Journal of Public Economics 26 (1985) 221–236. North-Holland

CHARACTERISTICS, CONSUMER SURPLUS, AND NEW ACTIVITIES

A proposed ski area

Edward R. MOREY*

University of Colorado, Boulder, CO 80309, USA

Received January 1984, revised version received September 1984

Physical characteristics of activities and personal characteristics of the individual are incorporated into an expenditure function. This function is used to define the compensating and equivalent variation for changes in the costs or physical characteristics of the existing activities, or for a proposed activity as a function of its proposed characteristics and cost. The model is used to estimate the demand for, and the CVs and EVs associated with, the development of a Colorado ski area. These vary across skiers as a function of skiing ability, value of time, location of residence, and skiing budget.

1. Introduction

A characteristics approach to the demand for activities is integrated with some of the recent theoretical developments on how the market demand for private goods can be used to determine the preferences for public goods. The model is then used to determine the equivalent variations (EVs) and compensating variations (CVs) associated with the development of a new ski area in Colorado as a function of its proposed characteristics and costs. These estimated consumer surplus measures are found to vary extensively across Colorado skiers as a function of their ability level, location of residence, and skiing expenditures. An aggregate CV and an aggregate EV are obtained by summing across skiers. The demand for the proposed site is also determined. It is argued that if data are available this methodology for obtaining the 'consumer surplus' associated with a new recreational site is preferrable to the existing methodology as developed by Cicchetti, Fisher and Smith (1976).

There is a growing literature on how information on the demand for private goods can be used to estimate the consumer surplus associated with

*Thanks go to Dennis Schurmeier for excellent research assistance and to Chris Archibald, A.B. Atkinson, Chuck Blackorby, Bill Desvousges, Phil Graves, Michael Hanemann, Ulrich Kohli, Karl-Göran Mäler, Hugh Neary, Margaret Slade, V. Kerry Smith, John Weymark and the two referees for their helpful suggestions and insights.

0047-2727/85/$3.30

the change in the quantity of a public good. The theory was developed by Mäler (1974), and Bradford and Hildebrandt (1977). Freeman (1979) provides elaboration. Mäler (1974) incorporated environmental commodities into an expenditure function and showed that the CV (or EV) associated with a change in a commodity's quantity can be defined as the difference between the values of the expenditure function evaluated at the two different commodity levels. Mäler then went on to show that if an environmental commodity is weakly complementary with some market good one can use the estimated demand equations for market goods to recover the expenditure function and use it to determine the EV (or CV) associated with a change in the quantity of the environmental commodity. A commodity and a market good are weakly complementary if the marginal willingness to pay for the commodity is zero when the demand for the good is zero. Bradford and Hildebrandt (1977) obtained much the same results, but their argument is in terms of public goods and they do not derive consumer surplus measures per se. More recently, Bockstael and McConnell (1983) expanded these results to consider the production of activities. These works suggest a new approach to the valuation of public goods, but rigorous examples of the approach's empirical applicability are lacking. This paper provides one such example.

The applicability of the Mäler technique for evaluating public goods is greatly expanded by noting that the characteristics of an activity (or good) are just public goods that are weakly complementary with that activity (or good). The technique can therefore be used to estimate the consumer surplus associated with a change in the characteristics of an activity or a good. One should also note that if one assumes activities are weakly separable by groups, and if all the characteristics of a given type of activity are explicitly included as exogenous variables in the utility function, there is only one conditional demand function for activities in that category. Differences in the demand for activities are accounted for by variations in the value of the independent variables (prices and characteristics) in the one demand function. The inclusion of all the characteristics thereby makes it possible to estimate the conditional demand for a proposed activity as a function of its proposed characteristics and also makes it possible to use the Mäler technique to estimate the CV or conditional EV associated with the new activity. This paper makes these points in a formal model of consumer behavior. Two separate expenditure functions are estimated for skiing activity in Colorado and each is then used to estimate the consumer surplus associated with a new area. Section 2 outlines the theoretical model; section 3 considers the example; and section 4 summarizes the methodological contribution.

2. The model

Suppose there are J potential activities, the quantity of the jth activity consumed being denoted by y_j.[1] Let $Y \equiv [y_j]$ denote the vector of activities consumed. It is assumed that activities are nonjointly produced subject to constant returns to scale. Associated with each activity is a vector of K effective physical characteristics, $a_{\cdot j} = (a_{1j}, \ldots, a_{kj}, \ldots, a_{Kj})$, where K is assumed to include all the characteristics of all activities.[2] The complete characteristic matrix is $A \equiv [a_{kj}]$. The individual ranks bundles of activities on the basis of the quantities of the different activities in each bundle and their characteristics, not on the basis of the activities' names. When an activity is completely described in terms of its characteristics one does not need its name to identify it. If the individual's ranking fulfills the standard regularity conditions in terms of Y, the preference ordering can be represented with some direct utility function, $U(Y, A)$. Since all the characteristics of the activities are explicitly included as exogenous variables, the mathematical form of $U(Y, A)$ is invariant to which activity is associated with each of the j subscripts, i.e. $U(Y, A)$ is mathematically symmetric with respect to the activities' names.[3]

Denote the quantity of total expenditures on activities, τ, and the cost of producing one unit of activity, j, γ_j. Let $\Gamma \equiv [\gamma_j]$ denote the vector of these costs. Given the assumption of nonjointness and constant returns to scale in the production of activities, γ_j is well defined for all activities.[4] Faced with a given budget τ and vector of parametric activity costs Γ, the consumer chooses Y so as to maximize $U(Y, A)$ subject to the budget constant, $\sum \gamma_j y_j = \tau$. This yields an indirect utility function, $x(\tau, \Gamma, A)$, which may be inverted to obtain the expenditure function, $E(U, \Gamma, A)$.

This expenditure function $E(U, \Gamma, A)$ can be used to determine the dollar amount that must be given to, or taken from, the consumer to make him indifferent between two alternative price-characteristic configurations. Assume the consumer initially faces the parametric prices and characteristics Γ' and A'. These constraints allow the consumer to achieve some maximum utility level U'. Prices and characteristics then exogenously change to Γ'' and A''. With these new constraints the consumer can achieve some maximum

[1] J includes all activities that currently exist plus all activities that have the potential to exist. It is assumed that J is finite due to technological restrictions on the production of activities.

[2] The vector $a_{\cdot j}$ can include both public and private characteristics. In general a_{kj} is the amount of physical characteristic k that the individual encounters and can effectively utilize in activity j. If a_{kj} is a private characteristic, its presence in activity j does not influence the amount of characteristic k in activity i, $i \neq j$. However, if the existence of a_{kj} guarantees that $a_{kj} = a_{ki}$ $\forall_i$ and $_j$, then a_k can be described as a purely public characteristic. If activity j does not currently exist, $a_{kj} = 0$, $\forall_k$.

[3] For example, the functions $x = q_1 q_2$, $x = q_1 q_2^2 + q_2 q_1^2$, and $x = \ln q_1 + \ln q_2 + \ln q_1 \ln q_2$ are all symmetric in q_j; the functions $x = q_1 + q_2^2$, $x = q_1 q_2^2$ and $x = q_1 + \ln q_2$ are not. Eq. (3) is an example of a utility function that is symmetric with respect to the activities' names.

[4] Bockstael and McConnell (1983) have shown that if activities are jointly produced the cost of a given activity cannot be isolated from the cost of other activities. In this case, Marshallian demand functions for activities as a function of the separate costs of the different activities do not exist.

utility level U''. The compensating variation, CV, associated with this change is

$$CV = E[U', \Gamma', A'] - E[U', \Gamma'', A'']. \tag{1}$$

The CV is the amount of money that would make the consumer indifferent between facing the set of exogenous parameters (Γ', A', τ) and the set $(\Gamma'', A'', \tau - CV)$. The equivalent variation, EV, associated with this same change is

$$EV = E[U'', \Gamma', A'] - E[U'', \Gamma'', A'']. \tag{2}$$

The EV is the amount of money that would make the consumer indifferent between facing the set of exogenous parameters (Γ'', A'', τ) and the set $(\Gamma', A', \tau + EV)$.

These points are clarified with an example. Assume a CES preference ordering that incorporates all the characteristics,

$$U(Y, A) = \sum_{j=1}^{J} y_j^{\beta} g(a_{1j}, a_{2j}, \ldots, a_{Kj}), \tag{3}$$

where $1 > \beta \neq 0$, and $g(a_{.j})$ is of the same sign $\forall_j$. Further assume that the consumer maximizes this utility function (3) subject to a fixed budget τ and the vector of parametric activity costs Γ. The resulting Marshallian demand function[5] for activity j is

$$y_j = m(\gamma_j, \Gamma, a_{.j}, A) = \tau \Bigg/ \sum_{h=1}^{J} \gamma_h \left[\frac{\gamma_h g(a_{1j}, a_{2j}, \ldots, a_{Kj})}{\gamma_j g(a_{1h}, a_{2h}, \ldots, a_{Kh})} \right]^{1/(\beta - 1)},$$
$$j = 1, 2, \ldots, J. \tag{4}$$

These demand functions are identical, i.e. all the demand functions have identical functional forms and parameters. What varies across the demand equations is the magnitudes of γ_j, and $a_{1j}, a_{2j}, \ldots, a_{Kj}$; the exogenous variables are defined the same in each equation but they take different values

[5]The reader should be aware that this demand function implies that activities are divisible and that there is a positive demand for each activity. This is a standard assumption but one that is not always appropriate. The impact of this assumption on the estimated demand for skiing activities is discussed in Morey (1981) where it is argued that the assumption is not overly restrictive. See Hanemann (1984) for an example of a model of consumer behavior that does not assume there is a positive demand for each good (activity). Hanemann integrates a qualitative choice model with a continuous choice model under the assumption that the individual will only consume one of the alternatives. His model needs to be generalized before it can be applied to situations such as skiing where more than one alternative is chosen.

in each equation. Demand functions are generally not identical because not all factors (prices and characteristics) that explain variations in demand are included as exogeneous variables. When all characteristics are included, differences in the demand for activities can be accounted for by variations in the values of the independent variables (prices and characteristics) in the demand function rather than having the variations appear in the form of different name-specific demand functions. When all the characteristics are included, an activity's name is not necessary to explain the demand for that activity. The symmetry of $U(\cdot)$, and the resulting single demand function, simplifies estimation of the demand for activities, and allows one to accurately specify the demand for a proposed, but not yet existent, activity. Inclusion of the characteristics also makes it possible to determine the CV and EV associated with either the introduction of a new activity or a change in an existing activiity.

Using this single demand function (4) and the direct utility function (3), one can solve for the indirect utility function and then invert it to obtain a CES expenditure function:

$$E(U,\Gamma,A)=-e(\Gamma,A)/U \tag{5}$$

where

$$e(\Gamma,A)=\left[\sum_{j=1}^{J} g(a_{.j})^{-1/(\beta-1)}\gamma_j^{\beta/(\beta-1)}\right]^{(\beta-1)/\beta}. \tag{6}$$

Introduction of a new activity i will not change the form or dimensions of (6), it will just change $a_{.i}$. The CES based CV and EV for a new or modified activity are therefore

$$\mathrm{CV}=[e(\Gamma'',A'']-e(\Gamma',A')]/U' \tag{7}$$

and

$$\mathrm{EV}=[e(\Gamma'',A'')-e(\Gamma',A')]/U''. \tag{8}$$

The applicability and usefulness of the approach is demonstrated with an example. We first use the model to develop a conservative estimate of the total demand for a proposed ski area at Copper Mountain in Colorado. This is accomplished by first estimating the demand for Copper for each of a large number of distinct individuals. These estimates are conservative in that it is assumed that each individual's total ski days will not increase when Copper is introduced. Projected demand for Copper varies from individual to individual as a function of skiing ability, location of residence, value of time, expenditures on skiing, etc. A conservative estimate of total demand is obtained by aggregating across Colorado skiers.

A lower limit on the one year aggregate CV and EV associated with the development of Copper is then estimated. The aggregate CV is an estimate of how much money could be extracted from Colorado skiers each year when Copper exists and still leave them in positions just as preferred as the positions they were in before Copper was developed. The sum of the EVs is a measure of how much money would have to be transferred to Colorado skiers each year to put them in positions just as preferred as the positions they would have been in if Copper had been developed. The aggregate CV and EV are obtained by first estimating the CV and EV for many different types of individuals. Individual's CVs and EVs depend on ability level, location of residence, expenditures on skiing, value of time, etc. The aggregate CV and EV are obtained by summing the CVs and EVs across individuals. Finally, the aggregate CV and EV obtained here for Copper are compared with the aggregate consumer surplus measure Cicchetti, Fisher and Smith (1976) obtained for the proposed Mineral King Ski Area in California.

3. The example: Copper Mountain

Copper Mountain is a major ski area located approximately 90 miles west of Denver, Colorado. It opened in the fall of 1972 with approximately 145 acres of novice terrain, 436 acres of intermediate terrain, and 146 acres of advanced terrain [Colorado Ski Country U.S.A. (1976)]; an uphill capacity of 5114 vertical transport feet [Colorado Ski Country U.S.A. (1975)], and an expected annual snowfall of 200 inches [Colorado Ski Country U.S.A. (1972)]. A lift ticket in 1972 cost $7.00 [Colorado Ski Country U.S.A. (1972)].

In Morey (1981), a CES expenditure function was estimated for skiing activities in Colorado. In Morey (1984b), a generalized form of this preference ordering was developed and estimated. The data available were from the 1967/68 season. At that time there were 15 major ski areas in the state: Aspen (an aggregate of four separate areas), Vail, A-Basin, Breckenridge, Loveland, Winter Park, Broadmoor, Crested Butte, Lake Eldora, Monarch, Mt. Werner, Wolf Creek, Purgatory, Cooper, and Hidden Valley. The following information was available for 163 post-secondary Colorado students: (1) a complete record of each individual's skiing activities during the 1967/68 season; (2) the individual's skiing ability; (3) information on the individual's family and their skiing habits; and (4) the location of the individual's residence. The value of their time was assumed to be $1.15 per hour (the Federal minimum wage). Lift ticket prices and data on the physical characteristics of the fifteen areas were also collected. For the purposes of our example, we will assume that, except with respect to the value of their time, the 163 students are a random sample of all Colorado skiers. The minimum wage is assumed to be a lower limit on the value of a skier's time.[6]

Skiing activities were assumed weakly separable from all other activities, and the complete A matrix was assumed block diagonal such that the characteristics associated with skiing form one of the blocks. This allows one to specify the demand for skiing activity $j(y_j)$ as a function of the cost of visiting the different sites (Γ), their effective physical characteristics (A), and total expenditures on skiing (τ). It was assumed that one unit of skiing activity j (one day of skiing at site j) could be described in terms of four characteristics: a_{1j} = the acres of ski runs which the individual is capable of skiing; a_{2j} = the acres of ski runs specifically designed for the individual's skiing ability; a_{3j} = vertical transport feet (VTF); and a_{4j} = average annual snowfall. Note that a_{1j} and a_{2j} are not just a function of site characteristics but also depend on the individual's skiing ability. For example, for an intermediate skier, a_{1j} is acres of novice and intermediate terrain and a_{2j} is acres of intermediate terrain. The cost of a visit to ski area $j(\gamma_j)$ depends on the lift ticket price, the opportunity cost of the individual's time, the location of the individual's residence, and the location of site j.

Morey (1981) assumed a CES preference ordering and estimated the share equation for the 15 existing sites. The algebraic form of $g(a_{.j})$ was assumed to be:[7]

$$\begin{aligned} g(a_{1j},a_{2j},a_{3j},a_{4j}) = {} & \alpha_0+\alpha_1 a_{1j}+\alpha_2(a_1,a_{2j})^{1/2}+\alpha_3 a_{2j}+\alpha_4 a_{1j}^{1/2} \\ & +\alpha_5 a_{2j}^{1/2}+\alpha_6 a_{3j}+\alpha_7(a_{1j}a_{3j})^{1/2}+\alpha_8(a_{2j}a_{3j})^{1/2} \\ & +\alpha_9 a_{3j}^{1/2}+\alpha_{10}a_{4j}+\alpha_{11}(a_{1j}a_{4j})^{1/2}+\alpha_{12}(a_{2j}a_{4j})^{1/2} \\ & +\alpha_{13}(a_{3j}a_{4j})^{1/2}+\alpha_{14}a_{4j}^{1/2}. \end{aligned} \tag{9}$$

This specific form (9), a generalized Leontief, was chosen because it is linear in its parameters and because it provides a second-order approximation to any twice differentiable function in the a_{kj}'s.

The CES preference ordering is restrictive in that it assumes that preferences are homothetic and directly additive. Morey (1984b) tested these restrictions by specifying and estimating a generalized CES (GENCES)

[6]The reader should note that the magnitudes of the CVs and EVs for Copper are dependent upon this assumption; a significant proportion of the total expenditures on skiing are attributable to the value of travel and onsite time. For more details on this and other aspects of the data, see Morey (1981).

[7]The CES parameter estimates are

α_0	α_1	α_2	α_3	α_4	α_5	α_6	α_7
1	−0.6144	1.445	−1.095	−3.164	−10.70	−0.0165	0.0945
α_8	α_9	α_{10}	α_{11}	α_{12}	α_{13}	α_{14}	$1/(\beta-1)$
−0.1058	21.95	2.464	1.137	0.5934	−1.124	−48.209	−1.984

The parameter α_0 in $g(a\cdot j)$ is assumed to equal zero if site j does not currently exist.

preference ordering. The indirect GENCES utility function is[8]

$$\Psi(\Gamma, A, \tau) = [-e(\Gamma, A)/\tau] + [e(\Gamma, A)/f(/\Gamma, A)], \tag{10}$$

where

$$f(\Gamma, A) = \left[\sum_{j=1}^{15} d(a_{\cdot j})^{-1/(\beta-1)} \gamma_j^{\beta/(\beta-1)} \right]^{(\beta-1)/\beta} \tag{11}$$

and

$$d(a_{1j}, a_{2j}) = \varepsilon_0 + \varepsilon_1 a_{1j} + \varepsilon_2 (a_{1j} a_{2j})^{1/2} + \varepsilon_3 a_{2j} + \varepsilon_4 a_{1j}^{1/2} + \varepsilon_5 a_{2j}^{1/2}. \tag{12}$$

The size of the model allowed consideration of characteristics a_{1j} and a_{2j} only. The null hypothesis of direct additivity and homotheticity was rejected. The expenditure function for the GENCES is

$$E(U, \Gamma, A) = -e(\Gamma, A) \Bigg/ \left[U - \frac{e(\Gamma, A)}{f(\Gamma, A)} \right]. \tag{13}$$

The CV and EV for the CES preference ordering were defined in eqs. (7) and (8). The CV and EV for the GENCES preference ordering are

$$\mathrm{CV} = \frac{e(\Gamma'', A'')}{\left[U' - \dfrac{e(\Gamma'', A'')}{f(\Gamma'', A'')} \right]} - \frac{e(\Gamma', A')}{\left[U' - \dfrac{e(\Gamma', A')}{f(\Gamma', A')} \right]} \tag{14}$$

and

$$\mathrm{EV} = \frac{e(\Gamma'', A'')}{\left[U'' - \dfrac{e(\Gamma'', A'')}{f(\Gamma'', A'')} \right]} - \frac{e(\Gamma', A')}{\left[U'' - \dfrac{e(\Gamma', A')}{f(\Gamma', A')} \right]}. \tag{15}$$

Note that the magnitude of the CV does not depend on the fact that skiing activities were assumed weakly separable from all other activities; however, the EV is a conditional EV (it is the EV associated with the change, derived assuming total expenditures on skiing do not change). Derivation of

[8]The GENCES is a special case of the Quadratic Expenditure System [Howe, Pollak and Wales (1979)] generalized to include characteristics. If $\alpha_m = \varepsilon_m, \forall_m$, the GENCES reduces to the CES. The direct form of the GENCES utility function is not known. The GENCES parameter estimates are

α_0	α_1	α_2	α_3	α_4	α_5	
1	−0.0138008	0.0316539	−0.0293046	0.5802476	−0.0204941	
ε_0	ε_1	ε_2	ε_3	ε_4	ε_5	$1/(\beta-1)$
1	−0.0138023	0.0316608	−0.0293038	0.5801316	−0.0206069	−2.369728

The parameters α_0 in $g(a \cdot j)$ and ε_0 in $d(a \cdot j)$ are both assumed to equal zero if site j does not currently exist.

the EV requires knowledge of U''. Given the weak separability assumption, U'' is obtainable from the indirect utility function for skiing activities. This indirect is a function of total skiing expenditures, not total income. U'' derived in this manner, for a welfare gain, will be less than the true U'' because it is derived assuming total skiing expenditures remain constant when in fact they increase by an unknown amount. The EV associated with the development of Copper Mountain will therefore be a conservative EV.

3.1. The projected demand for Copper

The estimated CES and GENCES share functions are used to estimate: (1) what the demand for Copper would have been if it had opened in 1967; and (2) how the introduction of Copper in 1967 would have affected the demand for the other areas.[9] For the purposes of our example we are assuming that Copper was scheduled to open in 1967 but did not. This assumption is made because characteristics data for the other areas are not available for the 1972/73 season. It is further assumed that the Copper that might have opened in 1967 would have been identical to the one that did open in 1972 except that its lift ticket price would have been $5.50 instead of $7.00.

Table 1 lists the predicted shares with and without Copper for a few representative individuals (see also table 2).[10] For each individual, the shares for the 15 existing sites and the proposed site, Copper, are obtained from the estimated share equation, either the CES or GENCES, by increasing the actual J from 15 to 16, where γ_{16} is this individual's cost of visiting Copper, and a_{k16}, $k=1,\dots,K$, are the characteristics this individual can utilize at Copper. The important thing to note is that given the estimated share function, one can estimate the share for a proposed site as a function of the characteristics and costs of the existing sites and proposed site. If the share equation was estimated correctly, its parameters will not change when a new site is introduced.

Examining the estimated shares in table 1, one observes the large differences between the four-characteristic CES preference ordering and the two-characteristic GENCES. The CES, without exception, predicts a much larger share for Copper. The choice of functional form is obviously important. Since the four-characteristic CES is not a special case of the two characteristic GENCES, it is difficult to say which of the forms is more appropriate than the other. A priori, Copper was expected to have the biggest impact on intermediate skiers who lived in front-range cities such as Denver and Ft. Collins since Copper has mostly intermediate terrain and is

[9]The CES and GENCES share functions are easily derived from the respective expenditure functions by inverting each to obtain the indirect utility function and then applying Roy's Identity. Their exact forms are reported in Morey (1981, 1984b).

[10]The full tables can be obtained from the author.

Table 1
Predicted shares, with and without Copper.

	Aspen	Vail	A-Basin	Breckenridge	Loveland	Winter Park	Broadmoor	Crested Butte	Lake Eldora	Monarch	Mt. Werner	Wolf Creek	Purgatory	Cooper	Hidden Valley	Copper
Individual 2[a]																
CES Shares without Copper	0.1731	0.1395	0.0851	0.0645	0.1260	0.1702	0.0590	0.0194	0.0694	0.0085	0.0265	0.0214	0.0030	0.0178	0.0167	—
CES Shares with Copper	0.1388	0.1119	0.0683	0.0518	0.1011	0.1365	0.0474	0.0155	0.0557	0.0068	0.0213	0.0172	0.0024	0.0143	0.0134	0.1977
GENCES Shares without Copper	0.0867	0.1397	0.1185	0.0772	0.1461	0.1350	0.0287	0.0325	0.0539	0.0183	0.0408	0.0074	0.0073	0.0841	0.0237	—
GENCES Shares with Copper	0.0780	0.1263	0.1062	0.0692	0.1310	0.1210	0.0258	0.0292	0.0484	0.0165	0.0366	0.0067	0.0065	0.0754	0.0213	0.1020
Individual 12[a]																
CES Shares without Copper	0.1480	0.1171	0.1056	0.0819	0.1539	0.1631	0.0319	0.0178	0.0475	0.0208	0.0458	0.0186	0.0040	0.0318	0.0122	—
CES Shares with Copper	0.1262	0.0998	0.0900	0.0698	0.1312	0.1391	0.0272	0.0152	0.0405	0.0177	0.0390	0.0159	0.0034	0.0271	0.0104	0.1474
GENCES Shares without Copper	0.2063	0.1210	0.1057	0.0671	0.1453	0.1204	0.0194	0.0201	0.0459	0.0156	0.0371	0.0058	0.0050	0.0673	0.0180	—
GENCES Shares with Copper	0.1921	0.1156	0.0884	0.0554	0.1226	0.1014	0.0170	0.0171	0.368	0.0125	0.0306	0.0049	0.0042	0.0561	0.0152	0.1300

Individual 26[a]																
CES Shares without Copper	0.2208	0.1932	0.0857	0.0816	0.1242	0.1195	0.0173	0.0112	0.0416	0.0133	0.0332	0.0141	0.0045	0.0193	0.0105	—
CES Shares with Copper	0.1893	0.1656	0.0820	0.0699	0.1064	0.1024	0.0148	0.0096	0.0357	0.0114	0.0285	0.0120	0.0039	0.0165	0.0090	0.1427
GENCES Shares without Copper	0.1351	0.1545	0.1311	0.0970	0.1364	0.1055	0.0124	0.0163	0.0586	0.0201	0.0366	0.0067	0.0062	0.0558	0.0277	—
GENCES Shares with Copper	0.1192	0.1355	0.1141	0.0844	0.1182	0.0914	0.0109	0.0142	0.0511	0.0175	0.0317	0.0059	0.0054	0.0484	0.0239	0.1281
Individual 159[a]																
CES Shares without Copper	0.3745	0.1622	0.0507	0.0544	0.0589	0.0530	0.0078	0.0282	0.0134	0.0201	0.0218	0.0745	0.0604	0.0160	0.0041	—
CES Shares with Copper	0.3375	0.1462	0.0457	0.0490	0.0531	0.0477	0.0071	0.0254	0.0121	0.0181	0.0196	0.0671	0.0544	0.0144	0.0037	0.0989
GENCES Shares without Copper	0.3698	0.1521	0.0560	0.0535	0.0410	0.0300	0.0063	0.0432	0.0145	0.0321	0.0159	0.0469	0.0992	0.0342	0.0052	—
GENCES Shares with Copper	0.3524	0.1438	0.0521	0.0497	0.0375	0.0275	0.0060	0.0400	0.0136	0.0300	0.0145	0.0438	0.0908	0.0314	0.0047	0.0623

[a]Characteristics of the individuals:

Individual	2	12	26	159
Residence:	Denver	Denver	Denver	Durango
Skiing ability	Novice	Intermediate	Advanced	Advanced
Skiing budget	$61.38	$332.21	$83.06	$570.79
Number of days	3	12	4	12

located relatively close to the front range. Copper's share was assumed to come at the expense of areas with a lot of intermediate terrain that were located farther from Denver, i.e. Aspen or Vail. The GENCES, but not the CES, results agreed with the conjecture that Copper would appeal most to intermediates. Both models suggest that a lot of Copper's share would come at the expense of Aspen and Vail. The results suggest Copper will be popular but less so for those living in distant cities such as Durango.

The aggregate share for each area can be obtained by estimating the number of trips each individual in the sample will take to each area, aggregating across those individuals, and then using this information to calculate aggregate shares. The aggregate CES share for Copper is 0.144 and the aggregate GENCES share for Copper is 0.106. Skiers bought 1 718 983 lift tickets at the 15 areas in 1967/68 [Colorado Ski Country U.S.A. (1975)]. Given this, the aggregate CES share conservatively predicts that Copper would have sold 247 534 lift tickets to Colorado skiers in 1967/68. The GENCES predicts 182 212 tickets.

3.2. The CVs and EVs for Copper

Eqs. (7), (8), (14), and (15) were used to calculate the CV and EV associated with the introduction of Copper for each individual in the sample. Table 2 lists these for a few representative individuals. The CES predicts larger CVs and EVs than the GENCES model does (not surprising since the CES predicted a larger demand for Copper). For the CES model, but not the GENCES, the CV and EV for a given type of individual (all those with the same residence and ability) is a constant proportion of their skiing budget. For example, the CV for novices from Denver is 19.2 percent of their budget, the EV is 23.8 percent. This outcome follows from the homotheticity of the CES function. Another implication of homotheticity is that (EV/skiing budget)$\equiv$(CV/(skiing budget$-$CV)), i.e. the CV and EV, as a percentage of 'compensated income', are equal if preferences are homothetic. For example, both are 23.8 percent for novices from Denver. Alternatively, for the nonhomothetic GENCES, the CV, and EV, as a proportion of the budget declines as the budget increases and are not equal as a percentage of 'compensated income'. Note that the CV and EV depend on the value of the individual's time. Table 2 also makes explicit the importance of personal characteristics (in this case skiing ability and residential location). Willig (1976) encourages one to examine the differences between the CVs and EVs. Whether the differences are large or small is left to the reader.

The sum of the CVs and EVs for the 163 students are respectively \$5556.20 and \$6459.96 for the CES model, and \$3034.58 and \$3236.52 for the GENCES model. Assuming that the sample is representative of the 193 144

Table 2
Some CVs, EVs, and predicted shares for Copper.

	Skiing			CES			GENCES		
Residence	Ability	Budget	Number of ski days	Predicted share Copper	CV	EV	Predicted share Copper	CV	EV
Denver	N	$20.75	1	0.1977	$3.99	$4.95	0.1035	$1.56	$1.68
	N	61.38	3	0.1977	11.82	14.64	0.1020	$4.55	4.91
	I	82.46	4	0.1474	11.82	13.87	0.1346	8.26	9.15
	I	332.21	12	0.1474	47.82	55.86	0.1300	30.25	32.79
	A	83.06	4	0.1427	11.11	12.83	0.1282	7.67	8.40
	A	317.54	12	0.1427	42.49	49.06	0.1089	24.53	25.95
Pueblo	N	94.95	4	0.1807	17.41	21.32	0.0931	6.58	7.06
	I	191.20	6	0.1377	26.41	30.64	0.1251	17.73	19.37
	I	378.44	10	0.1377	52.27	60.64	0.1183	32.35	34.76
	A	636.67	25	0.1326	81.26	93.15	0.0792	36.48	37.14
Gunnison	I	47.93	2	0.1285	6.42	7.41	0.1118	4.38	4.81
	I	237.95	8	0.1285	31.85	36.77	0.1051	19.85	21.40
	A	27.27	5	0.1215	3.34	3.80	0.1087	2.32	2.53
	A	170.62	1	0.1215	20.87	23.77	0.0983	13.13	14.06
Durango	I	17.02	1	0.1098	2.12	2.42	0.0996	1.49	1.63
	I	190.49	5	0.1098	23.75	27.13	0.0923	15.30	16.49
	A	190.49	5	0.0989	21.20	23.85	0.0818	13.41	14.29
	A	570.79	12	0.0989	63.51	71.46	0.0623	30.54	31.37

Sum of the CVs for the 163 individuals: CES = $5556.20; GENCES = $3034.58.
Sum of the EVs for the 163 individuals: CES = $6459.96; GENCES = $3236.52.

Colorado skiers in 1967/68,[11] we obtain the aggregate measures listed in table 3.

The aggregate CV is the total amount of money that would have to be paid out by all Colorado skiers to make them each indifferent between the payout with Copper and no payout without Copper. It can be interpreted as the maximum amount Colorado skiers would be willing to pay for the opportunity to ski at Copper during the 1967/68 season. The aggregate EV is how much money would have to be paid to all Colorado skiers to make

Table 3
Aggregate CV and aggregate EV for Copper.

CES model	CV = $6 583 722	EV = $7 654 617
GENCES model	CV = $3 595 772	EV = $3 835 058

[11]The figure was obtained by dividing total lift ticket sales (1 718 983) by the average number of ski days for each individual in the sample (8.9). This estimate of total skiers is conservative; the Denver Research Institute (1968) estimated 379 000 skiers.

each of them indifferent between no Copper with the payment and Copper without the payment. It can be interpreted as the minimum lump-sum payment Colorado skiers would have to receive to induce them to voluntarily forgo the opportunity to ski at Copper during the 1967/68 season. These estimates are open to criticism in that, for example, the number of skiers or the value of each skier's time may be inappropriately estimated.

3.3. *The estimates and the model: the alternative*

Is the model useful and are the CV and EV estimates plausible? One cannot answer these questions in the absolute, one can only compare the present technique with the alternatives. Many would argue that Cicchetti, Fisher and Smith (1976), hereafter CFS, is the obvious alternative when it comes to estimating the benefits of a new recreational site. CFS (1976) estimated that the annual benefits, in 1972 dollars, associated with the development of Mineral King Ski Area would have been \$6 125 000 if travel time is valued at \$3.00/hour and vehicle operating cost at \$0.044/mile. Deflated into 1967/68 dollars, \$6 125 000 is \$4 900 000, which is in the midrange of the CV and EV estimates for Copper. The estimates are of the same order of magnitude so let us compare the capabilities of the two models. The CFS model requires that one assumes the proposed site will be a perfect substitute, in terms of characteristics, for an existing site. This is because their model does not explicitly consider the characteristics of the sites or the users. One could use the present model to get an estimate of the error caused by this restrictive assumption by checking to see how much the aggregate CV and EV would change if one assumed Copper has the same physical characteristics as an existing site. For example, the aggregate CV and EV for Copper, assuming Copper has the same characteristics as Vail, are respectively \$7 287 208 and \$8 660 895 for the CES model and \$5 375 958 and \$6 605 862 for the GENCES model. The aggregate CV and EV for Copper, assuming Copper has the same characteristics as Breckenridge, are respectively \$3 092 144 and \$3 304 818 for the CES model and \$2 202 658 and \$2 283 736 for the GENCES model. Comparing these estimates with those in table 3 one can see that assuming Copper is a perfect physical substitute for Vail leads to much higher estimates than those obtained using Copper's actual characteristics, and assuming Copper is a perfect physical substitute for Breckenridge leads to much lower estimates. The exclusion of characteristics means the CFS technique will not work if a 'similar' site does not exist and also precludes the CFS model from estimating the 'benefits' associated with a change in the physical characteristics of an existing site. Alternatively, one can use the present model to estimate the changes in demand, the CV, and the EV associated with, for example, a conversion of advanced terrain into intermediate terrain at Aspen. If one could get data on National Parks, one might test the conjecture of a former Secretary of the Interior that consumers prefer improved roads and facilities at existing parks to increasing the size and number of parks. The model also allows one to identify impacts by groups more extensively than is possible with the CFS model. This is because individual behavior is estimated as a function of individual characteristics and then aggregated, whereas CFS deal only with aggregate behavior. One can therefore use this model to estimate how impacts vary from individual to individual. For example, GENCES results suggested that intermediate skiers would gain the most from Copper. Information on who benefits and who loses is the type of information that policy-makers like. The present model also gives us a way of determining the CV and EV associated with a change in personal characteristics. In this context one might determine that consumers would prefer ski lessons at the existing area to the existence of Copper. In another context consumers might be found to prefer a wilderness education program to a new wilderness area. The CFS methodology does not have these capabilities.

4. Conclusion

There is a growing theoretical literature, pioneered by Mäler (1974), that shows how the demand for private goods (activities) can be used to estimate the CV and EV associated with the change in the quantity of a public good if that public good is weakly complementary with one or more private goods (activities). However, rigorous empirical examples are lacking. This paper corrects that deficiency and generalizes the applicability of the technique by pointing out that the characteristics of a private activity can be treated in the individual's expenditure function as public goods that are weakly complementary with that activity. This is accomplished by using an expenditure function to integrate a characteristics approach to the demand for activities with the Mäler technique for evaluating public goods. As the example shows, the technique can be used to determine the CV and EV associated with either a change in the characteristics of an existing recreational site or the introduction of a new site. The demand for a proposed site can also be estimated as a function of its proposed characteristics and price. This technique for evaluating the demand for and benefits from a proposed site is superior to the currently used technique which assumes that the proposed site is a perfect substitute for one of the existing sites.

References

Bockstael, Nancy E. and Kenneth E. McConnell, 1983, Welfare measurement in the household production framework, American Economic Review 83, 806–815.

Bradford, David F. and Gregory G. Hildebrandt, 1977, Observable preferences for public goods, Journal of Public Economics 8, 111–131.

Business Research Division, 1976, The Colorado ski industry: highlights of the 1975–76 season, Graduate School of Business Administration, University of Colorado, Boulder, Colorado, mimeo.
Cicchetti, Charles J., Anthony C. Fisher and V. Kerry Smith, 1976, An econometric evaluation of a generalized consumer surplus measure: the mineral king controversy, Econometrica 44, 1259–1275.
Colorado Ski Country U.S.A., 1972, Guide to Colorado ski country U.S.A. 1972/73 (Colorado Ski Country U.S.A., Denver).
Colorado Ski Country U.S.A., 1975, Area statistics — 1973–74 season, Colorado Ski Country U.S.A., Denver, mimeo.
Colorado Ski Country, U.S.A., 1976, Unpublished data, Colorado Ski Country U.S.A., Denver, mimeo.
Deaton, Angus and John Muellbauer, 1980, Economics and consumer behavior (Cambridge University Press, Cambridge).
Denver Research Institute, 1968, A profile of the tourist market in Colorado 1968, Industrial Economics Division, Denver Research Institute, University of Denver, Denver.
Freeman, A. Myrick, 1979, The benefits of environmental improvement: theory and practice (Published for Resources for the Future by Johns Hopkins University Press, Baltimore).
Hanemann, W. Michael, 1984, Discrete/continuous models of consumer demand, Econometrica 52, 541–561.
Howe, Howard, Robert A. Pollak and Terence J. Wales, 1979, Theory and time series estimation of the quadratic expenditure system, Econometrica 47, 1231–1247.
Mäler, Karl-Göran, 1974, Environmental economics: a theoretical inquiry (Published for Resources for the Future by Johns Hopkins University Press, Baltimore).
Morey, Edward R., 1981, The demand for site-specific recreational activities: a characteristics approach, Journal of Environmental Economics and Management 8, 345–371.
Morey, Edward R., 1984a, Confuser surplus, American Economic Review 74, 163–173.
Morey, Edward R., 1984b, The choice of ski areas: estimation of a generalized CES preference ordering with characteristics, The Review of Economics and Statistics 66, 584–590.
Willig, Robert D., 1976, Consumer's surplus without apology, American Economic Review 66, 589–597.