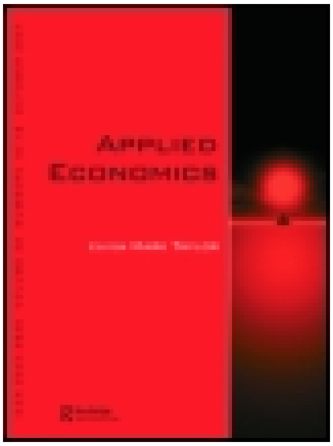

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Modelling choice and switching behaviour between Scottish ski centres

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The paper identifies the need to model the skier's choice of centre and the basic ideas underlying discrete choice models and their estimation. It then identifies data requirements and sources, the final choice of specification and the estimated parameters of the resultant nested multinomial logit model. The results indicate two quite distinct markets. For day-trippers snow cover, cost, and, to a lesser extent, the journey length, were the critical factors. For those staying overnight the key determinant in this market seems to be accommodation. Interestingly centres which for the day-tripper are competitors, become, for the overnight customer, complementary.

I. INTRODUCTION

A key element in appraising an investment is a forecast of the demand for the product or service. Often, when the market is relatively static, then the forecast revolves around the market share and particularly the way customers will switch from current purchase patterns to the new product or service. In turn this means that we need to develop an understanding of the way consumers choose their consumption patterns and to model the effect of the factors underlying the choice.

Over the last few years there has been considerable investment in the ski centres in Scotland and more, rather contentious, developments are planned. This paper tries to identify the factors that determine the effects of expenditure at a site by developing a model that quantifies the relationship between the quality of the facilities, prices and the choice of individual skiers. The layout of the paper is as follows. First the market for skiing in Scotland is briefly examined. Secondly we look at the specification and estimation of the chosen model, the Nested Multinomial Logit. Thirdly the data, and specifically the estimation of potential expenditures for non-chosen sites is discussed. Fourthly the final estimated models and the resultant implications for ski investment are examined. Finally the role and limitations of the approach to investment in leisure activities are discussed.

II. THE MARKET FOR SKIING IN SCOTLAND

Scotland has five ski centres; Glencoe, Nevis Range, Cairngorm, Glenshee and The Lecht. As Fig. 1 shows, these are geographically dispersed but four of the five are within two and a half hours driving from the densely populated central belt.

The demand for Scottish skiing is predominantly from a Scottish market, with over 90% being either day or weekend trips (Milne, 1997). Mackay (1995) estimates that there were 504 000 skier days in the 1994/1995 season at all five Scottish ski sites. Data on trip frequency gathered in the present study suggested that there were around 200 000 skiers making trips to Scottish ski centres in the 1995/1996 season. Central to the variation in the number of skier days are the snow and weather conditions. Figure 2, shows the total number of skier days each year in Scotland between 1981 and 1995. In this context one skier visiting three times would generate three skier days, no matter how short the day.

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Fig. 1. *The ski centres of Scotland*

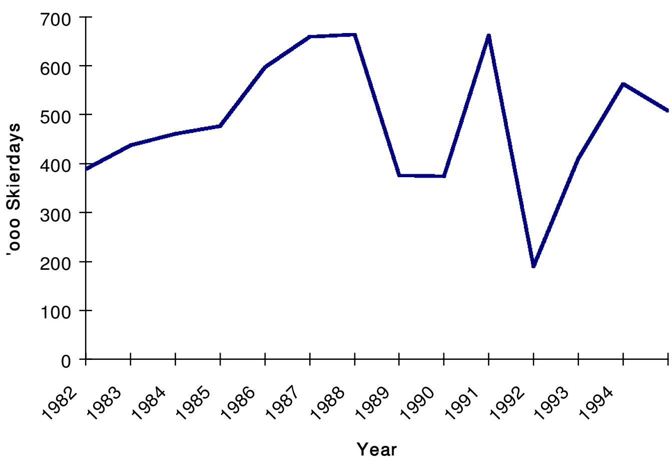

Fig. 2. *Skier days in Scottish centres*

In good seasons up to 680 000 skier days may be recorded, in poor as little as 190 000. With high fixed costs, overall the industry will only break-even at around half a million skier days. A series of bad winters makes investment extremely risky. Despite this, over the years there has been considerable extension and upgrading of facilities, largely made possible by public subsidy of up to 70% of capital costs.

Milne *et al.* (1998) estimated that skiers spent a total of £17 665 224 in the Highlands Enterprise area and that this level of spending supports directly and indirectly 1500 jobs during the winter months. The industry is thus generally regarded as making an extremely important contribution to the rural highland economy. However, overall demand and real prices are static and thus the investment in Scotland can best be viewed as an attempt to maintain market share through quality improvement in the face of increasing competition from overseas (Milne *et al.*, 1998).

III. NESTED MULTINOMIAL LOGIT MODELS

Choice models are used to explore and explain economic choices in a wide variety of areas ranging from labour force participation (e.g. Cogan, 1980) through brand preference (Baltas *et al.*, 1997) to church attendance (Sawkins *et al.,* 1997). Most commonly these are binary choice models using either a Probit or Logit specification. Multinomial models are concerned with situations where there are a number of choices available. Successful models can be found in many fields such as marketing (Bucklin *et al.*, 1995; Kamakura and Kim, 1996) evaluating environmental quality (Kling and Thomson, 1996), modal transport choice (Sinclair 1998) and quantifying recreational demand (Haab and Hicks, 1997). All can be dated back to Luce (1959) with the theory best developed and explained in Ben-Akiva and Lerman (1985).

The models assume that individuals seek to maximize their utility when choosing from a finite set of discrete alternatives (brands of commodities, transportation mode, ski sites etc.). Individuals are assumed to act within a framework of bounded rationality so that the utility of the alternative chosen exceeds the utility of all other feasible alternatives. If an individual chooses alternative k then

$$U_{ik} > \max(U_{ij}) \qquad \text{for all } j \neq k$$

Of course Utility cannot be observed, only the results. Utility is assumed to be a linear function generated by a set of known and unknown factors that relate to the characteristics of the individual, of the products, or of both. Thus if a skier from Aberdeen chooses to ski at the Lecht then for this customer at this time,

(1) the snow might be satisfactory (a feature of the choice)
(2) the day pass cheapest (again a feature of choice)
(3) suits the level of expertise (a feature of the individual)
(4) the road distance shortest (a function of both choice and individual).

These identifiable factors together with a number of 'other' unidentified factors (e.g. friend from England is staying close to the centre) generates a higher utility for skiing at the Lecht than anywhere else for that particular skier/individual.

The unknown factors are represented by a stochastic term and the effects of the characteristics are assumed to be additive. Thus the additive utility model is

$$U_{ij} = \beta X_{ij} + \varepsilon_{ij}$$

where β is a $1{*}n$ vector of fixed coefficients and X_{ij} an $n{*}1$ vector of characteristics.

The value of the stochastic term is of course unknown, but we can estimate the choice that is most likely given the set of characteristics. For example if, for an individual i, Glencoe is cheaper, nearer, has better snow, more runs, and more accommodation then the probability of choice will be very high but not 100%, because, unknown to us, a partner might have a season ticket for Nevis Range.

Whilst the limited number of factors considered (discussed in the next section) contributes to the uncertainty there are two other elements in the specification that will also generate error. The underlying model implies that overall satisfaction (or dissatisfaction) is the sum of a number of smaller satisfactions generated by the factors. This is unlikely to be completely valid (e.g. snow conditions and weather might combine in a multiplicative fashion) and will lead to error. Possibly even more importantly the effect of each factor on the satisfaction of the individual is assumed to be constant; everyone responds to the weather or the cost in the same way. The obvious invalidity of such a model has led to the assumption that the parameter coefficient represents some 'average' effect and that individual variance from the mean is independent of factor size, appropriately distributed and simply forms part of the stochastic term. However, as we discuss in the final section, economic logic leads one to hypothesize that the variances are not independent e.g. the least cost conscious will gravitate towards the most expensive sites. This will thus introduce a downward bias when assessing the effects of the factors on the choice.

Assumptions about the size, distribution and independence of these unknown effects (the stochastic term) are critical to the estimation of the effects of the known factors. Consider first the simple binary model where the stochastic terms are assumed to be zero-mean normally distributed. For simplicity we term the known element $\boldsymbol{\beta}\mathbf{X}_{\mathbf{ij}}$, the systematic component and label it V_{ij}. If individual i chooses product 1 rather than 0 $U_{i1} > U_{i0}$, i.e. $V_{i1} + \varepsilon_{i1} > V_{i0} + \varepsilon_{i0}$ or $\varepsilon_{i1} - \varepsilon_{i0} > V_{i0} - V_{i1}$. Since the stochastic terms are zero-mean normally distributed the difference will also be zero-mean normally distributed. The variance of the stochastic term will depend upon the scale of the utility measure or alternatively we can make the scale consistent with unit variance. If we assume that $\varepsilon_{i1} - \varepsilon_{i0}$ is standard normal then, if we have estimates of β and values for X_{ij} and consequently $\mathbf{V_{i0} - V_{i1}}$, we can establish the probability that $\mathbf{U_{i1} > U_{i0}}$. For estimation purposes we choose values of β that maximize the product of the probabilities for all individuals in the sample.

The multinomial case is similar in theory but much more complex in practice. Consider the three-choice case where product 2 has been chosen over 1 and 0. In this case we need to establish the joint probability that $U_{i2} > U_{i1}$ and $U_{i2} > U_{i0}$ or rather $\varepsilon_{i2} - \varepsilon_{i1} > V_{i1} - V_{i2}$ and $\varepsilon_{i2} - \varepsilon_{i0} > V_{i0} - V_{i2}$. Since the differences are normally distributed this is theoretically possible, but we need, in addition to β, the variance of each of the stochastic terms and, importantly, the relationship between the differences in the stochastic terms. Even if we assume independent, identically distributed standard normal distributions we still have to calculate, by integration, the joint probability for each observation at each set of potential values of β. This generates significant computing cost. When we have five choices and we allow for different variances and nonindependence, the model is extremely difficult to estimate.

An alternative is based on the use of the Gumbel distribution. The Gumbel has a similar shape to the normal, logistic and Weibull distributions, but has one extremely useful feature. If the stochastic terms are independent identically distributed with a Gumbel distribution with scale μ then

$$\text{Max}\,(V_{1i} + \varepsilon_{1i}, V_{2i} + \varepsilon_{2i}, V_{3i} + \varepsilon_{3i}, V_{4i} + \varepsilon_{4i}, \ldots, V_{mi} + \varepsilon_{mi}) = V_i^* + \varepsilon_i^*$$

where $V_i^* = (\log(\sum \exp(\mu V_{ki})/\mu)$ and $\varepsilon_{\mathrm{I}}^*$ is Gumbel with zero mean and scale μ. If the scale is set to unity then we obtain the multinomial logit model.

$$\Pr(y = j) = \frac{e^{\beta_j x_i}}{\sum_{j=1}^{J} e^{\beta_j x_i}} \quad \text{for } j = 1, 2, \ldots, J$$

The above model is based on the concept of cardinal utility. There are, however, two areas of indeterminacy. First utility can only be assessed in terms of other products; there is no agreed base value. Secondly there is no scale. To meet these problems we normalize on either one particular or one 'average' product (i.e. give the utility of that product the base value of zero) and scale the utility measures so that the stochastic term has a variance (scale) that makes estimation easier.

The assumption that disturbances are independently and identically distributed introduces an important restriction in the model known as the independence of irrelevant alternatives (IIA) property. 'The IIA property holds that for a specific individual the ratio of the choice probabilities of any two alternatives is entirely unaffected by the systematic utilities of any other alternatives' (Ben-Akiva and Lerman, 1985, p. 108). This assumption may, in some instances, lead to paradoxical results. Under this structural restriction the cross elasticities of any response l with respect to any of the independent variables for choice k will be the same for all $l \neq k$. The probability of the individual choosing l over k thus remains constant irrespective of the composition of the choice set. In marketing for example, a new brand would draw proportionately equal shares from every existing brand. The IIA property assumes all brands to be perceived as distinct and independent so that errors in estimating the utility associated with each alternative (which could arise for example, from a perception of similarities among the brands unobserved by the model) are not correlated.

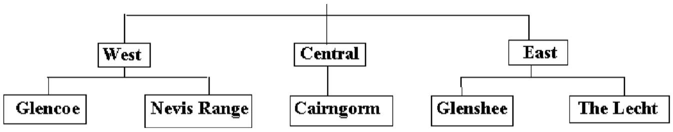

Fig. 3. *Tree structure for ski centre choice*

Unfortunately this is unlikely in the context of geographically based variables. Unknown factors, such as the presence of family or friends in an area, will apply to all sites close to that area. Similarly poor road conditions make the assumption of independent stochastic terms unlikely.

A partial solution is to apply a Nested Logit model, where similar alternatives are clustered together in a manner reflecting their correlated utilities. The nested model has a hierarchical structure like a tree with branches showing choices among elemental alternatives such as East or West and twigs representing choices among the various branches (Glencoe or Nevis Range, Glenshee or The Lecht).

Figure 3 shows the nest used in our problem. In this case a change in the price at Nevis Range is assumed to have more effect on Glencoe than on the other centres, whilst a change at Cairngorm would have equal effects on all the other sites. The equal effects simplification is undesirable although not, we believe, untenable. As with the assumption of the Gumbel, it is simply necessary to allow estimation.

Originally estimation was sequential. First, for a given β, the relative utility of the best choice at the base (twig) level is established. This is termed the inclusive value. This value (together with any factors that only operate at the branch level) is then compared to the maximum values from the other branches and the maximum identified. The probability of this choice is then assessed. Again values of β that maximize the joint probabilities are sought iteratively.

Maximum likelihood techniques now allow nesting up to 4 deep (Greene 1998) and are relatively robust if the model has been specified correctly. The problem of the IIA is not, however, completely resolved through the nesting structure; cross elasticities will still be identical within a branch. The alternative approach is to drop the assumption of identical distributions, replacing them with normal distributions with different variances for each choice, and with errors that may be correlated. However, unless we applied *a priori* values to the correlation matrix (equivalent to nesting) we could not find a solution to our five choice problem. Work presented elsewhere (McFadden, 1984, Riddington, 1998) suggests that differences between this multinomial probit model and the nested logit would be slight and possibly more biased. We present here, therefore, only results from the nested model.

IV. THE DATA SET AND MODIFICATIONS

During February and March 1996, the authors interviewed a total of 670 adults at the five Scottish ski centres. The responses of 340 children were gained indirectly through the responses of the adult in their party. In an attempt to avoid biased results, all interviews took place over one weekend day and one (quieter) weekday at each site. The spread of responses is shown in Table 1. Of the 670 adults in the sample 62% were male and 38% female. These proportions are in line with those reported in the System Three (1994) and Mackay (1986) studies. Children were taken to be individuals with similar characteristics and choice patterns as the adult interviewed.

The utility of a ski centre for an individual skier is determined by a combination of centre characteristics; snow cover, type of runs, availability of accommodation and individual specific characteristics, such as, distance between the site and the individual's place of residence and expenditure per person per day.

The snow coverage at the site at which interviews took place on any particular day was known and details of snow coverage, weather conditions and the number of runs which were open on those days was kindly provided by the other ski companies. This allowed a ranking for quality of snow at the five sites to be calculated. The percentage of

Table 1. *The Survey*

Sites	No. skiers at each site in sample	Skiers at each site in sample (%)	Population skier days at each site	Population skier days at each site (%)
Glencoe	212	21	34 000	7
Glenshee	193	19	129 000	26
Cairngorm	254	25	211 000	42
Nevis	218	22	87 000	17
The Lecht	133	13	43 000	8
Total	1010	100	504 000	100

Notes: Skier Day Source: Mackay (1995) hard (black and red) runs was calculated from the piste maps of the ski sites and included as a variable.

The availability of accommodation around the locality of each ski site was estimated by a simple count of the number of beds reported to be near each site in Ski Scotland (1995). This brochure could reasonably be expected to act as a point of reference for skiers wishing to make an overnight stop near their chosen ski centre.

The total expenditure of each individual at the site they visited was known. This figure covered all costs that had been incurred in the area, including price of the tow ticket, ski hire, tuition, accommodation and food and entertainment. It did not include costs such as petrol purchased outside the area although this may have been used in order to go skiing. In addition no cost was placed against journey time. The distance travelled was used instead and was simply calculated on the basis of the hometown of the respondent. It was believed that, for day-trippers, journey times are of critical importance because they reduce skiing time and therefore have dis-utility.

The cost that would have been incurred elsewhere was obviously unknown but it is possible to infer the expected expenditure by using regression analysis. This was the method employed by Eymann and Ronning (1997) and involves relating actual expenditure by individuals at each site to known costs such as tow prices and local expenditure and characteristics of the individual such as age and whether they were hiring skis, taking tuition and staying overnight. These models explained between 44% (Glencoe) and 68% (Glenshee) of the variance. The characteristics of the individual was then substituted in the models for those centres that had not been chosen, and projected expenditures for that individual at that site estimated.

V. EMPIRICAL RESULTS

Initially the variables shown in Table 2 were specified in a simple multinomial logit model. Distance was, surprisingly found to have both the wrong sign and be insignificant and was initially dropped from the model. The revised model was then tested for the IIA property using the Hausman and McFadden (1984) specification test. Effectively if the IIA property holds, modelling the system with four or five choices should yield roughly the same parameter coefficients. In our experience it is difficult to find situations when there is little parameter change, even if there is no reason to suppose correlation of the stochastic terms. Instead we tend to look for situations of very clear change. In this case the model showed chi-squared statistics with significance values > 0.97 suggesting there was a very serious problem and that a nesting structure ought to be applied to the model.

Table 2. *Variables used in the models*

Variable	Description
EXPEST	Expected expenditure at all sites.
HARD	% proportion of ski runs which were hard at each site
BEDS	Amount of accommodation in locality of each site
COVER	Relative quality of snow cover at each site
DISTANCE	Distance of site from home of individual

The nesting structure chosen was to split the sites into a West branch which contained Glencoe and Nevis Range – the sites on the West coast; an East branch which contained Glenshee and the Lecht – sites on the Eastern side of Scotland and a final branch with Cairngorm on its own. Nesting on a geographical basis was justified by an *a priori* belief that undefined geographical features would exert influence on skier choice. Cairngorm, which is closest to the sites in the East branch geographically, was kept in a separate branch on its own. In part this reflects the fact that Cairngorm, with its dominance of the overnight and long stay markets would have unknown factors that were very different from all other sites. It was also believed that a change at Cairngorm would have a roughly equal effect on all other sites.

This revised specification was again unsatisfactory in terms of the distance variable. After some discussion it was suggested that the result reflected the fact that there existed two markets for skiers, the day trip market where journey time was critical and the overnight market where journeys normally took place during the hours of darkness (Friday nights and Sunday evenings). Two nested models were then estimated, one for day-tripper and one for skiers staying overnight in the locality. Not surprisingly accommodation was totally insignificant for day-trippers whilst distance and snow cover were unimportant for the overnight market. Table 3 gives the resulting coefficients and their z statistics.

Apart from the signs, the coefficients themselves are difficult to interpret being dependent upon the scale of the variable, the normalization and the scale of the utility measure (which has been chosen to give unit variance). The Z scores, however, still identify the significance of the variable and in this case strongly indicate the critical role of the cost on consumer choice.

It is also difficult to obtain meaningful fit statistics. First we can examine the proportion predicted correctly, the 'count R^2'. These have been strongly criticized because applying a simple constant proportion can apparently lead to significant explanation. For example in a binary model with a 50:50 split, a Monkey that always predicted the same choice would obtain a count R^2 of 50%. In this case however the count R^2 values are substantially in excess of the constants only 'Monkey Score' of 20%. As an alternative we can use a Likelihood Ratio or Lagrangian

Table 3. *Coefficients and Z statistics of the two models*

	Day trippers		Weekenders	
Factor	Coefficient	Z statistic	Coefficient	Z statistic
Cost (expest)	−0.149	11.48	−0.0203	7.64
Difficulty	0.017	3.28	0.003	0.06
Accommodation	–	–	0.0024	4.81
Snow cover	−1.17	6.04	–	–
Distance	−0.0019	0.56	–	–

Table 4. *Measures of goodness of fit*

	Count R^2	McFadden's R^2
Day tripper	49.7%	16.7%
Weekender	35.5%	0.49%

Multiplier Test to ascertain if there has been a significant increase in the log likelihood over the constant only (proportions) model. The chi-squared test on the log likelihood ratio gave highly significant results for both models. McFadden's R^2, (which is effectively the LM ratio) is presented, along with the count R^2, in Table 4. Whilst both models are significant, the impact of the identified characteristics is much less strong on the weekend market. Customers staying for the week or weekend would appear to choose their location some time before the departure date and on the basis of what might generate a good holiday rather than a cost effective skiing experience. In contrast day-trippers will only travel if there is a good chance of good skiing.

Tables 5 and 6 give both the own and cross elasticities derived by applying the models to changes around the mean values of the parameters and examining the change in likelihoods. Table 5 clearly distinguishes the different cost elasticities between day-trippers and weekenders. In the case of Cairngorm we believe that the true figure for weekenders is probably around zero. Our hypothesis is that since Aviemore is the only ski centre with recognizable 'apres ski,' it attracts a younger clientele with little cost consciousness. The second feature is the very high cross elasticity between Glencoe and Nevis Range for day-trippers, which disappears completely for weekenders. For the latter the sites appear to be largely complementary.

Table 6 shows the suggested effect of an increase in accommodation availability on the choice of a particular centre. The result for Nevis Range suggests that there is a clear shortage of appropriate accommodation in the immediate vicinity and that improvements would draw skiers predominantly from Cairngorm. The Cairngorm result, if it is anything more than a statistical illusion, possibly indicates an over supply.

For day-trippers the average elasticity for the distance was low at around 0.2. This is a relatively surprising and important result as the outstanding characteristic of the next projected ski centre at Drumochter is its closeness to the central belt.

The only choice where range and difficulty of the site is important is Nevis Range, where the model predicts that an increase in the number of difficult runs would significantly increase the likelihood of a skier choosing the centre. The cross elasticity indicates that the extra skiers would predominantly come from Glencoe. Interestingly, after the surveys which underlie this work, were undertaken, Nevis Range opened a new area of difficult runs.

Table 5. *Cost elasticities*

From\To		Cairngorm	Nevis Range	Glencoe	Glenshee	The Lecht
Cairngorm	Day	**−1.353**	0.367	0.367	0.367	0.367
	Ont	**0.372**	−0.21	−0.21	−0.21	−0.21
Nevis Range	Day	0.390	**−3.76**	**2.14**	0.392	0.392
	Ont	0.321	**−1.116**	*0*	0.321	0.321
Glencoe	Day	0.411	*2.246*	**−3.24**	0.411	0.411
	Ont	0.199	*0*	**−1.07**	0.199	0.199
Glenshee	Day	0.22	0.22	0.22	**−4.126**	1.051
	Ont	0.087	0.087	0.087	**−0.544**	0.415
The Lecht	Day	0.317	0.317	0.317	1.737	**−2.285**
	Ont	0.049	0.049	0.049	0.235	**−0.626**

Notes: Ont represents those who are staying overnight.
Own Price elasticity is in bold font.

Table 6. *The effect of accommodation*

From\To	Cairngorm	Nevis Range	Glencoe	Glenshee	The Lecht
Cairngorm	**- 0.473**	0.204	0.204	0.204	0.204
Nevis Range	−0.214	**0.644**	−0.018	−0.214	−0.214
Glencoe	−0.04	−0.04	**0.184**	−0.039	−0.039
Glenshee	−0.065	−0.065	−0.065	**0.393**	−0.308
The Lecht	−0.007	−0.007	−0.007	−0.033	**0.089**

Note: Own elasticity shown in bold.

VI. CONCLUSION

When undertaking new projects most analysts tend to use the stated preferences of consumers. As is well known stated preferences always overstate the effect of a change, for example many individuals would seriously believe (and state) that they would go skiing if prices were lower and slopes closer to their homes. In reality, however, existing social and recreational patterns would act as a strong but unrecognized deterrent and there would be substantially less change than predicted. The alternative therefore is to examine the revealed preferences and try to model their choices in the past. As this paper shows this is possible but is by no means an easy task.

The results presented here almost certainly underestimate change, largely because of sample bias discussed in Section III. In the models we assume that the parameter linking utility and journey time is constant for all individuals with individual variations from the mean being part of the stochastic term. Since those who place least cost on journey time will be sampled at the sites furthest away, the stochastic term will be correlated with the distance which will, in turn, bias the coefficient downwards. A similar effect is apparent with price elasticity where the least price conscious will be sampled at the location with the highest prices.

How useful, then, are these models and results? Choice modelling is undoubtedly complex and often makes suspect assumptions. It tries to extract cardinal values from ordinal data, and place values on the subjective assessments of individuals. Econometrically it is probably subject to significant downward bias. This paper shows, however that, despite these caveats, valuable information can be obtained. First, in general terms, the models act as an important counterbalance to stated preference. Secondly in this case they do reveal quite vividly the importance of cost to the day-tripper and the significant competition that does exist between centres (suggesting the sense in pursuing strategies that tie individuals to a centre). Finally they do provide site owners and local development agencies with guides to the most effective development strategies.

As computing power expands and data-bases increase in number, we are convinced that this type of modelling will become increasingly important. This work shows that choice models are possible and useful for a product as unique as Skiing.

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