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ABSTRACT

Any good measure of the net benefit of a government program will depend in part on the preferences of affected households. Since many programs confront households with all-or-nothing choices or create kinks in their budget frontiers, the consumption patterns of households under these programs often provide little information about their preferences. In these cases, a typical approach to benefit estimation involves using data on nonparticipants who face linear budget constraints to estimate the preferences of participants with the same observed characteristics.

It has been shown that the estimator of mean benefit corresponding to this approach is biased and that the bias can be in either direction. This paper uses data on the consumption patterns of public housing tenants prior to and after entering the program to make the first estimates of the extent of the bias for an in-kind transfer. We estimate that the typical approach is likely to overestimate the mean benefit to participants in the public housing program by 10 to 30 percent depending upon the assumed functional form of their indifference maps.

Aggregation Bias in the Estimation of Benefits of Government Programs

In recent years information on individual households has been increasingly used to estimate sophisticated measures of the net benefit of government programs (see, for example, DeSalvo, 1975; Love, 1978; Olsen and Barton, 1983; Rosen, 1978). Any good measure of the net benefit of a government program will depend in part on the preferences of affected households. Since many government programs confront households with all-or-nothing choices or create kinks in their budget frontiers, the consumption patterns of households under these programs often provide little information about their preferences.[1]

The typical approach to benefit estimation used in these recent studies is to (1) identify families who can be presumed to face the usual linear budget constraint, (2) divide these families into groups according to such characteristics as family size and race, (3) posit a particular functional form for the indifference map of families of each type, (4) estimate its parameters by estimating the parameters of the implied system of demand equations, and (5) use the estimated indifference map for families of each type to estimate the net benefit of the program that will accrue to similar households participating in it. The indifference-map parameters estimated are the means of the parameters for households of each type.

One problem with this procedure is that it ignores variation in preferences among affected households that have similar objective characteristics.[2] Since, for any good, some households have stronger-than-average tastes and others weaker-than-average tastes, it might appear that there would be no bias in the estimate of mean benefit because overestimates of net benefit for some households would be offset by underestimates for others. Unfortunately, the formulas for calculating net benefit are rarely, if ever, linear, and so the absence of bias is the exception rather than the rule.

Aaron (1977, p. 68) has shown that the mean benefit of a program that distributed lump-sum grants would be typically underestimated by the new procedure. Olsen and Caniglia (1982) have estimated the magnitude of the bias in this case and have shown that the bias in estimating the mean benefit of other types of government programs can be positive or negative.

To make a preliminary judgment as to whether aggregation bias is sufficiently large to merit further research, we use data on the preprogram consumption patterns of public housing tenants to make individualized estimates of their indifference maps, use these indifference maps and information on consumption patterns under the program to estimate its benefit to each household, and compare the mean of these benefits with the mean benefit obtained using the aforementioned approach to benefit estimation.

I. Theoretical Framework

Assume that in the absence of the public housing program a participating family would have an income Y, buy housing services and other goods at prices P_h and P_x respectively, and choose the bundle (Q_h^m, Q_x^m) where one of its indifference curves is tangent to its budget line. Under the program, the family has the option of renting a specific apartment for an amount below its market rent. That is, the program essentially adds one point (Q_h^g, Q_x^g) to the family's budget space. Our measure of the benefit of the public housing program to this family is the magnitude of the lump-sum grant that would be as satisfactory to the family as its participation in the program.

This magnitude will depend in part on the shape of the indifference curve through the family's consumption bundle under the program. Since any indifference map that could be used for this study is at best a rough approximation of the family's preferences over a part of consumption space, we have used two types of utility functions--the Constant Elasticity of Substitution (CES) and the Stone-Geary--and a range of parameter values for each. These indifference maps were selected because they yield explicit formulas for calculating benefits.

The form of the CES utility function is

$$U = (\delta Q_h^{-\rho} + (1 - \delta) \; Q_x^{-\rho})^{-1/\rho} \tag{1}$$

where Q_h and Q_x are the quantities of housing services and other goods and δ and ρ are parameters of the indifference map. It is well known that the elasticity of substitution σ is equal to $1/(1 + \rho)$ and that, as ρ approaches zero, the CES approaches the Cobb-Douglas indifference map. For the CES indifference map, the benefit from participating in the public housing program is

$$\frac{\delta(K/P_h)^{-\rho} + (1-\delta)(1-K)/P_x)^{-\rho}}{\delta(Q_h^g)^{-\rho} + (1-\delta)(Q_x^g)^{-\rho}} - Y \tag{2}$$

where $K = [(1-\delta)/\delta]^{-\sigma}[P_h/P_x]^{1-\sigma}/[1+((1-\delta)/\delta)^{-\sigma}(P_h/P_x)^{1-\sigma}]$, which is the family's rent-income ratio in the absence of the program.[3]

The Stone-Geary utility function has the form

$$U = (Q_h - \beta_h)^{\gamma}(Q_x - \beta_x)^{1-\gamma} \tag{3}$$

where γ, β_x, and β_h are parameters. For this indifference map, the benefit from participating in the public housing program is

$$[(P_hQ_h^g - P_h\beta_h)/\gamma]^{\gamma}[(P_xQ_x^g - P_x\beta_x)/(1 - \gamma)]^{1-\gamma} + P_h\beta_h + P_x\beta_x - Y. \tag{4}$$

The Cobb-Douglas is obviously a special case of the Stone-Geary utility function.

In order to calculate the benefit of public housing based on either type of indifference map, we need to know or estimate the market rent of the public housing unit $P_hQ_h^g$, expenditures on other goods while living in public housing $P_xQ_x^g$, the parameters of the indifference map, indices of the market prices of housing services and other goods, and the family's income. We will now describe how these magnitudes were obtained.

II. Data

The data for this study were collected as part of the National Housing Policy Review (U.S. Department of Housing and Urban Development, 1974). The sample consists of 208 families who lived in San Francisco, Los Angeles, Washington, D.C., Boston, or St. Louis and had just moved into public housing. We have information on their housing expenditure before and after entry, income, family size, the age, race, and sex of the head of the household, and some characteristics of their public housing unit. Data obtained from the U.S. Department of Labor's (1972) Three Budgets for an Urban Family of Four Persons are used to construct cross-sectional indices of housing and nonhousing prices with a value equal to one in Washington, D.C. Quantity indices are obtained by dividing market expenditures by the relevant price indices.

III. Prediction of the Market Rent of a Public Housing Unit

Robert Gillingham (1973) has estimated relationships between market rent and various housing characteristics in each of the five cities, using data for 1960.[4] The housing characteristics were age of structure, number of rooms, number of bathrooms, condition of unit, inclusion in rent of furnishings, refrigerator, air conditioning, and stove, the presence of hot running water, central heat, covered parking, and elevator, number of persons in unit, and race of the head of the household. We tried to obtain data on these characteristics for the 208 public housing units in our sample. There were some gaps in the data. For example, year built was not reported for the 34 leased existing units in the sample. We assumed that the age of each of these units was equal to the median age of private housing in the same city. The condition of each unit was not directly observed. However, such observations were made for another sample of units collected in conjunction with the National Housing Policy Review, and almost all of these units were considered to be in sound condition. We assumed that this was the case for all units in our sample. Educated guesses were made concerning the number of rooms and the number of bathrooms in each unit, based on the number of bedrooms in the unit and the number of other rooms per dwelling unit in the project of which it is a part. The information and guesses concerning the characteristics of the public housing units in the sample were substituted into Gillingham's equations to predict the market rents of these units in 1960. The housing component of the Consumer Price Index for each city was used to adjust these predictions to 1972.

IV. Estimation of the Parameters of a Family's Indifference Map

Individualized estimates of the parameters of the indifference maps had to be obtained in order to calculate the individualized benefits from the public housing program for the families in our sample. This was no problem for the Cobb-Douglas indifference map because its only parameter is equal to the family's preprogram rent-income ratio, and our data contains this information. Except in this special case, however, it is not possible to infer the parameters of the CES or Stone-Geary indifference map of a family based on its response to a single set of prices and income.

Our solution to this problem is to make assumptions about the values of all but one parameter and to use data on the consumption pattern of each family in our sample before entering public housing to estimate its remaining parameters. To determine the sensitivity of the results to our assumptions about indifference-map parameters, a range of plausible values is used.

In his dissertation research, Richard Clemmer estimated the CES indifference map for a number of different types of families, and most of his estimates of the elasticity of substitution between housing services and other goods were in the range .5 to 1.0. In our study we have calculated individualized benefits using values of .50, .75, 1.0 (the Cobb-Douglas case), and 1.25. The first order conditions for utility maximization subject to the usual linear budget constraint imply that

$$\delta = 1/[1 + (P_h/P_x)^{\sigma}(Q_h^m/Q_x^m)]. \tag{5}$$

Each family's δ is calculated from this equation using data on the prices that it faced and quantities that it chose prior to entering public housing and alternative assumptions about its elasticity of substitution.

The Stone-Geary is a three-parameter utility function where β_h and β_x are usually interpreted as the family's subsistence quantities of housing services and nonhousing goods and γ is the marginal propensity to spend on housing services out of income. In this case we assume that β_h and β_x are each the same for all families of the same size and allow only the parameter γ to vary for each observation in our sample.

If the subsistence quantities are each the same for all households of a particular size, if the population of households of each size contains a household at subsistence, if the sample is drawn randomly from the population, if the preprogram expenditures of the families in our sample are accurately reported, and if these families receive neither private nor public charity in kind prior to entering public housing, then the sample minimum quantity of each good for families of each size is a consistent estimator of the subsistence quantity and its upward bias declines to zero as the sample size approaches the population size.

Table 1 presents the sample minimum values of our quantity indices Q_h and Q_x for five family sizes. Recall that the quantity indices can be

Table 1

Sample Minima of Annual Preprogram Housing (Q_h) and Nonhousing (Q_x) Expenditure in Washington, D.C. Prices

Family Size	Sample Minima		Number of Cases
	Q_h	Q_x	
1	156	276	42
2	168	336	37
3	336	228	42
4	444	792	48
6	276	516	39

Note: Sample is 208 families living in public housing, included in National Housing Policy Review (U.S. Department of Housing and Urban Development, 1974).

thought of as expenditures in Washington, D.C., prices, since they are obtained by deflating expenditures by price indices that are equal to one for this city. In order to maintain reasonable sample sizes, we used the data on four- and five-person families to estimate the sample minima for four-person families and data on families with more than five persons to make estimates for six-person families. This is justified by the presumption that the subsistence consumption increases with family size. Even so, the sample sizes are rather small for estimating a population minimum, and this, together with violations of the assumptions underlying the use of the sample minimum as an estimator of a subsistence parameter, has resulted in an erratic pattern in the estimates.

To obtain a more acceptable pattern, we first regressed the sample minima for each good on family size. The OLS estimates are

$$\hat{\beta}_h = \underset{(1.51)}{164.43} + \underset{(1.16)}{34.86}*FS \qquad R^2 = .31$$

and

$$\hat{\beta}_x = \underset{(1.02)}{208.54} + \underset{(1.23)}{69.08}*FS \qquad R^2 = .33$$

where the t-scores are in parentheses. Second, we used these relationships to estimate β_h and β_x. Table 2 reports the results for the family sizes in Table 1. While these estimates clearly leave much to be desired, we believe that they are better than the sample minima.

To test the sensitivity of the results to the estimates of β_x and β_h used, we use three other sets of values for the parameters: namely, zero (the Cobb-Douglas case), half the values in Table 2, and one and a half times those values.[5]

Table 2

Estimated Values of Subsistence Parameters

Family Size	$\hat{\beta}_h$	$\hat{\beta}_x$
1	199	278
2	234	347
3	269	416
4	304	485
6	374	623

Conditional on a particular set of values for the subsistence parameters, it is possible to make an individualized estimate of each family's marginal propensity to spend on housing, using data on its preprogram income and housing expenditure. Specifically, the first order conditions for utility maximization subject to the usual linear budget constraint imply that

$$\gamma = (P_h Q_h^m - P_h \beta_h)/(Y - P_h \beta_h - P_x \beta_x).$$

We expect γ to lie between 0 and 1. However, our estimates did not always satisfy this requirement. When we used one and a half times the estimated subsistence quantities in Table 2, about 13 percent of the estimates of γ were outside of the acceptable interval, ranging from -.31 to 2.14. When the estimated subsistence quantities in Table 2 were used, about 5 percent of the estimates were outside of the interval, ranging from -.07 to 1.27. In all of these cases, if the estimated marginal propensity to spend on housing was less than .001, it was set equal to this number, and if it was greater than .999, it was set equal to this number.

We have now described the sources of the data and predictions necessary to make an individualized estimate of the benefit from public housing to each family in our sample. To obtain an estimate of the direction and magnitude of the aggregation bias, we need to obtain estimates of the benefits of public housing using average values of the indifference map parameters for families that are the same with respect to characteristics observable while they are participating in the program.

To calculate the predicted benefits using average values of the indifference map parameters for similar families, we had first to predict the average values of these parameters. Each of the indifference maps used in our study has one parameter that has been allowed to vary among families in our sample. In each case, the average parameter for families of a certain type has been obtained by first regressing the value of the individual parameter on certain observable family characteristics (see Table 3) and then substituting each family's characteristics into the estimated relationships. These predicted values of the indifference-map parameters were then substituted into the benefit formula, instead of the individualized values of these parameters, and the benefit from public housing was then calculated for each family.[6]

V. Mean Benefit and Distributive Effects of Public Housing

Table 4 reports the estimated mean benefits of public housing based on individualized and average indifference-map parameters. For two widely used indifference maps and a range of plausible parameter values, the use of average indifference maps for all families with the same observed characteristics results in overestimates of mean benefit. The degree of overestimation is quite significant: it ranges from a minimum of 10 percent for the CES utility function, when elasticity of substitution is 1.25, to 30 percent for the Stone-Geary utility function, when the subsistence parameters are valued at one and a half times our best estimates.

To see the extent to which the use of average indifference maps distorts our perceptions of the distributive effects of the public housing program, we regressed the real benefits derived from the program on family characteristics. The results obtained when using individualized estimates of indifference-map parameters are reported in Table 5 and those when using average estimates of indifference map parameters, in

Table 3

Estimated Relationship between Individualized Indifference-Map Parameters and Family Characteristics

	Constant Elasticity of Substitution Utility Function[a]				Stone-Geary Utility Function[b]		
Explanatory Variables	ES=.50	ES=.75	ES=1.00	ES=1.25	0.5*S	1.0*S	1.5*S
Constant	.3371 (2.64)	.3582 (3.45)	.3789 (4.39)	.3962 (5.41)	.3764 (3.73)	.3755 (3.11)	.4092 (2.84)
Family size	-.0048 (-1.93)	-.0343 (-1.82)	-.0276 (-1.76)	-.0232 (-1.74)	-.0306 (-1.67)	-.0354 (-1.61)	-.0433 (-1.65)
Family size squared	.0013 (.65)	.0008 (.49)	.0006 (.43)	.0005 (.41)	.0006 (.41)	.0008 (.42)	.0011 (.51)
1 if black head; 0 otherwise	-.0257 (-.53)	-.0300 (-.75)	-.0293 (-.89)	-.0275 (-.98)	-.0331 (-.86)	-.0365 (-.79)	-.0386 (-.70)
1 if female head; 0 otherwise	.1406 (3.87)	.1169 (3.95)	.0982 (3.99)	.0838 (4.01)	.1131 (3.93)	.1330 (3.86)	.1560 (3.80)
Age of the head of the household	.0020 (.34)	.0023 (.48)	.0022 (.55)	.0020 (.58)	.0027 (.58)	.0034 (.60)	.0028 (.42)
Age squared	-.00004 (-.64)	-.00004 (-.77)	-.00004 (-.82)	-.00003 (-.84)	-.00004 (-.87)	-.00006 (-.91)	-.00006 (-.78)
R^2	.14	.14	.14	.14	.13	.12	.12

Note: The numbers in parentheses are t-scores.

[a]ES is the value of the elasticity substitution. A Cobb-Douglas utility function is a CES utility function with ES = 1.

[b]S is the vector of estimates of subsistence quantities reported in Table 2.

Table 4

Mean Annual Benefit Using Individualized and Average Indifference Maps (in Washington, D.C., Prices)

	Mean Benefit		
Type of Utility Function Used	Individualized Indifference Maps	Average Indifference Maps	Bias from Using Average Indifference Maps
CES			
ES = 0.50	829.4	1015.1	22.4%
ES = 0.75	921.7	1072.1	16.3
ES = 1.00	981.1	1104.6	12.6
ES = 1.25	1022.2	1125.2	10.1
Stone-Geary			
$0.0(\hat{B}_h,\hat{B}_x)$	981.1	1104.6	12.6
$0.5(\hat{B}_h,\hat{B}_x)$	936.7	1092.5	16.6
$1.0(\hat{B}_h,\hat{B}_x)$	873.7	1074.0	22.9
$1.5(\hat{B}_h,\hat{B}_x)$	808.7	1051.0	30.0

Table 6. The results are qualitatively similar. The R^2's are low and the signs of the estimated coefficients of a particular family characteristic are the same in all regressions except for the coefficient of family size in the last column of Table 6. However, there are notable quantitative differences. The R^2's of the relationships based on individualized indifference maps are much lower than those based on average indifference maps, suggesting that previous studies have underestimated the extent to which equally situated families are treated unequally. Furthermore, the magnitudes of the estimated coefficients based on average indifference maps are quite different from the magnitudes based on individualized indifference maps, resulting in a very different impression of the difference in mean benefit received by different types of families.

VI. Conclusion

Unobserved differences in tastes can result in biased estimates, even when sophisticated methods for estimating the benefit of a government program are used. The empirical evidence in this paper shows that this aggregation bias is likely to lead to a substantial overestimate of the mean benefit from the public housing program and to estimates of the distributive effects of the program that are not quantitatively accurate. These results suggest the desirability of studies of other programs to determine whether bias of this magnitude is the exception or the rule. If it is the rule, then greater efforts should be made to base studies of the effects of government programs on individualized estimates of indifference maps.

Table 5

Estimated Relationship between Benefit and Family Characteristics Based on Individualized Indifference Maps

	CES				Stone-Geary		
Explanatory Variables	ES=.50	ES=.75	ES=1.00	ES=1.25	0.5*S	1.0*S	1.5*S
Constant	1125.15 (6.29)	1196.88 (6.97)	1249.33 (7.47)	1288.36 (7.83)	1201.39 (6.90)	1149.33 (6.24)	1089.29 (5.80)
Real income	0.0391 (-1.07)	-.0316 (-.90)	-.0283 (-.83)	-.0267 (-.80)	-.0236 (-.67)	-.0140 (-.37)	-.0016 (-.04)
Family size	38.89 (1.49)	38.24 (1.53)	37.76 (1.55)	37.50 (1.56)	35.47 (1.40)	29.58 (1.10)	16.87 (.61)
1 if black head; 0 otherwise	-383.64 (-3.68)	-406.49 (-4.06)	-427.45 (-4.38)	-444.74 (-4.63)	-417.44 (-4.11)	-410.99 (-3.83)	-392.45 (-3.58)
1 if female head; 0 otherwise	150.58 (1.69)	159.76 (1.87)	166.90 (2.00)	172.39 (2.10)	157.66 (1.82)	144.40 (1.57)	137.49 (1.47)
Age of head	-2.60 (-1.09)	-2.30 (-1.00)	-2.03 (-.91)	-1.82 (-.83)	-2.16 (-.93)	-2.59 (-1.06)	-2.83 (-1.13)
R^2	.08	.09	.10	.11	.09	.08	.07

Note: See notes to Table 3.

Table 6

Estimated Relationship between Benefit and Family Characteristics
Based on Average Indifference Maps

	CES				Stone-Geary		
Explanatory Variables	ES=.50	ES=.75	ES=1.00	ES=1.25	0.5*S	1.0*S	1.5*S
Constant	1586.58 (8.66)	1470.31 (9.05)	1418.41 (9.04)	1419.36 (9.10)	1440.30 (9.10)	1475.28 (9.02)	1533.23 (8.95)
Real income	-.0441 (-1.18)	-.0149 (-.45)	-.0057 (-.18)	-.0063 (-.20)	-.0084 (-.26)	-.0056 (-.17)	-.0066 (-.19)
Family size	2.89 (.11)	8.41 (.35)	15.99 (.70)	19.68 (.86)	12.32 (.53)	.91 (.04)	-11.96 (-.48)
1 if black head; 0 otherwise	-489.57 (-4.58)	-495.32 (-5.23)	-505.11 (-5.52)	-515.29 (-5.66)	-503.62 (-5.46)	-497.01 (-5.21)	-494.01 (-4.94)
1 if female head; 0 otherwise	304.85 (3.34)	302.76 (3.74)	294.93 (3.77)	287.12 (3.70)	308.58 (3.92)	327.62 (4.02)	347.93 (4.08)
Age of head	-6.44 (-2.64)	-4.73 (-2.18)	-3.66 (-1.75)	-3.10 (-1.49)	-4.25 (-2.02)	-5.27 (-2.42)	-6.51 (-2.85)
R^2	.15	.16	.17	.17	.17	.17.	.17

Note: See notes to Table 3.

Footnotes

[1]Public housing, for example, offers each family that reaches the top of the waiting list a particular dwelling at a below-market rent. The food stamp program creates a kink in the budget frontier at the consumption bundle that can be attained by spending the food stamp on food and all cash on other goods. Methods for estimating consumer demand functions based on data for families facing piecewise-linear budget constraints have been developed. See Burtless and Hausman (1978) for an important early contribution and Moffitt (1982) for an up-to-date list of references and a presentation of the model and econometric methods in a simpler and more general fashion.

[2]Another problem is that households who participate in a government program may, as a group, have tastes that differ from the tastes of others. The direction of the bias is clearest for in-kind subsidies where participation is voluntary and funding is available to serve all eligible families. Participation rates will be highest for households with a stronger-than-average taste for the subsidized good.

[3]The formula for calculating net benefit can be obtained by deriving the expenditure function corresponding to the utility function (see, for example, Henderson and Quandt, 1980, pp. 44-45) and substituting in the quantities of housing and other goods consumed when the family lives in public housing.

[4]The regressand in these regressions is the natural logarithm of gross rent, data on individual dwelling units are used, and the coefficients of determination range in value from 0.55 to 0.75.

[5]When values 50 percent greater than those in Table 2 were used, annual nonhousing expenditure fell short of estimated subsistence expenditures by $130 for one family. In this case nonhousing expenditure was set equal to estimated subsistence expenditure plus $1.

[6]For an assumed elasticity of substitution equal to .50, there were two cases for which the predicted value of δ was somewhat less than .001. In each of these cases, the predicted value was set equal to .001. When we assumed that the subsistence parameters were one and a half times our best estimates, the minimum predicted value of γ was $-.004$. For all cases where the predicted marginal propensity to spend on housing was less than .001, we set it equal to this number.

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