}_w = \sum_{c=1}^{4} \hat{\gamma}_c \hat{Q}_c. \qquad [10]$$

We also report a measure of relative diversity across *MRS* values of classes:

$$\hat{\Omega} = \frac{\sum_{c=1}^{4} |\hat{\gamma}_c - \hat{\gamma}_w|}{|\hat{\gamma}_w|}. \qquad [11]$$

We propose to interpret this quantity as a measure of preference intensity dispersion across classes.

Preference Classes

Class *A* is the largest with about 40% of the sample, followed by class *B* with 28% and class *C* with 22%. The residual 10% is in class *D*.

All classes dislike sites with intermediate and high indices for the severity of the environment, although they show quite a wide range of intensities of taste: for intermediate severity the *MRS* ranges from a minimum of €0.08 in class *D* to a maximum of €1.20 in class *A*; while for high severity it ranges from €0.71 in class *D* to €2.06 in class *C*. Notice that the expected monotonicity property is respected in the estimates: high severity is more disliked than intermediate in all classes.

The matching of difficulty of climbs and ability in climbing is always desirable, ranging from a *MRS* value of –€0.14 in class *C* to one of –€0.02 in class *A*.

Two classes (*A, B*) find the presence of equipped shelters attractive and statistically significant, while a third (*C*) shows no significance, and a fourth (*D*) shows a negative effect. This is consistent with the fact that focussed climbers do not make a great use of these shelters, which are mainly there for ramblers and hikers. It is not surprising that overall shelters play a little role in climbers' utility function, with a weighted average of part-worth of only €0.007.

The taste parameters for the number of climbing routes at destination are found to be always significant and positive, with the highest intensity in the largest class (*A*). Class *D* and *C* have similar MRS values (around €0.4), while class *B* shows the lowest.

Finally, both dummy variables for intermediate and good access are always positive, although they are not significant in class *C*. Incidentally, this is the same class in which we find indifference for the number of shelters and for two out of three of the alternative specific constants included in the model.

We speculate that class *D* is perhaps representative of the *hardened focussed climbers* who might be thought of as "lone wolves." They are not discouraged by severity of climbs, they like easy access, but shun away from sites with shelters, perhaps in avoidance of congestion.

Class *A* shows a pattern of tastes that is somewhat similar to class *D*, although these types of *focussed climbers* seem to be *less hardened*, as they shun destinations with severe environments and enjoy, although only to a small extent, the presence of shelters.

Although the other two classes are more difficult to identify with a given stereotype, we would also suggest that class *B* tends to conform with what one would expect to be the pattern of taste intensities associated with *occasional alpine climbers*: with highest appreciation for the presence of shelters, an a sound respect for severe climbing environments, some interest for ease of access.

Finally, class *C* collects what we called *"choosy" focussed climbers*, who shun severe environments and seem not to care about ease of access or presence of shelters as long as they can get to the "right" destination for their skills.

Distributions of Individual-Specific Marginal Welfare Changes

Figures 3 to 5 illustrate the sample distributions of various per-visit marginal WTP values computed conditionally on observed choices using equation [4]. Each distribution is smoothed using a normal kernel with optimal bandwidth.

Kernel densities of individual-specific welfare estimates uncover how the number of modal values for *WTP* distributions may differ from four, which is the number of preference groups. For example, in Figure 3 we plot the kernel-smoothed distribution of *WTP* estimates for an extra alpine shelter. Note that there are three modal values: one around –€0.11, with lowest density, a second with highest density at €0.025, and a third with intermediate density at €0.08. The plot shows substantial preference heterogeneity and although most of the sample hold positive values, a smaller fraction hold negative ones. These are probably

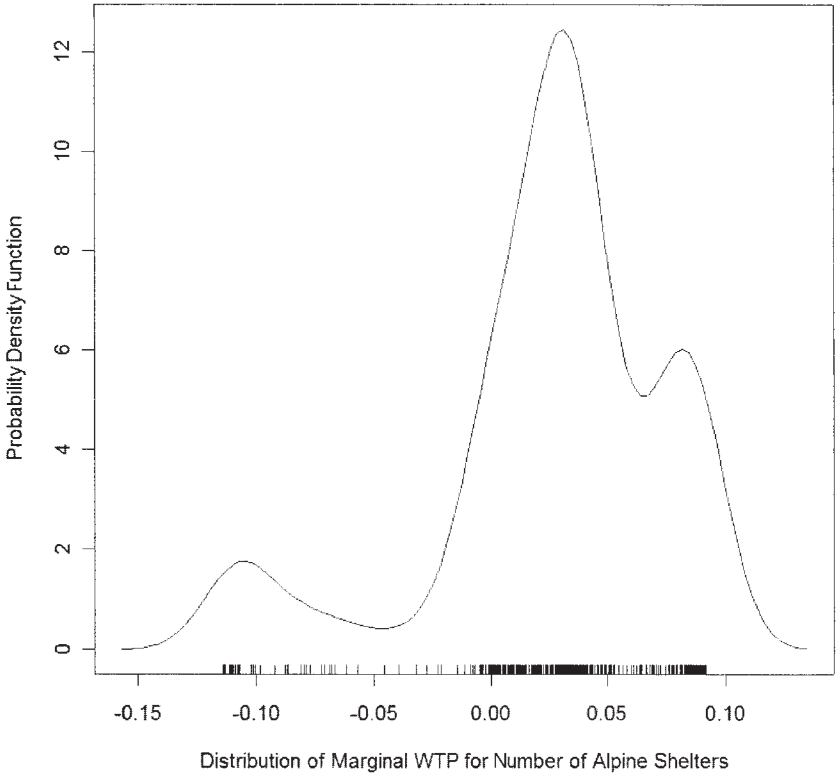

FIGURE 3
MARGINAL WTP FOR NUMBER OF ALPINE SHELTER

climbers who shun congested sites. It would seem that climbers, although they recognize alpine shelters have a positive role as protective facilities, they nevertheless tend to hold low marginal values for them, perhaps because amongst the various categories of alpine visitors they tend to make relatively little use of shelters.

Figure 4 shows iso-quantile curves of a bivariate kernel density of *WTP* estimates for high and intermediate ease of access. A high and a low value group are clearly visible, with two more groupings, one intermediate and one with very low value for ease of access on the extreme left. This separation of preference intensities in the sample is consistent with the postulated presence of at least two major preference classes, perhaps corresponding to the alpine/focussed climber divide. We speculate the lowest value group might be associated with traditional alpine climbers, who enjoy the stroll in the approach as much as the climb itself once they reached the face of the cliff.

Figure 5 shows the analogue of Figure 4 for *WTP* values associated with the two dummy variables for high and intermediate severity. These sample values are polarized in two perhaps three groups, but not four. The pattern displayed is still consistent with the existence of alpine climbers, who show moderate dislike for severity, and focussed climbers, who—instead—show stronger dislike, especially for high severity environments.

Distributions of Individual-Specific Discrete Welfare Changes

The policy described in Section 3 improves attributes valuable to climbers in sites with low values for the number of

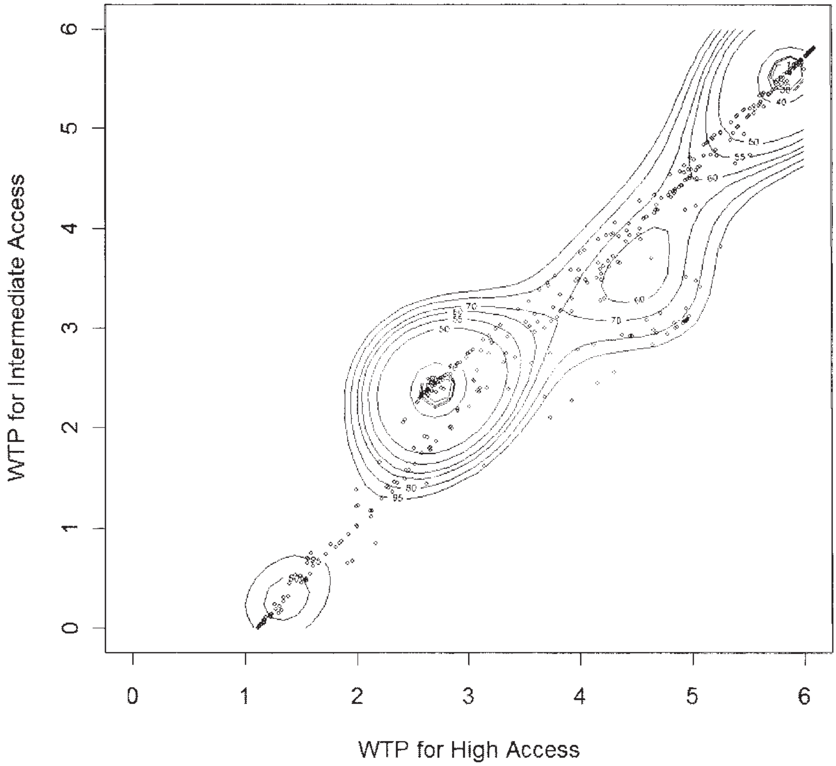

FIGURE 4
Iso-Quantile Plot of Bivariate Kernel Density for WTP for High Ease of Access (All Values in Euro)

climbs (which is used in the interaction variable with climbing ability) and brings ease of access to intermediate levels across the board. It therefore produces a discrete welfare change whose overall distribution of values in the two sub-samples is a combination of the patterns in the individual distributions of each attribute. This is confirmed in Figure 6, where we note that the degree of heterogeneity of preferences is still quite strong.

In order for the per trip consumer surplus for the total sample to be zero, the access fee h^* was found to be equal to €3.70. At this fee level, the conditional sample distributions of benefits (mean €0.52, median €0.53, and standard dev. €0.22) and losses (mean –€0.56, median –€0.51, and standard dev. 0.27) show that benefit values are more concentrated around their central modal value, while losses are more spread out. When per trip consumer surplus from the policy are multiplied by the observed individual number of trips[5] to obtain the overall individual welfare changes from the policy, we obtain values ranging from –€44.23 to €37.57, with an average loss of –€11.05 (median –8.04, standard dev. 9.85), and an average gain of €8.87 (median 6.90, standard dev. 7.43).

In Table 3, we present the results of a logit model in which the dummy variable y_i

[5] However, the reader must be reminded that we do not deal with total demand, but only with site selection. If a policy such as the one we describe were to be implemented along with an entrance fee of this magnitude, then climbers would revise their total demand accordingly: net losers will decrease demand, while net winners will increase it. Hence these aggregate values must be interpreted with care.

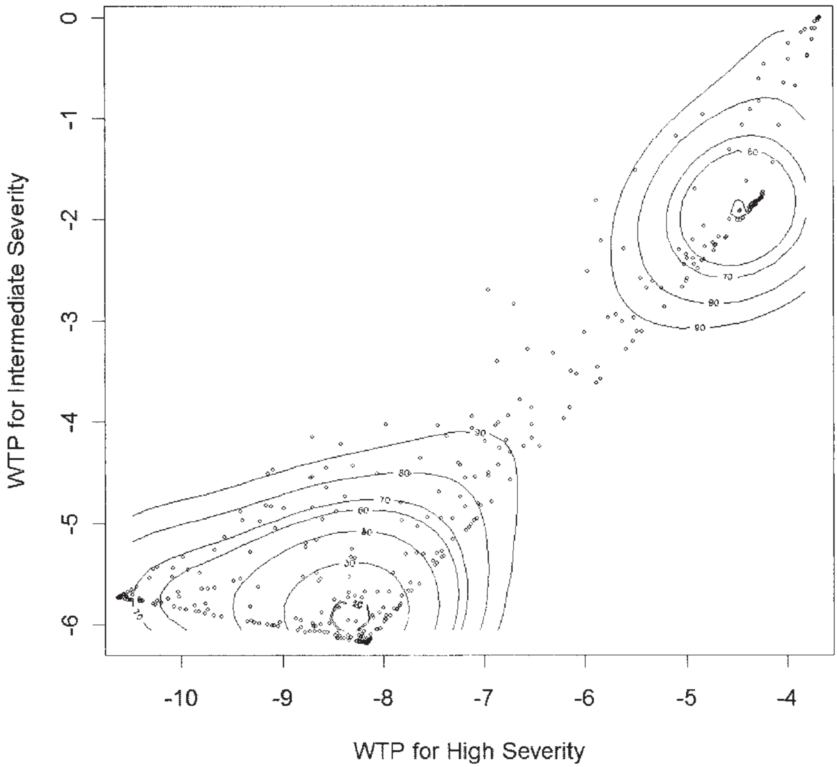

FIGURE 5
Iso-Quantile Plot of Bivariate Kernel Density for WTP for Intermediate and High Severity (All Values in Euro)

indicates the status of being a net beneficiary from the policy (i.e., having a positive predicted surplus conditional on the observed choices, as per equation [5] above) is regressed against a few select covariates. The number of trips taken over the year and income both show negative effects and have high statistical significance, thereby indicating that the policy is progressive and that frequent users tend to be among the losers.

VI. CONCLUSIONS

In this paper, we reported selected results from an extensive data analysis aimed at capturing and rationalizing heterogeneity of taste and its consequences in a destination choice model for climbers in the Northeastern Alps. We used random utility models based on latent class (finite mixing) modelling, a less restrictive preference structure than the one implied by the use of mixed logit models.

In the model specification search, we failed to associate class membership with measurable socio-economic covariates. Only the number of visits (demand intensity) was found to play a statistically significant role in explaining membership to preference classes, and this was limited to the case in which there were two classes. In the analysis that followed we found evidence of at least four classes with statistically well-defined preferences. The signs of the taste parameters made coherent sense within each class, and altogether quite an amount of taste variation was found. Such heterogeneity implies a complex and rich pattern of information in terms of distributions of individual-specific welfare estimates conditional on observed

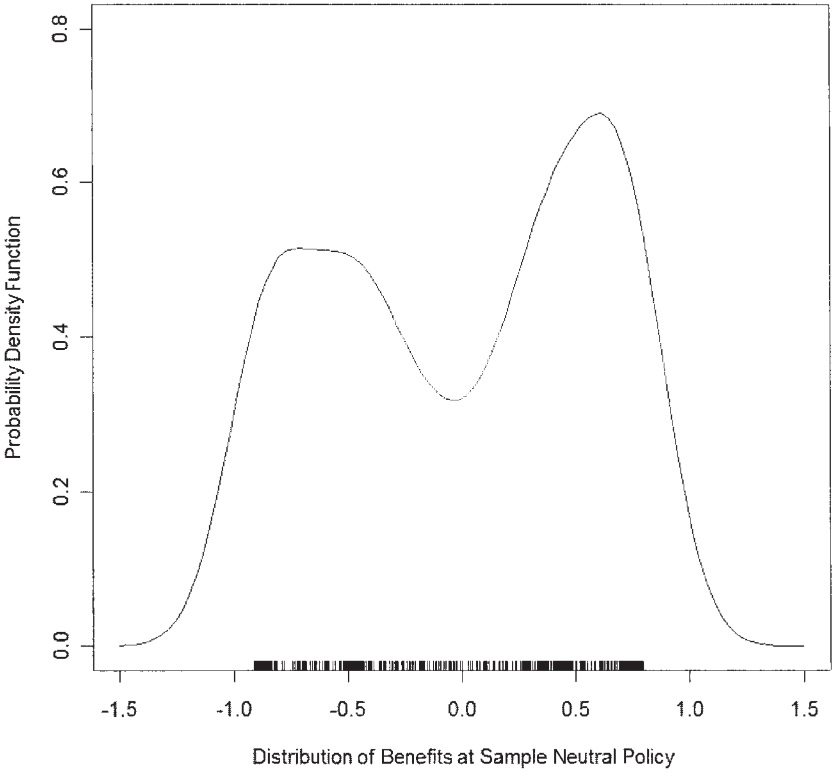

FIGURE 6
Distribution of Benefits at Sample Neutral Policy

choices. This is true for both the individual values of various climbing attributes of alpine destinations, and for a policy scenario evaluation.

Some findings are relevant for the wider literature on travel cost models with preference heterogeneity. First, we found evidence that preference heterogeneity takes up substantially different and "lumpy" forms.

Second, by focussing on the conditional distribution of welfare measures, we found evidence of multi-modality mostly consistent with *a-priori* expectations. For example, the parameter estimates in the preference classes seem to be consistent with those expected of focussed climbers and more traditional alpine climbers. Multi-modal taste distributions are not easily captured by conventional logit models and latent-class specifications may be instrumental to highlight these features.

Third, by focussing on the effects of a policy with neutral welfare change at the sample level, we identified winners and losers in the sample and highlighted how the proposed policy package is progressive, with more losers among avid and high-income climbers and winners among less-avid and low income-ones. Our proposed approach focused on the distributional consequences, rather than simply on efficiency outcomes. When equity matters to policymakers—and in a numerical democracies it often does—an approach capable of identifying regressive policy outcomes might be deemed superior to one that only dwells on the potential compensation criterion.

Finally, in direct contrast with other approaches for heterogeneous preferences that assume continuous mixing distributions, latent class modelling (LCM) does

TABLE 3
LOGIT ESTIMATES FOR THE PROBABILITY OF BEING A BENEFICIARY FROM THE POLICY

Variables	Parameter Estimate	Marginal Effect on y_i
CONSTANT	1.091	
	(1.82)	
WOMAN	−0.297	−0.074
	(−1.21)	(−1.21)
AGE	0.007	0.002
	(0.98)	(0.98)
HH_SIZE	0.060	0.015
	(0.75)	(0.75)
INCOME	−0.025	−0.006
	(−1.69)	(−1.70)
TRIPS	−0.017	−0.004
	(−2.08)	(−2.08)

Notes: $N = 528$; asymptotic z-values in parentheses.

not require any parametric distributional assumptions about the mixing variable, except the number of mixing points, which can be empirically evaluated. In a sense LCMs "let the data speak more," thereby providing more robust insights into the process at hand by identifying groups of users who have high or low preferences for particular "bundled goods," and the share of users each class represents. Availability of such detailed information is potentially very useful to natural resource managers, for example, in budgeting maintenance or improvement plans for destination sites with high recreational values, and for a wider range of other purposes.

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