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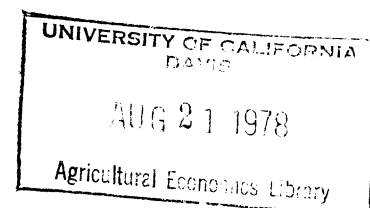
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MEASUREMENT OF ECONOMIC BENEFITS FOR POTENTIAL PUBLIC GOODS

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ABSTRACT

The assumptions necessary to make current economic benefit measurement techniques consistent with the theory of public expenditures are explored. An alternative measurement technique more directly related to the theory is presented. Limited results indicate the technique could be a feasible alternative to existing methods.

MEASUREMENT OF ECONOMIC BENEFITS FOR POTENTIAL PUBLIC GOODS

Introduction

The computation of economic benefits is one of the most difficult tasks in the evaluation of publicly-provided goods. Ideally, techniques for measuring these benefits would be derived directly from the theory of public expenditure. The theory, however, is a general equilibrium model of a frictionless world, one in which individuals simultaneously allocate their gross income among all existing and potential goods. Devices to accomplish this allocation include omniscient social planners (Samuelson) or social tatonnement processes (Malinvaud). These have no real counterparts, and their function is not easily built into techniques for measuring benefits from publicly-provided goods.

We will explore some of the relationships between the public expenditure theory and current benefit estimation techniques in this paper. Benefit measurements are often needed by government agencies such as the Army Corps of Engineers or the National Park Service (U.S. Congress). Consequently, particular attention will be given to the assumptions needed to convert the theory's general equilibrium framework into a partial equilibrium framework suitable for the evaluation of benefits on an agency-by-agency basis. Within this partial equilibrium framework, we will examine the required conditions for consistency among the theory of public expenditure, benefit estimates derived from user-demand functions (for existing goods), and benefits derived from willingness-to-pay surveys.

In the paper, we also suggest another technique for estimating benefits from government projects. The suggested technique seems to have two advantages. It is a straightforward modification of the utility

maximization problem inherent in the public expenditure theory, thus is easily related to that theory. It also offers an opportunity to eliminate some potentially troublesome assumptions of the existing techniques. The proposed method has not been completely implemented or tested: all that is available for presentation are some results from an initial study. These results indicate, however, that the suggested technique has promise and merits further consideration.

The Individual in Public Expenditure Theory

The individual utility maximization problem inherent in the theory of public expenditure has been stated by Samuelson (1969). His expression, in slightly modified form,[†] is

$$(1) \underset{X, Q}{\text{Maximize}} L = u(X, Q) + \lambda(g - X P_X - Q P_Q)$$

where

X is a (row) vector of all market goods and
available collective consumption goods,

Q is a (row) vector of potential collective
consumption goods which can be provided by
the government,

P_X is a (column) vector of private good market
prices and public good supply prices,

P_Q is a (column) vector of "psuedo-tax-prices"
for the potential public goods,

g is gross income after all transfer payments,

λ is the marginal utility of gross income.

[†]We have expressed Samuelson's problem as a Lagrangian and have combined his income and transfer payment terms into gross income.

This theoretical formulation includes all potential and available goods, whether public or private. Potential public goods are separated into Q , while all existing public and private goods are in X . P_Q represents the individuals' tax payments necessary for the provision of the new collective consumption goods. P_X contains both market prices and supply prices for the use of existing public goods. A notable feature of Samuelson's problem is that the government provides only collective consumption goods: all others are provided by the private sector.

Formulation (1) must be re-cast into a partial equilibrium framework if it is to be put into a form consistent with agency-by-agency benefit estimation. Partial equilibrium analysis implies the assumption that individual preferences are weakly separable for the goods in X and Q (Phlips). In addition, the division of potential public goods among the various agencies must follow the same separable preference groupings. Then problem (1) can be re-written as

$$(2) \text{ Maximize } L_j = u(X_j, Q_j) + \mu(b_j - X_j P_{X_j}) + \theta_j(z_j - Q_j P_{Q_j})$$

$$X_j, Q_j$$

where

Q_j is the group of potential public goods agency j can produce,

X_j represents the available goods in preference grouping j ,

P_{X_j} and P_{Q_j} are the respective price subvectors,

b_j is the disposable income allocated by the individual for the purchase of X_j ,

μ is the marginal utility of disposable income,

z_j is the part of the individuals' tax bill allocated to agency j ,

θ_j is the marginal utility of z_j
subject to the conditions that

$$(2') \quad \sum_j (z_j + b_j) = g$$

$$(2'') \quad \theta_1 = \theta_2 = \dots = \theta_m = \mu = \lambda.$$

The difficulty of achieving a Pareto-efficient level of public goods production within a partial equilibrium framework becomes apparent in formulation (2). Not only do the individual preferences have to be weakly separable and the government agencies organized to account for the separability, but it is also necessary that the government's budget be allocated among the agencies so that production of public goods equates the individuals' marginal utility of income across the m preference groupings. This Pareto-efficient budget allocation is required even if income is redistributed via transfer payments and government production is undertaken only to correct for market failures stemming from collective consumption.

Because the process of allocating public budgets is outside the individual's control and is exogenous to the partial equilibrium utility maximization problem, we shall assume that a Pareto-efficient budget allocation has been made and concentrate on the intra-agency production problem. This assumption is consistent with agency-by-agency benefit estimation. It places the entire process of allocating budgets to government agencies beyond the scope of this paper.

Benefit Measures from the Observed Demand for Existing Goods

One popular approach to the estimation of benefits for potential public goods measures these benefits by deriving changes in consumer's surplus. The changes result from expected supply price declines following

the introduction of the new public goods. Estimation of the underlying demand curves required in this approach is accomplished through the use of supply price techniques such as the Clawson "travel cost" method (Clawson). A recent example of the approach is the "Mineral King" study by Cicchetti, Fisher and Smith (1976).

The individual utility maximization problem embodied in the approach is

$$(3) \quad \underset{X_j}{\text{Maximize}} \quad L_j^* = u(X_j) + \mu(b_j - X_j P_{X_j})$$

where

X_j , b_j , P_{X_j} and μ are as earlier defined.

Formulation (3) is consistent with the multi-equation approach used in other recent recreational demand studies (Gum and Martin, Cheshire and Stabler). As Vickerman has illustrated, multi-equation models remove the simultaneous equation biases of the older single equation models. Single equation models are a special case of (3) in which X_j is a scalar.

Comparison of problems (3) and (2) shows that demand functions based on supply prices can yield theoretically-consistent benefit estimates only if Q_j is the same as X_j .[†] Otherwise, the marginal rates of substitution in formulation (3) will be different from those in problem (2), and the benefit estimates will suffer from specification error. Although the use of observed demands is appealing, we suspect it is difficult to find situations where the marginal rates of substitution among the available goods matches those of an agency's potential products.

[†]Willig specifies the assumptions necessary for consumer surplus to be an adequate measure of benefits. For expositional purposes, we accept consumer surplus as a valid measure of benefits.

Benefit Measures from Expressed Willingness-to-Pay

In cases where tradeoffs between potential public goods do not match existing choices, benefits have been estimated by aggregating individual's expressed willingness-to-pay (Bradford). The utility maximization problem implicit in this approach is

$$(4) \text{ Maximize } L_j^{**} = u(X_j, Q_j) + \mu(b_j - X_j P_{X_j} - \sum_i \Pi_{ij}) - \sum_{i=1}^m \gamma_{ij}(k_{ij} - q_{ij})$$

where

X_j , Q_j , μ , b_j and P_{X_j} are defined as before

and

Π_{ij} is the individual's expressed willingness to pay for the i^{th} potential public good,

k_{ij} is the amount of public good i that the government agency is willing to provide,

q_{ij} is the quantity of good i in Q_j that the individual would choose to consume,

γ_{ij} is the marginal willingness-to-pay for an additional unit of good i .

This utility maximization problem is formulated to fit a question of the form "How much would you be willing to pay to have the government provide k_i units of q_i ?" Conceptually, any number of goods could be handled in this formulation, although most willingness-to-pay survey techniques do not handle more than one or two potential goods (Ridker; Sinden; Randall, Ives and Eastman).

A key element in formulation (4) is the inclusion of the Π_{ij} in the disposable income constraint. This is necessary to extract the individual's "true" willingness-to-pay, which is defined as the marginal rate of substitution between the potential good and a numeraire private good such as disposable income (Malinvaud). Most existing willingness-to-

pay survey techniques rest on the assumption that individuals will give their true willingness to pay. This assumption may not always be met, as both Samuelson and Malinvaud have stressed that there is an incentive for a rational individual to purposefully misstate his or her willingness-to-pay if it is not actually paid. Such misstatements would, of course, directly affect benefit estimates based on the willingness-to-pay approach.

A Suggested Approach to Benefit Estimation

One possible approach to the estimation of benefits for government projects is to modify the theoretical partial equilibrium formulation (2) by substituting an agency budget into the individual's choice problem. In the modified formulation, the individual's tax share would be replaced by the agency's budget (a_j) and the psuedo-prices would be scaled up to a magnitude equal to the entire cost (c_{ij}) of providing the public good.[†] The utility maximization problem then becomes

$$(5) \text{ Maximize } L_j^{***} = u(X_j, Q_j) + \mu(b_j - X_j P_{X_j}) + \theta_j(a_j - Q_j C_j) \\ \text{ } X_j, Q_j$$

where

$X_j, Q_j, \mu, b_j, P_{X_j}$ and θ_j are defined as before

and

a_j is a pre-set agency budget,

C_j is a (column) vector of alternative costs
of providing Q_j .

Problem (5) is stated so that each individual is allocating the agency's budget to produce maximum utility to the individual.

[†] For exposition, we have chosen to scale up the choice problem rather than to place the budget on a per capita basis.

With a_j and C_j fixed, problem (5) becomes a constrained utility maximization problem for the sub-set of public goods which agency j is authorized to produce. One possible way this constrained problem can be solved is to interview individuals utilizing a device similar to that employed in the Priority Evaluator Technique (Hoinville; Kirkley). Solutions from the device for different predetermined budgets and cost vectors will generate two or more points on the individuals' demand curves for Q_j . Representative psuedo-demand curves can then be obtained by weighting and pooling individual observations and employing econometric techniques such as restricted seemingly unrelated regressors (Cicchetti, et. al.).

Once the representative demand functions are estimated for the predetermined set of potential goods, the allocation of the agency's funds to the goods can be found by maximizing

$$(6) \quad B = \int_{Q_j} D^{-1}(Q_j) dQ_j + \eta_4 (\bar{a}_j - Q_j \bar{c}_j)$$

where

D^{-1} represents the inverse demand functions
for Q_j ,

\bar{c}_j is a (column) vector of the actual costs
of providing Q_j , expressed as the present
value of the discounted time stream of
project costs,

\bar{a}_j is the agency's current capital budget
allocated for the provision of Q_j .

The public goods would therefore be selected to maximize a generalized consumers surplus, given the representative demand curves and the agency's budget constraint.

This approach would be workable only if individuals have no money illusion. Given this assumption, the necessity of finding an exactly comparable set of available goods is eliminated by the inclusion of Q_j in the survey technique. Moreover, inclusion of the agency budget in the individual's utility maximization problem eliminates any incentive to misstate marginal rates of substitution between potential public goods. Thus, the suggested approach has some potential advantages over existing benefit measurement techniques.

Some Empirical Evidence

Existing surveys using the Priority Evaluator Technique (Hoinville; Pendse and Wyckoff) demonstrate that individuals can solve problems such as (5). However, these previous studies have been used to establish a set of equilibrium prices rather than to estimate demand curves or measure economic benefits.

Although not principally designed to test the methodology suggested above, Kirkley's survey of Maryland park users provides some validation of the suggested approach. In the survey, park users were asked to allocate the capital budget of the Maryland State Park Service among potential capital improvements such as lakes, campgrounds, resort complexes, nature trails and day-use facilities. Over five hundred interviews were conducted; each included a change in total capital budget and in the prices for the capital improvements. Prices were expressed as percentages of the total budget for each park unit and respondents were required to spend the entire budget.

Survey design restricted the number of price changes to three per individual. Because prices were changed for only three of the five park types in the interviews, specification and estimation of a complete demand

system was infeasible. Ordinary least squares regression was therefore used to estimate own-price demand functions of the form:

$$(7) \quad q_i = \alpha_{0i} + \alpha_{1i} p_i + \alpha_{2i} a + A S + e_i$$

where

q_i represents the quantity of parks of the i^{th} type,

p_i represents a price based on the discounted unit cost of the i^{th} park type,

a is the sub-budget allocated to the three park types,

S is a (column) vector of socio-economic characteristics,

A is a (row) vector of regression coefficients,

e_i is the error term.

Results from this estimation (Table 1) provide some evidence of the plausibility of implementing the suggested approach.

Despite the probable specification error due to omitted cross-price variables, the signs on the own-price coefficients conform to demand theory and are statistically significant. Based on mean values, the own-price elasticities of nature parks, camping parks and picnicking areas are .79, .78 and .28, respectively. The coefficients associated with sub-budgets are also significant in all equations, with picnic park demand having the greatest increase per additional million dollars in the sub-budget (2.66). This might be expected, as picnicking parks cost on the average about one-half of the nature parks and about one-third of the camping parks.

Table 1: Regression Coefficients of "Psuedo"
Demand Functions

Independent Variables	Park Type		
	Nature Parks	Camping Parks	Picnicking Parks
	----- (t-statistics in parenthesis) -----		
Constant	.58	12.00	1.58
<u>Continuous Variables</u>			
Price, Nature Parks	-33.35 (5.61)		
Price, Camping Parks		-18.21 (5.54)	
Price, Picnicking Parks			-63.67 (4.60)
Sub-budget	1.13 (9.52)	-.66 (9.20)	2.66 (11.64)
Education	1.12 (6.50)	-.28 (2.69)	
<u>Binary Variables</u>			
Marital Status	-5.65 (4.66)	2.05 (2.47)	
Resident		-1.53 (2.52)	4.64 (2.42)
Low Income Group*		-1.38 (2.04)	
Employment, sales	1.99 (1.85)		
Employment, blue collar		1.32 (2.02)	
Employment, service			8.80 (3.37)
Observations	565	565	565
\bar{R}^2	.27	.22	.23
F-statistic	43.44	21.30	42.72

*Low income group defined as having less than \$6,000 disposable income.

Education increased the demand for nature parks, a finding consistent with that of Vaux, whose study showed higher income (and presumably better educated) groups and students preferred wilderness areas. If education is positively related to income and the students are generally college students, the two sets of findings are quite consistent.

Only two of the binary variables deserve attention. One would expect Maryland residents to prefer picnic areas because they are more readily accessible to the residents. Also, if camping requires basic skills more culturally available to males, then the result that males prefer camping parks more than females is to be expected.

Conclusion

Our preliminary test of the suggested approach appears to support the plausibility of its implementation. Respondents are apparently able to reveal their preferences within the selected method and to do so in a manner which is consistent with classical demand theory.

The inability to explain a substantial portion of the variation in individual selections is the most negative aspect of the empirical test. Part of the reason for the relatively low \bar{R}^2 may be due to the survey design, which led people to believe that the first set of prices were more realistic than the second. Or it may be that respondents will not make choices simply on economic rationale. Further exploration of the suggested approach should indicate which explanation is correct and should establish the value of the budget simulation approach to measuring economic benefits.

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