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Distributional Welfare Impacts of Public Spending: The Case of Urban versus National Parks

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This study examines the optimal allocation of funds between national and urban parks. Since travel costs to national parks are significantly higher than to urban parks, poor households tend to visit the latter more frequently, whereas rich households favor the former. Therefore, allocating public funds to improving the quality of national parks at the expense of urban parks disproportionately benefits high-income households. By developing a theoretical model and implementing it using Israeli data, findings indicate all households, except for the richest decile, prefer that the park authority divert a larger proportion of its budget from national to urban parks.

Key words: budget allocation, income distribution, national parks, urban parks

Introduction and Background

Different income groups tend to consume different quantities of public goods. Therefore, funding the provision of certain public goods may disproportionately benefit some income groups at the expense of others. The importance of this issue with respect to outdoor recreation has been recognized by federal agencies in the United States, which have been directed to "identify differential patterns of consumption of natural resources among minority and low income populations" (U.S. Executive Order No. 12898, 3 C.F.R. 859, 1994).

The purpose of this study is threefold: first, to develop a theoretical model in which different income groups tend to consume different quantities of public goods—different types of parks in this paper; second, to analyze the welfare effects of budget allocation to the different park types; and third, using Israeli data, to assess empirically whether the different patterns of consumption of low- and high-income households are taken into consideration in the budgeting process. By achieving these goals, this analysis contributes to the growing literature on "environmental justice" (for a recent survey, see Floyd and Johnson, 2002).

Parks are public goods which in many countries are commonly maintained and preserved with public funds. Parks can be classified into two types: national or regional parks, and urban or local parks. The location of the parks obviously affects the numbers of visitors they receive. In contrast to urban parks, national parks are usually located in the countryside, away from urban centers, making them expensive and sometimes

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unaffordable for low-income, non-car-owning individuals [e.g., refer to the studies by Cordell et al. (1990) relating to the United States; The Countryside Agency (2000) relating to England; and Fleischer (1994) relating to Israel]. On the other hand, national parks are also typically larger, serve a larger population, and retain more natural characteristics than urban parks. Moreover, national parks may offer the added benefit of providing enjoyment merely through the traveling experience itself (Hanink and White, 1999), and may also be more attractive because their relative inaccessibility suggests less congestion (Mealey, 1988).

The literature on recreational sites is replete with studies addressing consumers' choices among a discrete number of heterogeneous sites (see, e.g., Kaoru, Smith, and Liu, 1995; Kling, 1988; Haab and McConnell, 1996; Phaneuf, 1999; Feather and Shaw, 1999). A few studies have examined the relationship between outdoor recreation habits and income. Suggesting a method of measuring the equity consequences of public programs, Kalter and Stevens (1971) found that the net benefits per household from the Stonewall Jackson Water Reservoir project in West Virginia were higher for high-income households compared to low- and medium-income households. Hill and Alterman (1979) studied the equity of the allocation of land for public services. They concluded "weak" communities are also relatively deprived in the allocation of open spaces for playgrounds and gardens. A study by Reiling, Cheng, and Trott (1992) reports a qualified discriminatory impact of Maine state park entrance fees on low-income users.

Given that urban and national parks are unevenly used by different income classes, the distribution of public funding between the two types of parks may reflect a possible preferential treatment of certain income groups over others. To detect the possibility of preferential treatment, we propose in this study a theoretical framework to examine the welfare effects of the budget allocation between urban and national parks. The empirical findings agree with the predictions of our theoretical model that high-income households visit national parks more frequently than urban parks, whereas the opposite holds true for low-income households. We use a comprehensive data set on funding and the number of visits to parks in Israel to calibrate our model and evaluate the optimal distribution of funds. Findings show that not only does the distribution of funds across the two types of parks not favor low-income households, it may even reflect (perhaps unintentionally) a bias toward high-income households.

The remainder of the paper is organized as follows. First, the theoretical framework is developed for the households' problem, proving that visits to urban parks are an inferior good while visits to national parks are a normal good. In addition, we derive the necessary conditions for the optimal budget allocation of a benevolent park authority. The validity of our theoretical predictions is then tested, and the model parameters are calibrated. In the next section, the optimal budget allocation between national and urban parks is determined. The final section presents some conclusions and possible extensions for future research.

The Model

Households

Households derive utility from recreational activities and all other goods. Recreational activities comprise three different types: visits to urban parks and to national parks (C_1 and C_2, respectively), measured by the annual number of visits, and all other recreational activities (R), measured in nominal annual spending. In addition, households derive utility from consumption of a composite good (Z), also measured in nominal annual spending.

For preferences, we choose a widely used utility function (e.g., Prescott, 1986; Romer, 2001, p. 206):

$$U = \alpha \ln(1 + C_1) + \beta \ln(1 + C_2) + \gamma \ln(R) + \ln(Z), \tag{1}$$

where α, β, and γ and are some positive parameters.[1] Note that (1) implies visits to parks are not essential goods, whereas some forms of other recreation and consumption of the composite goods are.

Households maximize utility subject to the budget constraint. While visits to urban parks are free, visits to national parks involve a travel cost of p per visit.[2] Thus, every household faces the budget constraint:

$$pC_2 + R + Z = I, \tag{2}$$

where I is the household's annual income.

A central feature of recreational activities is that they are time-consuming, and different types of recreational activities vary in the time they require. Hence, the following time constraint is added:

$$C_1 + tC_2 + eR = T. \tag{3}$$

Visit time in urban parks is normalized to one, hereafter a standard visit time (a day),[3] t is the standard visit time required for one visit in a national park, e is the standard visit time required for one dollar's worth of other recreational activities,[4] and T is the standard visit time available over a year for all types of recreation. The assumption that T is fixed and individuals cannot trade income and leisure is equivalent to restricting individuals to work a predetermined number of hours. The assumption of labor indivisibility has become standard in the labor and macroeconomics literature (e.g., Hansen, 1985; Diamond and Mirrlees, 1986; Prescott, 1986; Hamilton, 1988; Christiano and Eichenbaum, 1992; Mulligan, 1998). Empirical studies strongly suggest firms restrict their employees' labor supply. Hours of work are heavily influenced by the particular job a person holds, and hour changes within jobs are typically very limited (e.g., Altonji and Paxson, 1986; Biddle and Zarkin, 1989).

Finally, we follow the literature by assuming households' utility from visiting parks increases with public funding to these parks (Taylor, 1999), based on the notion that investment improves the quality of the parks, thereby increasing the pleasure from each visit. Specifically, we assume:

$$\alpha = s_1 g_1^{\rho_1} \text{ and } \beta = s_2 g_2^{\rho_2}, \tag{4}$$

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[1] The parameter multiplying $\ln(Z)$ is normalized to 1.

[2] Assuming C_1 is costly although cheaper than C_2 would not affect our results, but would add more notation.

[3] A visit to an urban park does not necessarily take a whole day; however, we assume that on a day when the household visits a park it will not consume other recreational activities.

[4] Conceivably, wealthier people engage in other recreational activities that are more expensive relative to poorer households, implying they use less time spending one dollar. Hence, e decreases with income. For simplicity, and since we do not have information on the relationship between I and e, the latter is assumed to be constant.

where g_1 and g_2 are public spending in urban and national parks, respectively, and s_1, s_2, ρ_1, and ρ_2 are some exogenous parameters, reflecting the technology of converting funding into park quality. Intuitively, ρ_1 and ρ_2 would be expected to be smaller than one to reflect decreasing marginal returns to park funding. Indeed, this intuition is confirmed by the estimations reported in the empirical analysis section. It should be emphasized that while households take α and β as given, the park authority affects them by determining g_1 and g_2.

Analysis of the Household's Problem

Every household maximizes (1) subject to (2) and (3), taking α and β as given. The first-order conditions are expressed as:

(5a) $$\frac{\alpha}{1+C_1} \leq \mu \quad \text{(with equality if } C_1 > 0\text{)},$$

(5b) $$\frac{\beta}{1+C_2} \leq p\lambda + t\mu \quad \text{(with equality if } C_2 > 0\text{)},$$

(5c) $$\gamma/R = q\lambda + e\mu,$$

(5d) $$1/Z = \lambda,$$

and equations (2) and (3), where λ and μ are the Lagrangian multipliers associated with equations (2) and (3), respectively.

Recall, by equation (1), visiting parks is not an essential good. To ensure households have enough time to induce them to visit at least one park, it is assumed T is sufficiently large. Specifically, we assume:

(6) $$T > ep\gamma/(q\beta - qt\alpha + pe\alpha) > 0.$$

The following lemma proves that if T satisfies (6), then every household visits at least one type of park.

■ LEMMA 1. *If $T > ep\gamma/(q\beta - qt\alpha + pe\alpha)$, then either $C_1 > 0$, or $C_2 > 0$, or both.*

Proof. Suppose not. Then $C_1 = C_2 = 0$, which by (5a), (5b), and (3) implies $\alpha \leq \mu$, $\beta \leq p\lambda + t\mu$, and $R = T/e$. Substituting into (5c) and rearranging, we find that $T \leq ep\gamma/(q\beta - qt\alpha + pe\alpha)$, in contradiction to equation (6), thus proving lemma 1.

The threshold level of T is proportional to γ because visiting parks and other types of recreation come one at the expense of the other, and the more desirable is R, the less time is allocated to visiting parks. It is assumed throughout the paper that (6) is maintained. Later on, it is shown that the calibrated parameters are well within the boundaries defined by (6).

As shown by lemma 2, given our assumption that all households visit parks, transportation costs may deter poor households from visiting national parks, and they consequently visit only urban parks. Specifically, we show there is a threshold level of income, I_1, below which households do not visit national parks at all.

■ LEMMA 2. *There is a critical income level, I_1, such that households with income $I \leq I_1$ choose $C_2 = 0$.*

Proof. The proof is in the appendix.

We also find that urban parks are an inferior good, whereas national parks are a normal good. Specifically, the richer the household, the less it visits urban parks and the more it visits national parks.

■ PROPOSITION 1. *For $I_1 < I$, C_1 strictly declines and C_2 strictly increases with I.*

Proof. The proof is in the appendix.

Proposition 1 reveals an important pattern in visiting parks: the poorer the household, the more frequently it visits urban parks, and the richer the household, the more it visits national parks. The intuition underlying this pattern is that poor households can afford to spend only small amounts of money on traveling to national parks (which are located far away) and on other recreation. This leaves them more time to visit the low-cost, urban parks, and therefore C_1 is relatively large and the marginal utility from another visit to a local park is low. As households get richer, they can afford to spend more on C_2 and R where the marginal utility is high. Consequently, the higher the household's income, the greater the shadow price of its time.[5] Hence, high-income households cut down on the cost-free recreation with the low marginal utility and switch to the other, more expensive forms of recreation where the marginal utility is greater. In other words, as households become richer, the time constraint becomes more pressing relative to the budget constraint.

Welfare and Policy

Public spending affects welfare by affecting the quality of parks, and consequently the level of enjoyment per visit and the number of visits. Investment in the various types of parks also has distributional effects because, as shown in proposition 1, poor households visit more urban parks whereas the richer households are biased toward national parks. Therefore, the allocation of public funds between urban and national parks reflects the relative importance the authorities attribute to the welfare of the poor. In Israel, for example, where our data originate, the policy of the park authority is to favor funding parks used more extensively by low-income households.

Our goal is to examine whether the composition of the actual public investment in parks is consistent with this policy. As a benchmark, the optimal distribution of public investment in the two types of parks is calculated assuming a Bergson-Samuelson social welfare function with equal weights. That is, *given* the aggregate public spending on parks, G, we calculate what should have been its composition if the authorities had assigned equal weights to the welfare of all the households in the economy. Then the actual public funding is compared to the benchmark results and to the allocations preferred by the various income deciles.

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[5] Usually, the shadow price of time is related to income through the wage rate. This is not the case here, since we regard T as exogenous.

For the theoretical derivation of the optimal budget allocation, it is useful to distinguish between households whose income exceeds I_1 (see lemma 2) and those whose income is lower than I_1. The optimal values for the former group are denoted by a single superscript asterisk, and for the latter group by superscript double asterisks, respectively. Let $G = n_1 g_1 + n_2 g_2$ be the predetermined aggregate spending on parks, where n_1, g_1, n_2, and g_2 are the number of urban parks, the actual public spending per urban park, the number of national parks, and the actual public spending per national park, respectively. Using (2), (3), (4), and (5a)–(5d), and substituting $g_2 = (G - n_1 g_1)/n_2$, yields: $C_1^{**} = C_1^{**}(I, g_1, \mathbf{k})$, $C_1^{*} = C_1^{*}(I, g_1, \mathbf{k})$, and $C_2^{*} = C_2^{*}(I, g_1, \mathbf{k})$, where $\mathbf{k}$ is a vector of exogenous parameters. Then:

(a) By lemma 2, for a representative household with $I \leq I_1(g_1)$, $C_2^{**} = 0$, and $U^{**} = U^{**}(C_1^{**}(I, g_1, \mathbf{k}), I, g_1, \mathbf{k})$. By the Envelope Theorem,

$$\frac{dU^{**}}{dg_1} = \frac{\partial U^{**}}{\partial g_1} \quad \text{and} \quad \frac{dU^{**}}{dI} = \frac{\partial U^{**}}{\partial I}.$$

(b) Similarly, for a representative household with $I > I_1(g_1)$, $U^{*} = U^{*}(C_1^{*}(I, g_1, \mathbf{k}), C_2^{*}(I, g_1, \mathbf{k}), I, g_1, \mathbf{k})$. By the Envelope Theorem,

$$\frac{dU^{*}}{dg_1} = \frac{\partial U^{*}}{\partial g_1} \quad \text{and} \quad \frac{dU^{*}}{dI} = \frac{\partial U^{*}}{\partial I}.$$

As noted above, our goal is to examine whether the composition of the actual public investment in parks is consistent with the aforementioned official policy of the park authority to favor funding parks which are used more extensively by low-income households. As a benchmark, the optimal distribution of public investment in the two parks is calculated, assuming a Bergeson-Samuelson social welfare function with equal weights, given the aggregate public spending. Formally, the benchmark social optimization problem is specified as:

$$\text{(7)} \qquad W(g_1) = \max_{g_1} \left\{ \int_0^{I_1(g_1)} U^{**}\big(C_1^{**}(I, g_1, \mathbf{k}), I, g_1, \mathbf{k}\big) f(I)\, dI + \int_{I_1(g_1)}^{\infty} U^{*}\big(C_1^{*}(I, g_1, \mathbf{k}), C_2^{*}(I, g_1, \mathbf{k}), I, g_1, \mathbf{k}\big) f(I)\, dI \right\},$$

where $f(I)$ is the probability density function of income.

Assuming an interior solution and utilizing Leibnitz's theorem for derivatives of the integral yield the necessary condition for an optimum:

$$\begin{aligned} \frac{\partial W(g_1)}{\partial g_1} = {} & U^{**}\big(C_1^{**}(I_1, g_1, \mathbf{k}), I_1, g_1, \mathbf{k}\big) f(I_1) \frac{\partial I_1}{\partial g_1} + \int_0^{I_1(g_1)} \frac{\partial U^{**}}{\partial g_1} f(I)\, dI \\ & - U^{*}\big(C_1^{*}(I_1, g_1, \mathbf{k}), C_2^{*}(I_1, g_1, \mathbf{k}), I_1, g_1, \mathbf{k}\big) f(I_1) \frac{\partial I_1}{\partial g_1} \\ & + \int_{I_1(g_1)}^{\infty} \frac{\partial U^{*}}{\partial g_1} f(I)\, dI = 0. \end{aligned}$$

Note that at the threshold income level $I = I_1$, $C_1^*(I_1, g_1, \mathbf{k}) = C_1^{**}(I_1, g_1, \mathbf{k})$, and $C_2^*(I_1, g_1, \mathbf{k}) = C_2^{**}(I_1, g_1, \mathbf{k}) = 0$, implying $U^*(C_1^*(I_1, g_1, \mathbf{k}), 0, I_1, g_1, \mathbf{k}) = U^{**}(C_1^{**}(I_1, g_1, \mathbf{k}), I_1, g_1, \mathbf{k})$. Thus, the first-order condition reduces to:

$$(8) \qquad \int_0^{I_1(g_1)} \frac{\partial U^{**}}{\partial g_1} f(I)\, d + \int_{I_1(g_1)}^{\infty} \frac{\partial U^*}{\partial g_1} f(I)\, dI = 0.$$

Let g_1^* denote the value of g_1 that solves (8), and $g_2^* = (G - n_1 g_1^*)/n_2$. Thus, g_1^* and g_2^* are the per urban and per national park investment, respectively, that maximize $W(g_1)$.

Since households with income smaller than I_1 visit only urban parks, an increase of g_1 (at the expense of g_2) can easily be shown to increase U^{**} ($\partial U^{**}/\partial g_1 > 0$). Hence, it follows from (8) that at the optimum, $\partial U^*/\partial g_1 < 0$. Namely, increasing the budget share allocated to local parks leads to a tradeoff between the welfare of low-income households (with $I < I_1$) and high-income households. Shifting one dollar from national to local parks raises the welfare of low-income households, who prefer local parks, and lowers the welfare of high-income households, who prefer national parks. At the margin, the gains of the first group and the losses of the second are balanced.

In the following section, we calibrate our model to find the optimal composition, g_1^*, g_2^* that solves (8), given G. Then g_1^* and g_2^* are compared to the actual public spending to assess whether the actual funding of parks is consistent with the stated policy of giving preference to low-income households. The finest available data on income distribution are given by deciles. Hence, in the actual calibration, the integral in (8) is replaced by summation over income deciles.

Empirical Analysis

An empirical analysis of the model is conducted starting with a brief description of the data. About 90% of the parks, urban and national, in Israel, have been planted within the last hundred years as part of a massive forestation effort. Israel has about 56 national parks, most of them located in peripheral regions. Although Israel is a small country, most of these parks are a one- to three-hour drive from the main population centers. Urban parks were planted at the fringe but still within city limits. They are smaller than national parks, and total 62 in number.

Most of the data for this analysis are taken from Hope and Fleischer (1998), and Fleischer (1994). Hope and Fleischer conducted a comprehensive survey of recreational preferences and actual participation in recreational activities of the adult (over the age of 18) Israeli population. Every other month, from October 1997 to August 1998, a sample of 400–500 respondents were asked about their recreational activities in the preceding two months. The survey was administered by telephone using a random-digit dialing procedure, providing a new sample each time. A total of 2,987 individuals were surveyed. After deleting ineligible numbers, the response rate to the survey was 78% (2,330 respondents). Repeating the survey every two months for a year enabled the avoidance of two potential problems. One is the problem of respondents not remembering all their recreational activities over the space of a year, and the other is the problem of seasonality. Table 1 presents a description of the variables and summary statistics based on the Hope and Fleischer survey.

Table 1. Variable Description and Summary Statistics: Survey of Recreational Preferences and Activities of Israeli Adult Population (N = 2,330)

Variable Name and Description		Mean	Standard Deviation
Number of Visits to Urban Parks		3.94	8.10
Number of Visits to National Parks		7.36	14.20
Education		2.69	1.20
1 = elementary	3 = vocational or partial college		
2 = high school	4 = university degree(s)		
Age		3.34	1.76
1 = 18 to 20 years	5 = 50 to 59 years		
2 = 21 to 29 years	6 = 60 to 69 years		
3 = 30 to 39 years	7 = 70+ years		
4 = 40 to 49 years			
Family Size (number of persons in household)		3.94	1.70
Religious (= 1 if respondents declare themselves observant, = 0 otherwise)		0.35	0.47

Source: Hope and Fleischer, 1998.

Fleischer (1994) conducted a survey regarding the visiting habits of the Israeli population to urban and national parks. The data were collected through a survey of in-person interviews of 1,143 respondents at their homes. The respondents received a list of 23 most popular parks in Israel and a map of their locations (11 urban parks and 12 national parks). They were asked to indicate whether they had visited any of these parks in the preceding year and if so, how many times.

Empirical Test and Theory

The preferences represented by equation (1), coupled with the budget and time constraints of equations (2) and (3), respectively, are simple but rich enough to capture the fundamental relationships between income and visits to urban and national parks. In this subsection, Hope and Fleischer's (1998) data are used to empirically test our main theoretical finding—namely that visits to urban parks are an inferior good while visits to national parks are a normal good. In the absence of data on the personal incomes of park visitors, level of education is used as a proxy for income.[6]

Due to the censored nature of the data—i.e., respondents who had not visited parks within the prior two months reported zero visits—the Tobit model is used. Beginning with the most parsimonious specification, education is found to be positively and significantly correlated with the number of visits to national parks, and to be negatively, although insignificantly, correlated with visits to urban parks (see model 1, table 2). While for the sake of simplicity the focus of our theoretical model is on the relation between income and visits to parks, there are clearly other household characteristics which affect the number of visits. These include the age of the respondents, their number of children, and whether they drive on the Sabbath. Once these factors are

[6] Because Hope and Fleischer (1998) expected their respondents might be reluctant to accurately reveal their income level, respondents were asked only to report their level of education, which is highly correlated with income (see Flug and Kasir, 2003).

Table 2. Tobit Model Estimates for the Number of Visits to Parks [dependent variable = *Number of Visits to Urban (National) Parks*]

	Urban Parks		National Parks	
Variable[a]	Model 1	Model 2	Model 1	Model 2
Constant	1.65**	1.27**	-1.38**	0.77**
	(9.30)	(2.31)	(-8.13)	(1.64)
Education	-0.02	-0.18*	0.19**	0.30**
	(-0.43)	(-1.67)	(3.51)	(3.32)
Age		-0.44**		-0.43**
		(-6.21)		(-7.37)
Family Size		0.21**		0.16**
		(3.26)		(2.82)
Religious		0.64**		0.51
		(2.78)		(2.52)

Notes: Single and double asterisks (*) denote statistical significance at the 10% and 5% levels, respectively. Numbers in parentheses are asymmetric t-values.
[a] For description of variables, refer to table 1.

taken into account (model 2, table 2), the results concur with our theoretical predictions—i.e., the number of visits to urban parks decreases (at the 10% significance level) and the number of visits to national parks increases, with level of education.

Calibration of the Model Parameters

Before proceeding with calibration of the model to match the data, ρ_1 and ρ_2 are estimated. For this purpose, data are taken from Fleischer (1994), who surveyed visiting habits and the funding of 11 urban parks and 12 national parks in Israel. We begin by estimating ρ_1, and assume every household visits only one park of each type.[7] By (4) and (5a), for each household i that visits an urban park j,

$$1 + C_1^i = s_1(g_1^j)^{\rho_1}/\mu^i,$$

where g_1^j is investment in park j. Summing over all the households that visit park j yields:

$$\sum_{i=1}^{n_j}(1 + C_1^i) = s_1(g_1^j)^{\rho_1}\sum_{i=1}^{n_j}\frac{1}{\mu^i},$$

where n_j is the number of households visiting park j. Next, the income distribution of households visiting urban parks is assumed to be the same across parks of this type. Therefore,

$$\frac{1}{n_j}\sum_{i=1}^{n_j}\frac{1}{\mu^i} = A,$$

[7] To estimate ρ_1, we evaluate the marginal utility of each household from visiting urban parks. However, if a household visits several different urban parks, its marginal utility is determined by the total number of visits to all of them. Although it is apparent from Fleischer (1994) that each household tends to visit a single urban park, this is not always the case. Therefore, wherever a household visits more than one park, we attribute its total number of visits to urban parks to the one it attended most frequently.

where A is the same for all urban parks. Taking the natural logarithm of both sides of this equation yields:

$$\ln\left(\sum_{i=1}^{n_j} \frac{1 + C_1^i}{n_j}\right) = a + \rho_1 \ln(g_1^j),$$

where $a \equiv \ln(s_1 A)$. Having the data on

$$\sum_{i=1}^{n_j} \frac{1 + C_1^i}{n_j}$$

and on g_1^j for every park j in the survey, using least squares we estimate $\rho_1 = 0.158$ (with t-ratio = 3.46). Similarly, we estimate $\rho_2 = 0.163$ (with t-ratio = 3.86) by substituting $\beta = s_2 g_2^{\rho_2}$ into (5b).

The parameter values $t = 1.25$ and $p = 80$ were calculated based upon the average distance households travel to national parks and the travel cost. The value of T is determined from the number of days in the year less the average number of working days in Israel. Last, we take into account the fact that religious Jews cannot leave their immediate neighborhood during religious holidays or on Saturdays. Following these considerations, T is approximated to equal 143.

Israel's Central Bureau of Statistics (2000) provides data on households' other recreational expenditures, R_i, for every income decile i. Given the average R (averaged over income deciles), e is calculated using (3):[8]

$$e = (T - C_1 - tC_2)/R.$$

Finally, the average expenditures on Z are calculated using (2):

$$Z = I - pC_2 - R.$$

We are now in a position to calibrate the parameters of the utility function, α, β, and γ. This is done for the "average" household, i.e., the household with the observed average values of C_1, C_2, R, and Z, and average income I. Then these averages and the calculated prices e, t, and p are substituted into the first-order conditions, (5a)–(5d). This results in four equations with five variables (α, β, γ, μ, and λ), leaving one undetermined variable.

The undetermined variable allows us to calibrate the model for a range of values. The range of α, β, and γ is limited by the observation that all the income deciles spend a smaller proportion of their income on recreational activities than on Z (between 7% and 12%). Since the prices of R and Z are the same, γ must not exceed 1. Thus, the "extra equation" and the conjecture that $\gamma \leq 1$ are used to analyze the model over the whole range of plausible parameters. Specifically, we set $\hat{\gamma}$ and calculate the values of $\hat{\alpha}$ and $\hat{\beta}$ that solve the first-order conditions (5a)–(5d), given the average values of C_1, C_2, R, Z, and I, where the hat (^) denotes calibrated values. Then $\hat{\alpha}$, $\hat{\beta}$, and $\hat{\gamma}$ are substituted into the first-order conditions (2), (3), and (5a)–(5d), to calculate the allocation generated by

[8] Recall from footnote 4 that due to lack of information on the (negative) relationship between I and e, we calculate e for the average consumer and assume it to be the same for all income deciles. However, in the calculation of the optimal budget allocation presented below, R, like C_1, C_2, and Z, is allowed to vary over income.

Table 3. Calibrated and Actual Values for a Range of γ

			Model-Generated Means			Data Means		
γ	$\hat{s}_1$	$\hat{s}_2$	C_1	C_2	R	C_1	C_2	R
0.25	0.007	0.019	10.70	6.82	7,998	3.94	7.36	8,117
0.50	0.019	0.039	5.55	7.19	8,029	3.94	7.36	8,117
0.75	0.030	0.059	4.72	7.23	8,074	3.94	7.36	8,117
1.00	0.042	0.078	4.49	7.25	8,090	3.94	7.36	8,117

the model, $\hat{C}_{1i}$, $\hat{C}_{2i}$, $\hat{R}_i$, $\hat{Z}_i$, for every income decile, $i = 1, 2, ..., 10$. This procedure is repeated for $\gamma = \{0.25, 0.5, 0.75, 1.0\}$.

The last parameters to be calibrated are $\hat{s}_1$ and $\hat{s}_2$. For each triplet $\hat{\alpha}$, $\hat{\beta}$, and $\hat{\gamma}$, these parameters are calculated using (4):

$$\hat{s}_1 = \hat{\alpha} g_1^{-\rho_1} \quad \text{and} \quad \hat{s}_2 = \hat{\beta} g_2^{-\rho_2},$$

where $g_1 = 0.3$ and $g_2 = 1.2$ million new Israeli shekels (henceforth, NIS), the actual 1997 average funding for the two park types.[9]

Table 3 reports the averages of $\hat{C}_1$, $\hat{C}_2$, and $\hat{R}$ that are generated by the model for different levels of γ and compares them to the observed values. The second and third columns report the calibrated values of s_1 and s_2 for each γ. It should be noted that for all values of γ, T is well within the boundaries defined by equation (6).

Interestingly, both $\hat{s}_1$ and $\hat{s}_2$ increase with γ, implying by (4) that α and β likewise increase with γ. The intuition underlying co-movement of α, β, and γ is that increasing γ raises the marginal utility of R, which must be compensated by a rise in α and β. Otherwise, because of the time constraint, R would increase at the expense of C_1 and C_2 which would decline below their observed values. And yet, although α, β, and γ increase jointly, a rise in γ lowers C_1. The intuition underlying the decline in C_1 is the following. Since α, β, and γ increase jointly, a rise in γ lowers the utility of Z relative to the utility from the recreational activities. However, recreational activities are time-consuming while other consumption is not, implying a rise in γ raises the value of time (μ) relative to the value of money (λ). On the other hand, the time constraint is always binding, suggesting C_1, C_2, and R cannot all change in the same direction. At the same time, the decline in the utility from Z reduces the expenditures on purchasing it, thereby freeing resources for buying the costly recreational activities C_2 and R, at the expense of the cheaper C_1.

While the data contain only the average of C_1 and C_2, our model generates a prediction for the number of visits for every income decile. Figures 1 and 2 graph the number of visits to urban parks and to national parks, respectively, by decile for the case $\gamma = 0.5$. The figures illustrate the main theoretical finding of this study: poor households visit urban parks more frequently than rich households, while rich households visit national parks more frequently than poor households.

[9] It should be emphasized that the estimated values of $\hat{\alpha}$ and $\hat{\beta}$ are used here to calculate $\hat{s}_1$ and $\hat{s}_2$. In the calculation of the optimal budget allocation in the following section, α and β are not held constant; given $\hat{s}_1$ and $\hat{s}_2$, they vary with g_1 and g_2 according to (4).

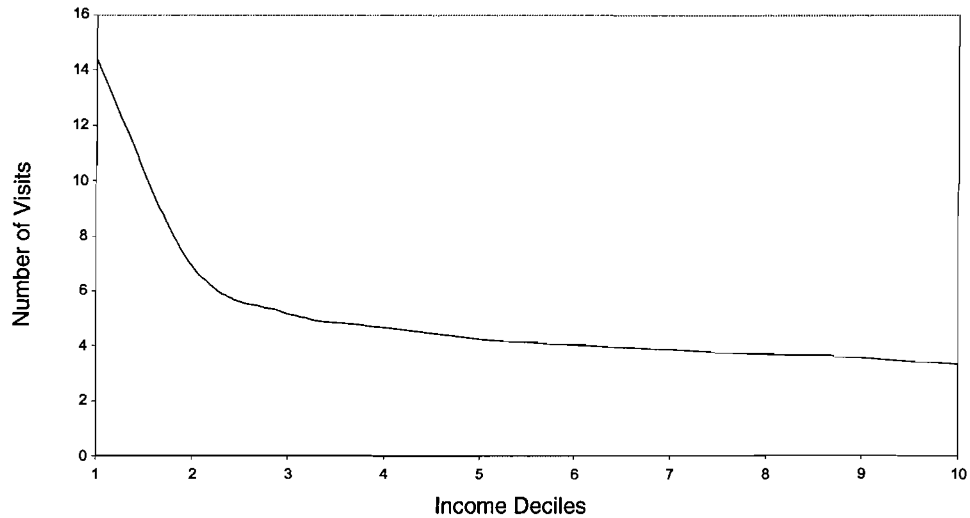

Figure 1. Visits per household to urban parks by income deciles

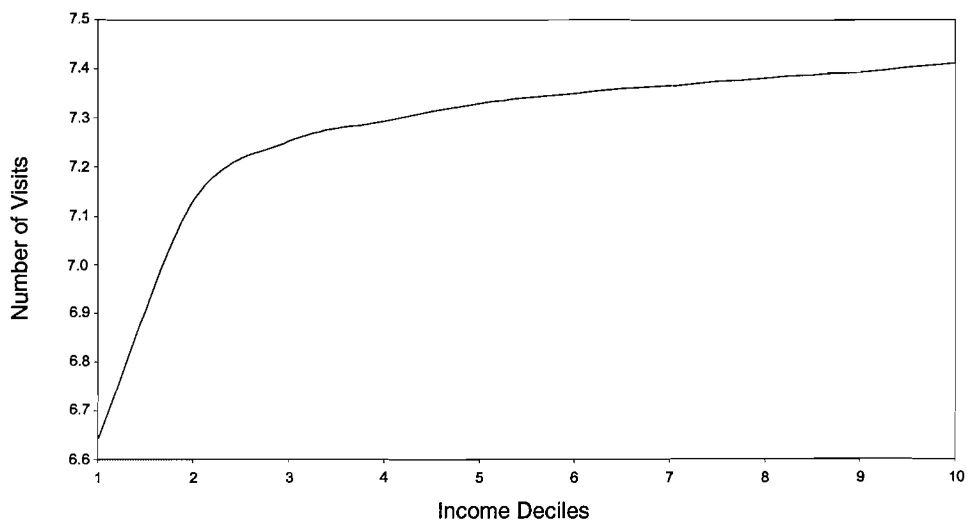

Figure 2. Visits per household to national parks by income deciles

Optimal Budget Allocation

Given all the calibrated parameters of the model, we are now in a position to achieve the main empirical goal of this analysis—to evaluate the optimal budget allocation by finding g_1^* and g_2^* that solve the optimization problem (7). This is done by simulating the economy for the whole range of g_1 and g_2 that satisfies $n_1 g_1 + n_2 g_2 = G$, where G is the actual 1997 aggregate funding for both types of parks. The optimal budget allocations for the various values of γ are as follows:

γ	g_1^*	g_2^*
0.25	0.36	1.14
0.50	0.40	1.10
0.75	0.42	1.08
1.00	0.43	1.07

In the surveyed year of 1997, the park authority allocated an average 0.3 million NIS (about $100,000) per urban park and 1.2 million NIS per national park. As observed from the above table, the optimal share for urban parks is between 36% ($\gamma = 0.25$) and 43% ($\gamma = 1$) greater than its actual share.[10]

Furthermore, because poorer households prefer urban parks and richer households prefer national parks, the gap between the actual and preferred allocation is larger the lower the household's income. Figure 3 illustrates this point: for each of the first, fifth, and tenth income deciles, we graph the difference between its utility level as a function of g_1 and its utility at the actual allocation.[11] At low levels of g_1, all the households prefer spending a greater proportion of the park authority's budget on local parks. Hence, all the graph lines in figure 3 are at first negative and increasing. By construction, all the graphs reach the zero point at the actual spending level, $g_1 = 0.3$, from which point the graphs of the first and fifth deciles continue to increase, while the graph of the tenth decile starts declining. The graph of the first income decile reaches its maximum at $g_1 = 0.58$, implying its utility is maximized at almost twice the actual spending on urban parks. The utility level of middle-income households (decile 5) reaches its maximum at $g_1 = 0.34$, indicating these households prefer a moderate increase of 13%, while households in the highest income decile prefer the current allocation. Therefore, we conclude that except for the highest decile, all the households prefer the park authority to allocate a larger proportion of its budget to urban parks at the expense of national parks.

Concluding Remarks

Providers of public goods, such as park authorities, often see it as one of their goals to favor the welfare of low-income households. In making budget-allocation decisions, park authorities may exploit the difference in consumption patterns of park services between

[10] Admittedly, our analysis does not take into consideration non-use values (option, bequest, existence, etc.), which could serve to justify government overspending on national parks.

[11] In the previous section, an "average household" over an "average year" between 1994 and 2000 was used to calibrate the model parameters. In other words, having calculated $\mathbf{k}$ allows us to numerically evaluate for every income decile i the equilibrium utility levels, $U^{**}(C_1^{**}(I, g_1, \mathbf{k}), I_i, g_1, \mathbf{k})$, and $U^*(C_1^*(I_i, g_1, \mathbf{k}), C_2^*(I_i, g_1, \mathbf{k}), I_i, g_1, \mathbf{k})$ as a function of g_1. In figure 3, we graph $U^{**}(C_1^{**}(I_i, g_1, \mathbf{k}), I_i, g_1, \mathbf{k}) - U^{**}(C_1^{**}(I_i, 0.3, \mathbf{k}), I_i, 0.3, \mathbf{k})$ and $U^*(C_1^*(I_i, g_1, \mathbf{k}), C_2^*(I_i, g_1, \mathbf{k}), I_i, g_1, \mathbf{k}) - U^*(C_1^*(I_i, 0.3, \mathbf{k}), C_2^*(I_i, 0.3, \mathbf{k}), I_i, 0.3, \mathbf{k})$ as a function of g_1.

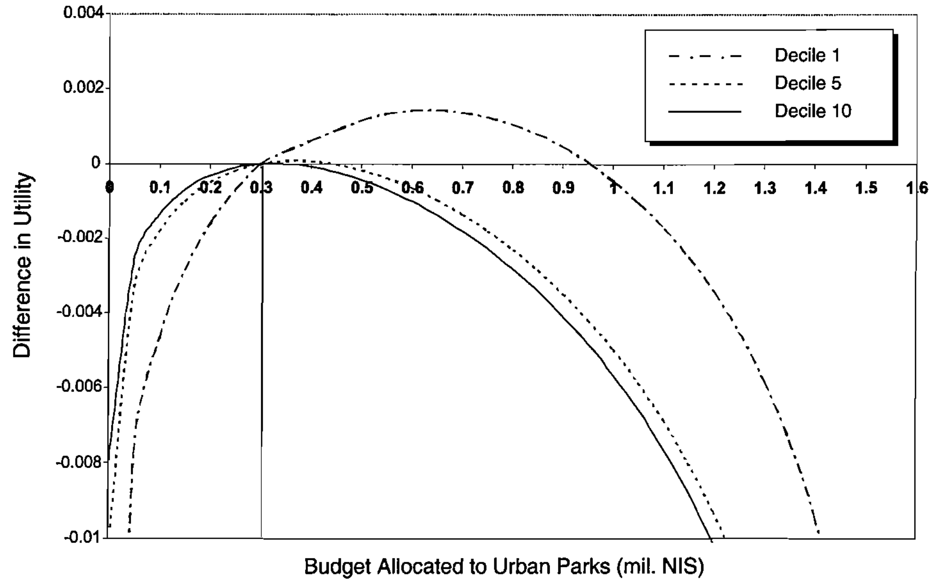

Figure 3. Difference in utility for income deciles 1, 5, and 10

low-and high-income households in order to compensate for social deprivation. Our findings confirm that visits to national parks increase with income, while the number of visits to urban parks declines with income. Therefore, equity can be increased by allocating a larger share of a limited budget to the development of urban parks at the expense of national parks.

In the Israeli case considered here, the budget allocated to national parks is found to be greater than the optimal. Specifically, except for the highest income decile, all the households in the economy would have preferred the share devoted to urban parks exceed the amount actually allocated. The existing bias toward the overprovision of resources to national parks at the expense of urban parks reveals that, in actuality, not only do the actions of the park authority not favor the welfare of the poor, there is a bias favoring the parks which are more frequently visited by the rich. We believe the major reason for the current budget allocation stems from a failure by the authorities to take into account that the level of income affects the frequency of visits to parks.

Assessing the equity implication of public policy requires disaggregated welfare analysis—namely, estimating the differential implications for the various segments of society. By segments of society, we also refer to differences in individual characteristics other than income. The method developed in this analysis is relevant to many settings in which equity is an important criterion for policy evaluation, such as recreational sites, environmental quality (e.g., clean water bodies), and the adverse effect of noxious facilities (e.g., landfills, power stations). These sites are located at different distances from the communities they serve, and the cost of using them depends on location. Thus, the demand for public goods is income-dependent, and the public funds allocated to these goods have social and equity consequences. Determining the optimal location of such sites, taking into account the spatial distribution of households' residence and income, is another direction in which our analysis can be profitably extended through future research.

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Appendix: Proof of Lemma 2 and Proposition 1

Proof of Lemma 2

The household is indifferent between visiting and not visiting national parks if and only if $\beta = p\lambda + t\mu$. By lemma 2, since $C_2 = 0$, it must be that $C_1 > 0$, implying $\alpha/(1 + C_1) = \mu$. Substituting $\beta = p\lambda + t\mu$, $\alpha/(1 + C_1) = \mu$, and $C_1 + eR = T$ into $\gamma/R = q\lambda + e\mu$ and rearranging yields:

$$R = \frac{(T + 1 - eR)p\gamma}{q\beta(T + 1 - eR) - qt\alpha + pe\alpha}.$$

Next, we show there exists $0 < R^* < T/e$ that solves the above equation. To prove this, note that both sides of the equation are continuous. Furthermore, the right-hand side (RHS) of the equation satisfies

$$RHS(R = 0) = \frac{(T + 1)p\gamma}{q\beta(T + 1) - qt\alpha + pe\alpha} > 0,$$

where the inequality follows from text equation (6). In addition,

$$RHS(R = T/e) = \frac{p\gamma}{q\beta - qt\alpha + pe\alpha} < T/e,$$

where the inequality follows from (6). Hence, by the Mean Value Theorem, there exists $0 < R^* < T/e$ such that

$$R^* = \frac{(T + 1 - eR^*)p\gamma}{q\beta(T + 1 - eR^*) - qt\alpha + pe\alpha}.$$

The existence of such R^* proves that there exists I_1 for which households choose $C_2 = 0$ and are indifferent to visiting or not visiting a national park.

To see that R^* is unique, note

$$\frac{\partial^2 RHS}{\partial R^2} = \frac{-e^2 p\gamma q\beta\alpha(pe - qt)}{\left[q\beta(T + 1 - eR) - qt\alpha + pe\alpha\right]^2}$$

is either positive or negative depending on the parameters. However, whether positive or negative, it does not change signs.

Finally, if $I < I_1$, then $\beta < p\lambda + t\mu$, which implies $C_2 = 0$, completing the proof of lemma 2.

Proof of Proposition 1

Suppose that $I_1 < I$. Then, by lemma 2, $C_2 > 0$, and it follows that whenever $C_1 > 0$, there is an interior solution. We begin by using text equations (2) and (3) to eliminate C_2 and R from (1):

$$U = \alpha\ln(1 + C_1) + \beta\ln\left(1 + \frac{e(I - Z) - q(T - C_1)}{pe - qt}\right) + \gamma\ln\left(\frac{p(T - C_1) - t(I - Z)}{pe - qt}\right) + \delta\ln(Z).$$

Deriving U with respect to C_1 and Z yields:

$$U_{C_1} = \frac{\alpha}{1 + C_1} + \frac{\beta q}{pe - qt + e(I - Z) - q(T - C_1)} - \frac{\gamma p}{p(T - C_1) - t(I - Z)},$$

$$U_Z = \frac{\delta}{Z} - \frac{\beta e}{pe - qt + e(I - Z) - q(T - C_1)} + \frac{\gamma t}{p(T - C_1) - t(I - Z)}.$$

Next, we follow the standard technique of differentiating $U_{C_1} = 0$ and $U_Z = 0$ with respect to I and solving for $\partial C_1/\partial I$ (e.g., Varian, 1984, pp. 134–135). We find

$$\frac{\partial C_1}{\partial I} = \frac{U_{C_1 Z} U_{ZI} - U_{ZZ} U_{C_1 I}}{U_{C_1 C_1} U_{ZZ} - U_{C_1 Z} U_{Z C_1}},$$

where U_{xy} is the derivative of U with respect to x and y. Straightforward derivation of the numerator reveals

$$U_{C_1 Z} U_{ZI} - U_{ZZ} U_{C_1 I} = -\frac{\delta}{(pe - qt)^2 Z^2}\left[\frac{\beta qe}{(1 + C_2)^2} + \frac{\gamma pt}{R^2}\right] < 0.$$

On the other hand, the second-order conditions for a maximum ensure the denominator is positive. Hence, $\partial C_1/\partial I < 0$.

Employing the same technique, text equations (2) and (3) are used to eliminate C_1 and R from (1). Deriving U with respect to C_2 and Z and solving for $\partial C_2/\partial I$, we find

$$\frac{\partial C_2}{\partial I} = \frac{U_{C_2 Z} U_{ZI} - U_{ZZ} U_{C_2 I}}{U_{C_2 C_2} U_{ZZ} - U_{C_2 Z} U_{Z C_2}}.$$

The second-order conditions for a maximum ensure the denominator is positive. Straightforward derivation of the numerator reveals

$$U_{C_2 Z} U_{ZI} - U_{ZZ} U_{C_2 I} = U_{C_2 I}/Z^2 = Z^{-4} > 0.$$

Hence, $\partial C_2/\partial I > 0$, completing the proof of proposition 1.