האוניברסיטה העברית בירושלים
The Hebrew University of Jerusalem

המרכז למחקר בכלכלה חקלאית
The Center for Agricultural Economic Research

המחלקה לכלכלה חקלאית ומנהל
The Department of Agricultural Economics and Management

Discussion Paper No. 2.02

Measuring the Recreational Value of Open Spaces

by

Aliza Fleischer and Yacov Tsur

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P.O. Box 12, Rehovot 76100

ת.ד. 12, רחובות 76100

Measuring the Recreational Value of Open Spaces

Aliza Fleischer[1] and Yacov Tsur[2]

Abstract

We develop aggregate measures of the recreational value of types of open spaces when data on individual site visitation are not available. Our procedure accounts for both the allocation (between the different types of open spaces) and participation (total number of trips) decisions. The procedure is applied to estimate the recreational value of three main types of open spaces (beaches, urban parks and national parks) in Israel.

Keywords: Open Space, Recreational Value, Two-Stage Budgeting

[1] Department of Agricultural Economics and Management, The Hebrew University of Jerusalem. P.O. Box 12, Rehovot 76100, Israel. Tel:+972-8-9489144 Fax:+972-8-9466267 (fleische@agri.huji.ac.il).

[2] Department of Agricultural Economics and Management, The Hebrew University of Jerusalem. P.O. Box 12, Rehovot 76100, Israel and Department of Applied Economics, The University of Minnesota, 1994 Bufford Ave., St. Paul, MN 55108, USA. Tel:+972-8-9489372 Fax:+972-8-9466267 (tsur@agri.huji.ac.il).

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We develop aggregate measures of the recreational value of types of open spaces when data on individual site visitation are not available. Our procedure accounts for both the allocation (between the different types of open spaces) and participation (total number of trips) decisions. The procedure is applied to an estimate of the recreational value of three main types of open spaces (beaches, urban parks and national parks) in Israel.

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1. Introduction

Population and income growth, combined with increased leisure and environmental awareness, have given rise to two conflicting trends underlining the allocation of open spaces in developed countries. On the one hand open spaces, such as public beaches, parks and cultivated farmland are shrinking in size, while on the other, the demand for outdoor activities that are based on such open spaces is on the rise (Lockeretz, 1989; English et al., 1990; Cordell et al., 1995; Ewer, 1995; Levia and Page, 2000). This conflict raises the need for open-space allocation, a process which requires, inter alia, an estimate of the recreational value of the different types of open spaces. In this work we offer a procedure to evaluate the recreational benefit of open spaces and apply it to measure the benefit of beaches, urban parks and national parks in Israel.

Our procedure is indirect in that it uses travel cost expenses as a proxy for willingness to pay. There are two basic approaches to estimating extra-market benefits based on travel cost: participation and allocation. The first is based on the total number of recreational trips. Changes in the characteristics of one or more sites will induce a change in the total number of trips and this change can be used to calculate the associated change in welfare. In the allocation approach, on the other hand, the total number of recreational trips is taken as a given and the decision involves the allocation of the total number of trips among the various sites. In the participation approach, welfare changes emanate from changes in the number of trips, whereas in the second (allocation) approach, welfare depends on the allocation among sites (see Freeman, 1993 and references therein).

A third approach has recently emerged that combines these two effects by simultaneously analyzing the participation and allocation decisions (Morey et al., 1993; Hausman, et al., 1995; Parsons and Kealy, 1995; Feather et al., 1995, Romano et al., 2000). The present effort belongs to this integrated approach, as it links the participation and allocation decisions using the methodology offered by Hausman, et al. (1995).

Our procedure differs from previous methods in that it evaluates the benefit of types of open spaces without the need to consider individual sites. When the number of sites is large, site visitation data are not always available, while data on open-space visitation is simpler and easier to collect. Like any other aggregation procedure, our estimates are not immune to the so-called aggregation bias (Kaoru and Smith, 1990; Parsons and Needleman, 1992; Lupi and Feather, 1998). While most aggregation procedures in the literature lump recreational sites geographically for different degrees of spatial resolution (Lupi and Feather, 1998), we aggregate with respect to types of open spaces. We believe that this form of aggregation satisfies the condition under which the aggregation bias is eliminated.

This condition results from the assumption that individuals derive utility from the performance of recreational activities, but not from the mere act of visiting a recreational site. Sites are instrumental inasmuch as they allow one to perform the selected activity. We also observe that the same recreational activity carried out in one type of open space (e.g., a picnic on the beach) is not quite the same when carried out in a different type of open space (e.g., a picnic in an urban park). By grouping recreational activities according to the types of open spaces in which they are performed, we achieve equivalence between groups of recreational activities and types of open spaces. We can then interpret a choice between recreational activities as a choice between types of open space. The latter forms the basis for our valuation of the benefit of types of open spaces.

The next section explains the overall setup. Section 3 specifies the open-spaces demand model along the lines of Hausman, et al.'s (1995) two-stage budgeting approach. Section 4 applies the model to an estimate of the benefits of beaches, urban parks and national parks in Israel and Section 5 concludes.

2. Measures of the use value of open spaces

The individual sites are arranged in M disjoint groups, each corresponding to a type of open space, such as sea beaches, fishing lakes, urban parks, national parks, or estuaries (we use the term "type of open space" and "group" interchangeably). A site is classified as belonging to a particular type of open space based on its dominant nature. By a suitably refined definition of types of open space, the classification of sites among the different types is straightforward.

Following the random utility – nested multinomial logit (NMNL) framework (McFadden, 1978, 1981), let

$$U_{mj} = v_{mj} + \xi_{mj} \equiv x_{mj}\beta - \rho c_{mj} + \xi_{mj};\ \ m = 1,2,\ldots,M;\ \ j = 1,2,\ldots,J_m \quad (1)$$

represent the utility an individual derives from visiting site j in an open-space type m, where x_{mj} is a vector of individual site characteristics, c_{ij} is the visiting cost, and J_m the number of sites in open-space type m. The ξ_{mj}'s are assumed to be extreme value random variates, uncorrelated between groups but correlated within groups, with the inclusive coefficient γ representing the degree of correlation within each group (assumed constant across groups): γ ranges between 1 (when sites within groups are uncorrelated) and 0 (when they are perfectly correlated).

Denoting by I_m and L_m the index set and the number of sites in group m, respectively, $m = 1,2,\ldots,M$, the utility an individual derives from visiting (a site in) open-space type m is (Ben Akiva and Lerman, 1985; Parsons and Needelman, 1992)

$$U_m = Max_{j \in I_m}\{u_{mj}\} = V_m + \gamma \ln L_m + \gamma \ln H_m + \varepsilon_m, \quad m = 1,2,...,M, \tag{2}$$

where $V_m = (1/L_m)\sum_{j\in I_m} v_{mj}$ is the average (deterministic) utility of nest *m*,

$$H_m = (1/L_m)\sum_{j\in I_m} e^{(v_{mj} - V_m)} \tag{3}$$

is a measure of the heterogeneity of sites in nest *m*, γ is the inclusive coefficient defined above and the ε_m, $m = 1,2,\ldots,M$, are iid extreme value variates.

The probability of visiting open-space type *k* is

$$P_k = \frac{\exp(V_k + \gamma \ln J_k + \gamma \ln H_k)}{\sum_{m=1}^{M} \exp(V_m + \gamma \ln J_m + \gamma \ln H_m)} \tag{4}$$

and the per trip consumer surplus is (Small and Rosen, 1981; McFadden, 1981; Hanemann, 1984; Bockstael, et al., 1991; Freeman, 1993, p. 471; Hausman et al., 1995)

$$CS = \frac{1}{\rho}\ln\left\{\sum_{m=1}^{M} \exp(V_m + \gamma \ln J_m + \gamma \ln H_m)\right\}. \tag{5}$$

The consumer surplus due to group ℓ is

$$CS_\ell = CS - CS_{-\ell}, \tag{6}$$

where

$$CS_{-\ell} = \frac{1}{\rho}\ln\left\{\sum_{\substack{m=1 \\ m\neq \ell}}^{M} \exp(V_m + \gamma \ln J_m + \gamma \ln H_m)\right\}. \tag{7}$$

is and the surplus at the absence of group ℓ .

The above index, CS_ℓ, does not account for the number-of-trips decision. To incorporate this effect we employ the two-stage budgeting approach of Hausman, et al., 1995). First, individuals decide on whether or not to participate in the recreational activities at all. Those that decided to participate proceed to choose the number of trips T_i, $i = 1,2,\ldots,N$, to undertake, where the subscript i signifies individual i and N is the size of the participants subsample. In the second stage, they allocate this (given) number of trips among the different activity groups, as indicated earlier.

2.1 Demand for recreational trips: Let $T_i = \sum_{m=1}^{M} T_{im}$ be the number of recreational trips individual i has taken during a year, say, where T_{im} represents the number of trips allocated to open space type m. Specifying the overall demand for recreational trips requires specifying the choice of T_i and its allocation T_{im}, $m = 1,2,\ldots,M$, among the M types.

The data realizations of the random variable T_i are counts on the number of trips individual i has taken during, say, one a year. Since a trip can be taken by any group, a per trip price index must summarize the prices (visit cost) of all groups. Following HLM, we use the negative of the consumer surplus from the trip allocation model above as the implicit trip price.

The regression function for the count variable T_{i} is specified as

$$E\{T_i \mid S_i, Z_i, \omega_i\} = \exp\{Z_i\beta - \alpha S_i + \omega_i\}, \qquad (8)$$

where S_i is the implicit per-trip price index (= the negative of the consumer surplus of equation 4), Z_i is a vector of the individual's socioeconomic characteristics, α and β are the respective coefficients, and ω_i is an error term representing effects of unobserved variables and measurement errors. It is assumed that $\exp(\omega_i)$, i=1,2,…,N, is independently drawn from the same distribution with $E\{\exp(\omega_i)\} = 1$ and $Var\{\exp(\omega_i)\} = \eta^2$. The unit mean assumption entails no loss of generality when β contains an intercept. When the ω_i are independent of $\{Z_i, \mathrm{S_i}\}$ for all i, then (see Gourieroux et al., 1980)

$$E\{T_i \mid S_i, Z_i\} = \exp\{Z_i\beta - \alpha S_i\} \equiv m_i \quad and \quad Var\{N_i \mid S_i, Z_i\} = m_i + \eta^2 m_i^2 \tag{9}$$

The negative binomial model arises when the exp(ω_i)'s are iid gamma(δ,1/δ) variates with $\delta = 1/\eta^2$ (the harmless normalization $E\{\exp(\omega_i)\} = 1$ requires that the product of the first and second parameters of the gamma variate equal unity), i.e., $\Pr\{e^{\omega_i} = y\} = \frac{y^{\delta-1}e^{-y\delta}}{\Gamma(\delta)(1/\delta)^\delta}$. In this case T_i has a negative binomial distribution with parameters $1/(1+m_i/\delta)$ and δ:

$$\Pr\{T_i = n \mid S_i, Z_i\} = \frac{\Gamma(n+\delta)}{n!\Gamma(\delta)}\left(\frac{m_i/\delta}{1+m_i/\delta}\right)^n\left(\frac{1}{1+m_i/\delta}\right)^\delta \tag{10}$$

When $1/\delta = \eta^2 \to 0$, the negative binomial, reduces to the Poisson distribution and

$$\Pr\{T_i = n \mid S_i, Z_i\} = m_i^n e^{-m_i}/n! \tag{11}$$

The Poisson specification is therefore nested in the negative binomial model.

Integrating the mean demand function $m_i = \exp\{Z_i\beta - \alpha S_i\}$ gives the consumer surplus index

$$W_i = \int_{S_i}^{\infty} \exp(Z_i\beta - \alpha S)dS = \frac{\exp(Z_i\beta - \alpha S_i)}{\alpha} = \frac{m_i}{\alpha}. \tag{12}$$

This index measures the total surplus for individual i, accounting for both the decision on the number of trips and the allocation of these trips among the different nests. Suppose that group ℓ ceases to be available, so that the surplus from the trip allocation model S_i changes to $S_{i-\ell} = -CS_{i-\ell}$ (equation 6). The corresponding change in the welfare for individual i is

$$\Delta W_i(\ell) = \frac{\exp(Z_i\beta - \alpha S_i) - \exp(Z_i\beta - \alpha S_{i-\ell})}{\alpha}, \tag{13}$$

which constitutes a measure for the use value of group ℓ.

3. Aggregation with respect to types of open space

It is seen from the above that parameter estimation and welfare evaluation require disaggregated data to calculate the heterogeneity variable H_m (equation 3), except when $\gamma = 0$, which is the case when sites of the same type are perfectly correlated (or substitutable), to the extent that individuals are indifferent between them. While unlikely to hold when aggregation is based on geographical location, assuming $\gamma = 0$ is quite reasonable when one aggregates with respect to types of open spaces, as each type of open space contains sites of the same type. After all, sites are instrumental in that they enable individuals to perform recreational activities. If two sites are of the same nature and accommodate the same activities, it is reasonable to assume that individuals will be indifferent between them and will choose the site based on the visiting cost. True, in actual practice there are no perfectly identical sites. But if the differences are small enough, so that the choice between sites is predominantly based on the visitation cost, the assumption $\gamma = 0$ is reasonable. The application below maintains this assumption.

4. Application to the value of open spaces in Israel

An intensive land relocation process is now under way in Israel, as urban areas spread over open spaces and agricultural lands that have gone out of production. While the value of urban land can be discerned from land prices, no market signals exist for the recreational value of open spaces. We proceed to estimate these values for three types of open spaces: beaches, urban parks and national parks.

4.1. Data: Our data come from a national survey of a representative sample of 500 adult Israelis. The data contain information on number of trips taken to each open space type (beaches, urban parks or national parks) during a year, trip cost and various socioeconomic characteristics (age, gender, education, income group). The survey was administered by telephone using a random-digit dialing procedure. Table 1 presents descriptive statistics of the sample data and explains each variable.

Table 1

The sites ranked according to popularity are beaches, urban parks and national parks. National parks are the most costly while urban parks are the least. Note that although beaches are costlier, they are used more intensely than urban parks.

4.2. Estimation: We begin with the second stage—the allocation of trips among types of open space given the total number of trips. The three types of open spaces are beaches, urban parks and national parks, indexed *1*, *2* and *3*, respectively. We consider two scenarios: when the three types are independent (not similar), and when urban parks and national parks are correlated (similar) and constitute a group (in the second scenario the urban park and national park groups constitute a nest). The first is referred to as the MNL case and the second as the nested multinomial model (NMNL). For the MNL, equation (4) specializes to

$$p_{ij} = \frac{\exp\{X_i\phi_{j3} - (c_{ij} - c_{i3})\rho\}}{1 + \sum_{k=1}^{2} \exp\{X_i\phi_{k3} - (c_{ik} - c_{i3})\rho\}}, \text{ j} = 1 \text{ or } 2, \text{ and } p_{i3} = 1 - p_{i1} - p_{i2}, \tag{14}$$

where $\phi_{j3} = \phi_j - \phi_3$, j = 1,2. The sample log-likelihood is given by $\sum_{i=1}^{N}\sum_{m=1}^{3} T_{im}\log(p_{im})$ where N is the participants sample size and T_{im} is the number of trips individual i has taken to open-space type m. Notice, observing equation (14), that we can estimate the differences of the individual characteristic coefficient vectors $\phi_{j3} = \phi_j - \phi_3$, j = 1,2, but not the coefficient vectors ϕ_j, j=1,2,3, themselves.

The individual characteristic vector (X_i in equation 1) is five-dimensional, consisting of a constant term, education, age, income and gender. The maximum-likelihood estimates for the MNL model are presented in Table 2.

Since national parks and urban parks accommodate a few activities of similar nature, we expect them to exhibit some degree of similarity. We thus nest the two in one group and run a NMNL model with two groups—beaches being the sole member of the other group. This means that individuals first decide on whether to visit a beach or a park. If they choose a park, they move on to select between national and urban parks.

The probability of visiting an urban park (open space type 2) given that the park group (group 2) was selected is (see, e.g., Hausman et al., 1995)

$$p_{i2|2} = \frac{\exp\{[X_i\phi_{23} - (c_{i2} - c_{i3})\rho]/\gamma\}}{1 + \exp\{[X_i\phi_{23} - (c_{i2} - c_{i3})\rho]/\gamma\}} \tag{15}$$

where γ is the inclusive coefficient of the parks group measuring the degree of similarity of urban parks and national parks (γ = 0 means perfectly correlated and γ =1 means independent). The probability of visiting a national park (open-space type 3) given that the park group (group 2) was chosen is $1 - p_{i2|2}$. The probability that a beach (group 1) will be visited is

$$p_{i1} = \frac{\exp\{X_i\phi_{13} - (c_{i1} - c_{i3})\rho\}}{\exp\{X_i\phi_{13} - (c_{i1} - c_{i3})\rho\} + (1 + \exp\{[X_i\phi_{23} - (c_{i2} - c_{i3})\rho]/\gamma\})^{\gamma}} \tag{16}$$

and the probability of choosing the park group (group 2) is $p_{i2} = 1 - p_{i1}$. The likelihood of the *i*'s observation (individual) is $(p_{i1})^{T_{i1}}(p_{i2}p_{i2|2})^{T_{i2}}(p_{i2}p_{i3|2})^{T_{i3}}$ and the sample log-likelihood is $\sum_{i=1}^{N}\{T_{i1}\ln(p_{i1}) + T_{i2}\ln(p_{i2}p_{i2|2}) + T_{i3}\ln(p_{i2}p_{i3|2})\}$. The maximum likelihood estimates are presented in Table 2 (as in the MNL model, the ϕ coefficients are presented as differences from ϕ_3).

Table 2

We can now calculate the per-trip consumer surplus indexes CS and $CS_{-\ell}$ (equations 5-7). The per-individual surplus due to each type of open space is obtained by subtracting the second index from the first and multiplying the result by the total number of trips the individual has taken. We obtain the averages presented in the first row in Table 3.

Table 3

Turning to the number of trips decisions (stage 1), since we confine our attention to the participants subsample (i.e., those with $T_i \geq 1$), we have a truncated sample. This, noting equation (10), implies that the likelihood function for individual i is given by

$$L_i = \Pr\{T_i \mid T_i \geq 1\} = \frac{\dfrac{\Gamma(T_i)}{T_i!}\left(\dfrac{m_i/\delta}{1+m_i/\delta}\right)^{T_i}\left(\dfrac{1}{1+m_i/\delta}\right)^{\delta}}{1-\left(\dfrac{1}{1+T_i/\delta}\right)^{\delta}} \tag{17}$$

where m_i is defined in terms of S_i (see equation 9)—the consumer surplus from the MNL or NMNL models. Maximizing the sample log-likelihood, we obtain the following estimates (Table 4).

Table 4

The consumer surplus from the trip demand model (which constitutes the overall surplus measure, also accounting for the change in number of trips) can now be calculated, as indicated in equation (13). The average consumer surplus measures are presented in the second row in Table 3.

We see that the surplus averages in Table 3 are smaller than those obtained from the conditional MNL or NMNL models. This is so because the NB estimates are based on a model that allows for total number of trips to be adjustable while the MNL and NMNL estimates assume that the number of trips is fixed. Thus, for instance, closure of beaches reduces the welfare of an average individual but the individual can mitigate the loss by adjusting the total number of recreational trips. Under the MNL and NMNL models, such an adjustment in not permitted. The last row in Table 3 shows the percent difference between the two models.

Beaches are seen to generate the highest benefit, followed by urban parks and national parks. This ranking is preserved with (NB) or without (MNL and NMNL) substitution effect. The difference in welfare indexes between the two models is not negligible, ranging between 47 and 16 %.

5. Concluding comments

The need to properly manage open spaces is enhanced as open spaces become scarcer, which is the inevitable outcome of economic development and population growth. Allocating open spaces requires evaluating their economic values. We offer a procedure to accomplish this task, which aggregates over sites that belong to the same type of open space. Due to the nature of our aggregation, our procedure does not suffer from aggregation bias when individuals gain utility not from the mere fact of visiting a site but from performing a recreational activity. In other words, sites are instrumental in that they allow performing recreational activities but have no other role whatsoever. Our procedure, thus, does away with the need to collect visitation data on individual sites.

Applying the procedure to three types of open spaces in Israel (beaches, national parks and urban parks), we find that beaches generate the greatest economic value and thus should be preserved with the outmost care. We also find that national and urban parks are substitutable to some degree, implying some flexibility in preserving and managing these two types of open spaces. The procedure here developed is particularly appropriate for land use planning at the regional or country level, where types of open spaces are of main concern, rather than individual sites.

Acknowledgement

Funding for this research was provided by the Institute of Land Policy and Land Use Research of the Jewish National Fund Israel.

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Table 1: Means and standard deviations (in parentheses) of sample data

Variable	
Number of visits -- beaches	8.8 (20.3)
Number of visits -- urban parks	3.2 (10.6)
Number of visits -- national parks	1.1 (4.0)
Travel cost -- beaches[a]	24.7 (25.7)
Travel cost -- urban parks[a]	20.5 (17.2)
Travel cost -- national parks[a]	46.0 (20.6)
Education[b]	2.6 (0.9)
Age[c]	3.3 (1.5)
Income[d]	3.0 (1.0)
Gender[e]	0.43 (0.5)
Ole[f]	0.16 (0.2)
Number of observations (after deletion of observations with missing data)	422

Notes:

[a] For visitors traveling by car, this is the number of kilometers (from residence to destination) multiplied by cost per km, plus other costs directly related to the visit as reported by respondents (e.g., parking). For visitors using public transportation it is the actual travel fare.
[b] 1 = elementary, 2 = partial high school, 3 = high school, 4 = vocational or partial college, 5 = university degree(s).
[c] 1=18-20, 2=21-30, 3=31-40, 4=41-50, 5=51-60, 6=61+
[d] 1 = far below average, 2 = below average, 3 = about average, 4 = above average, 5 = far above average.
[e] 1 = male.

[f] 1= New Immigrant from 1990.

Table 2: MNL and NMNL estimates of the trip allocation model (the indicates that the hypothesis that the coefficient equals zero is rejected at 5% significance level)

	MNL	NMNL
Visit cost coefficient ($-\rho$):	-0.0348*	-0.0283*
Beaches ($\phi_{13} = \phi_1 - \phi_3$):		
Constant	2.3575*	1.3627*
Education	-0.2549*	-0.2696*
Age	-0.1650*	-0.0745*
Income	0.0184	0.8334*
Gender	0.7996*	0.0998*
Urban parks ($\phi_{23} = \phi_2 - \phi_3$):		
Constant	1.7834	0.8058*
Education	-0.0347	-0.0421*
Age	-0.2187	-0.1183*
Income	-0.2025	0.0016*
Gender	-0.0082	-0.0926
Parks group Inclusive coefficient (γ)	-	0.5618*

Table 3: Average surplus indexes under the MNL/NMNL and under the count-data regression models

	MNL			NMNL		
	Beaches	Urban parks	National parks	Beaches	Urban parks	National parks
MNL&NMNL	670.66	161.42	47.77	810.92	144.26	39.57
Negative Binomial (NB)	526.72	127.35	39.92	432.72	102.01	26.27
% Difference	21.5	21.1	16.4	46.6	29.3	33.6

Table 4: Negative binomial estimates for the trips demand model (the asterisk indicates significant at 5%)

Variable	MNL	NMNL
-S	-0.0262*	-0.0267*
AGE	-0.0499	-0.0852*
EDUCA	0.2180*	0.0800
INCOME	0.1490*	0.1504*
GENDER	-0.0692	-0.1439
OLE	0.3766*	0.3841*
Constant	1.6975*	2.3471*

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