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Discussion Papers

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DP # 927-90

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Discussion Paper no. 927-90

Bias in Estimating the Benefits of Government Programs Due to Misapplication of Composite Commodity Theorems: Estimates for Major U.S. Housing Programs

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August 1990

This research was supported in part by a grant to the Institute for Research on Poverty from the U.S. Department of Health and Human Services. The opinions and conclusions expressed in this paper are those of the author and do not necessarily reflect the opinions or policy of DHHS or the IRP.

Abstract

All analyses of government programs treat groups of goods as composite commodities and many use the market value of the goods in a group divided by an index of the prices of these goods as an index of the quantity of the corresponding composite. It has been shown that using this quantity index along with a utility function defined over composites will lead to an overestimate of the net benefit of the government program to a participant unless the bundle of goods consumed in each category is preferred to all other bundles in that category with the same market value. This proviso is violated for many government programs, such as public housing, public schools, and government-operated hospitals. The only available estimates of the extent of the bias for an expenditure program suggest that it can be substantial. Based on a small sample, DeBorger (1987) found that the mean benefit of public housing in Belgium calculated using two composite commodities, housing and other goods, exceeded the mean benefit based on a more disaggregated approach by 50 to 80 percent.

This paper estimates the magnitude of the bias for public housing and other publicly subsidized housing, using data from the 1974 Annual Housing Survey, and for rent control, using data from the 1965 New York City Housing and Vacancy Survey. This is done by estimating the mean benefit of the program using the traditional approach (modified to account for unobserved housing characteristics) and comparing it with the mean benefit estimated using an approach in which observed housing characteristics are grouped into four categories--space, quality, amenities, and neighborhood. For the household types considered, these comparisons show that the composite commodity approach overstates the benefits to recipients of federal rental housing subsidies by almost 50 percent and to occupants of controlled units by a factor of 4.

Bias in Estimating the Benefits of Government Programs Due to Misapplication of Composite Commodity Theorems: Estimates for Major U.S. Housing Programs

I. INTRODUCTION

Few government programs subsidize the consumption of a homogeneous good. Instead they subsidize a broad class of goods (e.g., food) or a good that can possess different attributes to different extents (e.g., housing). In some cases, the recipient of the subsidy is free to choose any bundle of subsidized goods or attributes with the same market value. More frequently, this is not the case. Indeed, participating in a program often implies consumption of particular quantities of some goods or attributes. Among the many examples of programs of this type are public housing, public schools, and government-operated hospitals.

In analyzing the benefits and consumption effects of both types of programs, it is common to aggregate all goods into a small number of composite commodities and to define a utility function over composites. For example, a typical housing program analysis divides all goods into two categories, housing and other goods (see, for example, Clemmer, 1984; DeSalvo, 1975; Hammond, 1987; Murray, 1975; Olsen and Barton, 1983; Reeder, 1985; Rosen, 1979; Schwab, 1985). Similarly, in the few existing welfare analyses of the public school system one defines a utility function over a limited number of composite goods, where education is one of the composites (see, for example, Lankford, 1985; Sonstelie, 1982). These studies usually assume that all individuals living in a particular area would face the same set of prices in the absence of the government program under consideration and that unsubsidized individuals face this set of prices in the presence of the program. The value of the quantities of goods in each commodity group at these prices divided by an index of their prices is typically used as an index of the quantity of the corresponding composite.

It has been shown (Olsen and DeBorger, 1989) that the approach common in the literature leads to an overestimate of recipient benefit unless the bundle of goods consumed in each group is preferred to all other bundles in that group with the same market value. An example illustrates the bias. Public housing tenants are assigned to their apartments. If we were to allow these families to occupy private units with the same market rents as their public housing units and to pay the same rents as they pay in public housing, many would accept this option because they prefer the combination of attributes offered by some private unit. Although these households are better off, the usual approach to benefit estimation would yield the same estimated benefit before and after the change because market prices and the market value of each group of goods consumed are unchanged. Olsen and DeBorger's theorem shows that in the absence of prediction errors the composite commodity approach yields the correct answer after the change and overstates benefit under the public housing program.

The magnitude of the bias is an empirical matter. Shoven (1976) has calculated that the surtax on the corporate sector results in an estimated net welfare cost that is 33 to 42 percent greater when the economy is grouped into 12 production sectors rather than into the 2 sectors used by Harberger (1966) in his pathbreaking article. Using an improved version of the general equilibrium model underlying these calculations, Fullerton, Henderson, and Shoven (1984, pp. 378-383) found that integration of the corporate and personal income taxes yields an estimated net gain that is 56 percent greater when the economy is grouped into 19 rather than 2 production sectors. The only available estimates of the extent of the bias for an expenditure program also suggest that it can be substantial. Based on a small sample, DeBorger (1987) found that mean benefit of public housing in Belgium calculated using two composite commodities, housing and other goods, exceeded mean benefit based on a more disaggregated approach by 50 to 80 percent. Our theoretical results together with these empirical findings suggest the desirability of obtaining additional estimates of the magnitude of the bias in cases where composite commodity theorems have been misapplied.

The primary purpose of this research project is to estimate the magnitude of the bias for public and other subsidized housing in the United States. Ultimately these estimates will be based on data on more than 100,000 households living in rental housing in seven cities in two years from the Annual Housing Survey. In this survey the U.S. Bureau of the Census has collected information on the characteristics of dwelling units and their occupants, including whether the dwelling unit is in a public housing project or subsidized by some other housing program. This paper reports results for a small subsample of these observations, namely households with one or two members headed by a white female over 60 years old living in Minneapolis or Detroit in 1974.[1]

In the process of making these estimates, we deal with another shortcoming of all previous estimates of the benefits of housing programs, namely their failure to account for unobserved housing characteristics. The unobservability of housing characteristics creates problems at every stage of a study designed to estimate the benefit of a housing program. It affects estimation of the hedonic equation used to predict the market rent of the subsidized dwelling, estimation of the utility functions, prediction of consumption patterns of subsidized households in the presence and in the absence of the program, and estimation of the program's benefit.

The broad outline of the approach used is easy to understand. First, we estimate the benefit to each household using an approach in which observed housing characteristics are grouped into four categories--space, quality, amenities, and neighborhood, and calculate the mean of these benefits. Second, we estimate the benefit to each household served by a housing program using an approach in which all goods are divided into two categories, observed housing characteristics and other goods, and calculate the mean of these benefits. Third, we compare the two means. These estimates are based on the same assumption concerning the effect of the housing program on consumption of unobserved housing characteristics. We also estimate mean benefit using the traditional composite commodity approach assuming that all housing characteristics are observed.

II. GENERAL THEORETICAL FRAMEWORK

In the presence of housing subsidies, each recipient consumes some bundle of goods and attains some level of well-being. In their absence, each of these households would consume some other bundle and attain some other level of well-being. The benefit of a housing program to a participant is a measure of this difference in well-being. For purposes of this paper, benefit is defined to be the minimum unrestricted cash grant that the household would accept in place of its eligibility to participate in the housing program.

To facilitate the analysis, we make certain general assumptions.[2] First, we assume no saving or dissaving. This enables us to infer a household's expenditure on non-housing goods from its income and rent. Second, we assume that job choice and hours of work are immutable. This assumption implies that the household's income would be the same in the absence of the housing program. Third, we assume that unsubsidized consumers in a market face the same set of prices and this set of prices would be the same in the presence and the absence of the housing programs under consideration. That is to say subsidized households would face observed market prices in the absence of the program. Fourth, we assume that elimination of the housing programs does not affect the taxes of subsidized households or government expenditures. This implies that elimination of the housing program would not increase a subsidized household's disposable income by decreasing its taxes. Finally, we assume that housing subsidies are the only in-kind subsidies in existence. At the time that our data were collected, the majority of the recipients of rental housing subsidies participated in several other in-kind subsidy programs. Therefore, this assumption will lead us to understate their non-housing consumption in the presence of the housing program and their budget space in its absence. The direction of the bias in estimating the benefit of the housing program on this account is theoretically ambiguous, and there is nothing that can be done about it with this data base because it contains no information on participation in other in-kind subsidies.

These assumptions allow us to focus on the trade-offs that a household is willing to make between housing attributes and other produced goods in the current period. They also imply that each unsubsidized household faces a linear budget constraint in the space of these goods in the presence of the housing programs and that each participant would face a linear budget constraint in their absence. To deal with the problem of unobserved housing characteristics, assume that the conditional utility function under consideration is weakly separable between unobserved housing characteristics, on the one hand, and observed housing characteristics and other goods, on the other. That is, an individual's utility index can be written in the form

$$u(q_X, q_{HO}, q_{HU})=v(u_{XHO}(q_X, q_{HO}), u_{HU}(q_{HU})) \qquad (1)$$

where q_X, q_{HO}, and q_{HU} are vectors of quantities of nonhousing goods, observed housing attributes, and unobserved housing characteristics and u_{XHO} and u_{HU} are subutility functions. Since some housing characteristics are not observed, it will be impossible to estimate the trade-offs that households are willing to make between these characteristics and other goods or predict the effect of the housing programs on participants' consumption of these attributes. Furthermore, without some assumption about the effect of housing programs on participants' consumption of unobserved housing characteristics, it will be impossible to estimate the benefits of these programs. The assumption that underlies the results in this paper is that each participant is indifferent between the bundle of unobserved housing attributes consumed in the presence of the program and the bundle that would be consumed in its absence.

This assumption is completely arbitrary. Its only virtue is that it is the simplest assumption that allows us to proceed. If subsidized units are better with respect to unobserved characteristics than the units that program participants would otherwise occupy, our estimates of benefit will be too low on this account no matter whether they are based on a utility function defined over two or many composites. However, the effect of this error on the magnitude of interest here, namely the difference between the mean benefit based on a two-good utility function and mean benefit based on a utility function with many goods, is theoretically ambiguous.

With this assumption, it is possible to infer a participant's benefit from his trade-off between observed housing characteristics and other goods. To see why, let (q_X', q_{HO}', q_{HU}') be a participant's consumption bundle under the program and $(q_X^{\bullet}, q_{HO}^{\bullet}, q_{HU}^{\bullet})$ be his bundle in the absence of the program. Assume that $p_X^{\bullet}$, $p_{HO}^{\bullet}$, and $p_{HU}^{\bullet}$ are the prices facing all consumers in the market in the absence of the program and unsubsidized consumers in its presence. The equivalent variation measure of the benefit of the program is

$$B=e\,(p_X^{\bullet}, p_{HO}^{\bullet}, p_{HU}^{\bullet}, u(q_X', q_{HO}', q_{HU}') \qquad (2)$$

$$-e(p_X^{\bullet}, p_{HO}^{\bullet}, p_{HU}^{\bullet}, u(q_X^{\bullet}, q_{HO}^{\bullet}, q_{HU}^{\bullet}))$$

where e is the expenditure function corresponding to the underlying utility function u. The separability of the utility function allows us to rewrite (2) as

$$B = e_{XHO}\,(p_X^{\bullet}, p_{HO}^{\bullet}, u_{HXO}(q_X', q_{HO}')) + e_{HU}\,(p_{HU}^{\bullet}, u_{HU}(q_{HU}'))$$

$$-e_{XHO}\,(p_X^{\bullet}, p_{HO}^{\bullet}, u_{XHO}(q_X^{\bullet}, q_{HO}^{\bullet})) - e_{HU}(p_{HU}^{\bullet}, u_{HU}(q_{HU}^{\bullet})) \qquad (3)$$

where e_Z (Z=XHO, HU) is the expenditure function associated with the subutility function u_Z. If the household is indifferent between the bundle of unobserved housing characteristics consumed under the program and the bundle that would be consumed in its absence (i.e., $u_{HU}(q'_{HU}) = u_{HU}(q^{\bullet}_{HU})$), the last terms on the first and second lines of equation (3) sum to zero. Therefore,

$$B = e_{XHO}(p^{\bullet}_X, p^{\bullet}_{HO}, u_{XHO}(q'_X, q'_{HO})) - e_{XHO}(p^{\bullet}_X, p^{\bullet}_{HO}, u_{XHO}(q^{\bullet}_X, q^{\bullet}_{HO})) \qquad (4)$$

Calculating the first line of equation (4) requires a knowledge of the household's trade-offs between observed housing characteristics and nonhousing goods, the household's consumption of these goods under the program, and market prices. Calculating the second line requires a knowledge of the household's expenditure on these goods in the absence of the program.

The trade-offs that households are willing to make between housing attributes and other goods are estimated using information on differences in consumption patterns among households with different incomes and facing different prices. More specifically, the approach is to (1) identify unsubsidized households living in rental housing who can be presumed to face the usual linear budget constraint, (2) divide these households into groups according to their observed characteristics except for their income and the prices that they face, (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 expenditure equations, and (5) use the estimated indifference map for families of each type to estimate the benefit of the program to households with the same observed characteristics participating in it.

The usual approach to estimating the benefits of a housing program to participants involves treating observed housing characteristics and other goods as composite commodities and implicitly assuming that all housing characteristics are observed. The equivalent variation measure of benefit using this approach is

$$B_{CU} = E(P_X^*, P_H^*, U(Q_X', Q_H')) - E(P_X^*, P_H^*, U(Q_X^*, Q_H^*)) \quad (5)$$

where E is the expenditure function corresponding to the composite utility function U, P_X^* and P_H^* are indices of the prices of other goods and housing in the absence of the program, Q_X' and Q_H' are indices of the quantities of other goods and housing characteristics in the presence of the program, and Q_X^* and Q_H^* indices of these quantities in its absence.

When the usual approach is modified to account for unobserved housing characteristics, an analysis similar to the preceding leads to the following formula for calculating benefit:

$$B_{CM} = E_{XHO}(P_X^*, P_{HO}^*, U_{XHO}(Q_X', Q_{HO}')) - E_{XHO}(P_X^*, P_{HO}^*, U_{XHO}(Q_X^*, Q_{HO}^*)) \quad (6)$$

E_{XHO} is the expenditure function corresponding to the composite subutility function U_{XHO}, P_X^* and P_{HO}^* are indices of the market prices of other goods and observed housing characteristics, Q_X' and Q_{HO}' are indices of the quantities of other goods and observed housing characteristics in the presence of the program, and Q_X^* and Q_{HO}^* indices of these quantities in its absence.

The usual price indices indicate the difference in the market values of a specified bundle of goods in a group in different times and places. The usual quantity indices are the market values of the quantities of goods in a group divided by the corresponding price indices.

III. DATA

This paper is based on data from the metropolitan area sample of the 1974 Annual Housing Survey for Detroit and Minneapolis. The survey collected hundreds of pieces of information about the characteristics of about 5000 households living in rental housing in these cities and the characteristics of their housing. The available information includes the household's income, size, and composition, and the age, sex, and race of its head. The survey also contains information on many variables describing the space, amenities, condition, and neighborhood of each dwelling. The results reported in this paper are based on a subset of these households and variables. Specifically, in estimating indifference maps, we limited ourselves to the 355 unsubsidized households with one or two members headed by a white female over 60 years old. In estimating the benefits of the housing programs, we limited ourselves to the 83 subsidized households in this category.

Before describing how we used these data to estimate benefit based on a disaggregated and composite utility function, it is desirable to discuss several serious problems with the data and how we handled them. Income is an extremely important variable for our analysis, and it is quite clear that it is badly misreported or wildly inconsistent with our assumptions in some cases. For example, one household was reported to have had an income of $5 during the previous year and a rent of $231 in the previous month. If the annual income of current members of this household was $5, then this household must have dissaved to survive during this period, contrary to our assumption, or someone who had an income during this period left the household before the survey. When last month's rent is multiplied by 12 to get an estimate of last year's rent, 4.3 percent of unsubsidized households and 3.1 percent of subsidized households had reported rents in excess of their reported incomes.[3] In virtually all cases, this resulted from unbelievably low incomes rather than unbelievably high rents. In our experience, using observations on households for whom income is so badly misreported or wildly inconsistent with our assumptions has an enormous effect on estimates of the parameters of the indifference map and hence on benefit estimates. We have not, and probably will not, examine the data for these households closely enough to develop a refined method for choosing which cases to delete. After looking at the frequency distribution of the rent-income ratio for unsubsidized households reported in Table 1, we decided to base our calculations on households with a ratio between .05 and .75. We will

Table 1

Frequency Distribution of the Rent-Income Ratio
for Unsubsidized Households

Rent-Income Ratio		Percentage
Lower Limit	Upper Limit	of Cases
.00	.05	0.7
.05	.10	8.0
.10	.15	16.6
.15	.20	17.8
.20	.25	12.7
.25	.30	8.7
.30.	.35	6.6
.35	.40	5.0
.40	.45	4.1
.45	.50	2.8
.50	.55	2.6
.55	.60	2.8
.60	.65	1.9
.65	.70	1.5
.70	.75	1.3
.75	.80	1.0
.80	.85	.5
.85	.90	.7
.90	.95	.4
.95	1.00	.3
1.00	∞	4.3

estimate the bias in benefit estimation due to misapplication of the composite commodity theorems for alternative choices.

IV. METHODS

A. Disaggregated Approach with Unobserved Housing Characteristics

The Annual Housing Survey collects data on more than 50 characteristics of housing. In order to estimate the trade-offs that households are willing to make between these characteristics and nonhousing consumption, it would be necessary to estimate a system of more than 50 equations. We decided against this much detail. Instead we began by selecting the 27 characteristics that we thought would be most important for explaining the rents of unsubsidized units. Preliminary regressions revealed that many of these variables are unimportant in explaining rent or have estimated coefficients of the wrong sign. The results reported here are based on the 10 housing characteristics that performed the best in these preliminary regressions. Some of the variables representing these characteristics are quantitative (e.g., number of bedrooms). Others give the range of values in which a quantitative variable falls (e.g., year built). Others are qualitative (e.g., existence of central air conditioning). To simplify the analysis, we grouped the characteristics into four composites that we call space, condition, amenities, and neighborhood. Our disaggregated estimate of benefit is based on a utility function defined over these composites and a composite of all nonhousing goods. In order to estimate this utility function, it is necessary to have data on the prices of, and expenditures on, these housing attributes. Neither can be directly observed. We now turn to how they can be estimated.

1. **Prediction of Expenditures on Housing Attributes and Nonhousing Goods by Unsubsidized Households**

The market rent of each unsubsidized unit can be viewed as the sum of expenditures on space, condition, amenities, neighborhood, and unobserved housing characteristics as well as a term reflecting the extent to which the unit is under or overpriced. Since the households in the Annual Housing Survey are selected by random sampling, the rent of the unsubsidized unit that emerges on the ith draw can be written

$$R_i = R_{Si} + R_{Ci} + R_{Ai} + R_{Ni} + R_{Ui} + \epsilon_i \qquad (7)$$

where R_i is the rent of the unit, R_{Si} is that part of the rent attributable to space, R_{Ci} the part due to condition, R_{Ai} the part due to amenities, R_{Ni} the part due to neighborhood, R_{Ui} the part due to unobserved characteristics, and ϵ_i a white noise error term reflecting search costs in the housing market.

Each of the first four terms on the right-hand side of equation (7) can be written as a function of subsets of the variables representing the 10 observed housing characteristics. Many of these characteristics are represented by sets of dummy variables. This results in an equation of the form

$$R_i = \beta_o + \sum_{j=1}^{2} \beta_{Sj} X_{Sji} + \sum_{j=1}^{16} \beta_{Aj} X_{Aji} + \sum_{j=1}^{6} \beta_{Cj} X_{Cji}$$

$$+ \beta_N X_{Ni} + R_{Ui} + \epsilon_i \qquad (8)$$

where the X_{Kj} for K=S,A,C,N are defined in Table 2.

Since we believe that the effect of some characteristics (e.g., the existence of central air conditioning) on the market rent of an apartment is roughly proportional to its size, some of

Table 2

Estimated Relationship Explaining Annual Gross Rent of Unsubsidized Units

Regressors	Description of Regressors	Coefficients (standard errors) Detroit	Minneapolis
Space			
X_{S1}	Number of bedrooms	85.17	286.00
X_{S2}	Number of other rooms	.66 (52.10)	129.96 (87.94)
Amenities			
X_{A1}	1 if dwelling contains kitchen for exclusive use; 0 otherwise	112.98 (77.71)	248.72 (117.48)
X_{A2}	1 if dwelling contains shared kitchen; 0 otherwise	112.83 (199.83)	75.79 (206.50)
($X_{A1}=X_{A2}=0$	if dwelling has no kitchen)		
X_{A3}	1 if dwelling contains over 2 bathrooms; 0 otherwise	1481.90 (166.18)	2544.32 (469.01)
X_{A4}	1 if dwelling contains 2 full bathrooms; 0 otherwise	703.07 (120.89)	1127.79 (159.90)
X_{A5}	1 if dwelling contains 1 full bathroom and a half bathroom with toilet; 0 otherwise	464.51 (113.26)	983.22 (159.33)
X_{A6}	1 if dwelling contains 1 full bathroom and a half bathroom without toilet; 0 otherwise	1202.92 (232.13)	510.14 (242.39)
X_{A7}	1 if dwelling contains 1 full bathroom; 0 otherwise	172.55 (106.20)	590.00 (143.09)
X_{A8}	1 if dwelling contains all facilities but not in one room; 0 otherwise	124.45 (143.03)	754.16 (201.67)

Table 2, Continued

Regressors	Description of Regressors	Coefficients (standard errors) Detroit	Minneapolis
X_{A9}	1 if household shares plumbing facilities; 0 otherwise	-.88 (113.81)	184.49 (157.32)
(X_{A3} = ... = X_{A9} = 0 if no access to complete plumbing facilities)			
X_{A10}	Number of rooms if building has more than 12 floors; 0 otherwise	256.49 (26.37)	265.46 (48.06)
X_{A11}	Number of rooms if building has 7 to 12 floors; 0 otherwise	128.15 (24.23)	6.91 (59.38)
X_{A12}	Number of rooms if building has 4 to 6 floors and an elevator; 0 otherwise	5.58 (14.77)	88.98 (20.74)
X_{A13}	Number of rooms if building has 4 to 6 floors and no elevator; 0 otherwise	-51.84 (21.84)	-39.80 (50.45)
(X_{A10} = ... = X_{A13} = 0 if building has 1 to 3 floors)			
X_{A14}	Number of rooms if working electric wall outlets in every room; 0 otherwise	19.72 (7.42)	28.38 (14.25)
X_{A15}	Number of rooms if dwelling has central airconditioning; 0 otherwise	95.97 (10.23)	77.16 (17.27)
X_{A16}	Number of rooms if dwelling has room units; 0 otherwise	19.85 (5.33)	32.69 (7.94)
(X_{A15} = X_{A16} = 0 if no airconditioning)			

Table 2, Continued

Regressors	Description of Regressors	Coefficients (standard errors) Detroit	Minneapolis
Condition			
X_{C1}	Rooms if dwelling built after 4/1/70; 0 otherwise	172.60 (12.43)	176.97 (12.48)
X_{C2}	Rooms if dwelling built 1969 to 3/31/70; 0 otherwise	167.75 (14.37)	119.27 (16.69)
X_{C3}	Rooms if dwelling built 1965 to 1968; 0 otherwise	183.70 (10.73)	100.61 (12.45)
X_{C4}	Rooms if dwelling built 1960 to 1964; 0 otherwise	168.26 (11.24)	81.58 (12.35)
X_{C5}	Rooms if dwelling built 1950 to 1959; 0 otherwise	117.19 (8.08)	70.93 (11.69)
X_{C6}	Rooms if dwelling built 1940 to 1949; 0 otherwise	64.66 (7.29)	44.27 (19.46)
($X_{C1} = ... = X_{C6} = 0$ if dwelling built before 1940)			
Neighborhood			
X_N	Number of rooms if no crime exists in neighborhood; 0 otherwise	12.74 (4.35)	25.03 (7.02)
Demographic			
Z_1	Annual income in thousands	28.67 (11.85)	10.46 (15.51)
Z_2	Annual income squared	-.61 (.38)	.04 (.41)
Z_3	Number of persons	18.68 (66.37)	-265.09 (124.52)

Table 2, Continued

Regressors	Description of Regressors	Coefficients (standard errors) Detroit	Minneapolis
Z_4	Number of persons squared	9.19 (9.58)	47.79 (21.34)
Z_5	Age of head	-8.20 (9.00)	17.03 (11.35)
Z_6	Age of head squared	.04 (.09)	-.12 (.12)
Z_7	1 if head of household is white; 0 otherwise	71.18 (60.38)	58.58 (185.48)
Z_8	1 if head of household is male; 0 otherwise	-156.11 (63.59)	99.25 (85.37)
Z_9	ROOMS * Z_1	-3.39 (2.68)	-.53 (4.07)
Z_{10}	ROOMS * Z_2	.14 (.08)	.07 (.11)
Z_{11}	ROOMS * Z_3	12.33 (12.83)	57.29 (27.29)
Z_{12}	ROOMS * Z_4	-2.80 (1.67)	-9.62 (4.05)
Z_{13}	ROOMS * Z_5	-1.24 (2.10)	-6.29 (3.11)
Z_{14}	ROOMS * Z_6	.01 (.02)	.05 (.03)
Z_{15}	ROOMS * Z_7	28.14 (13.16)	26.18 (47.23)
Z_{16}	ROOMS * Z_8	19.50 (14.39)	-34.69 (22.14)

Table 2, Continued

Regressors	Description of Regressors	Coefficients (standard errors) Detroit	Minneapolis
Constant		1022.95	-41.85
		(251.30)	(360.75)
R^2		.59	.66
SEE		500.74	428.37
F		109.25	58.76
Cases		3146	1269

the variables X_{Aj}, X_{Cj}, and X_{Nj} are the product of the number of rooms and another variable such as a dummy variable for central air conditioning. Units with zero values for the variables X_{Aj}, X_{Cj}, and X_{Nj} are not of the smallest possible quality with respect to these variables. The coefficient β_O reflects the contribution to rent of the amenities, condition, and neighborhood of units in this category.

All previous studies of housing programs that have estimated an equation similar to (8) have implicitly assumed that there are no unobserved housing characteristics (i.e. $R_{Ui}=0$) or that unobserved housing characteristics are uncorrelated with observed housing characteristics. In the latter case, the constant term includes the expected value of R_{Ui} and the error term includes the deviation of R_{Ui} from its expected value. Neither assumption is strictly true, and both may be far from the mark. For example, unobserved characteristics are likely to be correlated with observed housing characteristics because richer households occupy housing that is better in all respects. Holding income constant, larger families occupy units that are more spacious but of lower quality.

To ameliorate the bias that results from omitting unobserved housing characteristics in equation (8), we write expenditure on these characteristics as a function of the characteristics of their occupants, that is,

$$R_{Ui} = \alpha_o + \sum_{j=1}^{m} \alpha_j Z_{ji} + \eta_i \tag{9}$$

where the Z_j are defined in Table 2. Such a relationship is implied by constrained utility maximization. Substituting (9) into (8), we get

$$R_i = (\alpha_o+\beta_o) + \sum_{j=1}^{2} \beta_{Sj}X_{Sji} + \sum_{j=1}^{16} \beta_{Aj}X_{Aji} + \sum_{j=1}^{6} \beta_{Cj}X_{Cji}$$

$$+ \beta_N X_{Ni} + \sum_{j=1}^{m} \alpha_j Z_{ji} + (\epsilon_i+\eta_i). \tag{10}$$

We estimate (10) separately for each market because there is no reason to expect the β's to be the same in different markets. Since the implicit prices of housing attributes are assumed to be the same throughout each market, they are not included among the Z_j but affect the value of α_o. It cannot be argued that the error term $\epsilon_i + \eta_i$ in equation (10) is uncorrelated with the X_{Kj} because η_i reflects primarily differences in taste and households with the same observed characteristics who have stronger than average tastes for unobserved housing attributes may have stronger or weaker than average tastes for particular observed housing attributes. However, inclusion of the Z_j in equation (10) undoubtedly reduces the bias in the OLS estimators of the β_{Kj}.

Table 2 contains the OLS estimates of the coefficients of equation (10) for each city. In almost all cases, the signs and relative magnitudes conform with expectations.

These results can be used to estimate how much each unsubsidized household spent on housing attributes in each group. For example, a household's estimated expenditure on space is

$$EXPS_i = \sum_{j=1}^{2} \hat{\beta}_{Sj} X_{Sji} \tag{11}$$

where the $\hat{\beta}_{Sj}$ are the OLS estimates for its city.

Under our assumptions, a household's expenditure on nonhousing goods can be obtained by subtracting its rent from its income.

2. Market Prices of Housing Attributes and Nonhousing Goods

In order to estimate the trade-offs that households are willing to make between observed housing attributes (space, amenities, condition, and neighborhood) and nonhousing goods, it is necessary to have price indices for these composites. The BLS cross-sectional price index is used for nonhousing goods. Its values for Detroit and Minneapolis are reported in Table 3. We construct price indices for observed housing attributes by comparing the mean market values of a unit with the mean characteristics of unsubsidized units in the two cities. For example, the price of space in market N (N=DET,MINN) is

$$PS_N = \sum_{j=1}^{2} \hat{\beta}_{Sj}^{N} \bar{X}_{sj} \Big/ \sum_{j=1}^{2} \hat{\beta}_{Sj}^{MINN} \bar{X}_{sj} \tag{12}$$

The values of these price indices are reported in Table 3.

3. Estimation of Indifference Maps of Households

With the preceding estimates of expenditure on space, amenities, condition, neighborhood, and nonhousing goods and the prices of these goods, it is possible to estimate household indifference maps. We begin with an assumption concerning their functional form, namely

$$U_i = \prod_{K} (Q_{Ki}-B_{Ki})^{C_{Ki}} \quad K=S,A,C,N,X \tag{13}$$

where the Q_{Ki} are quantities of goods consumed by the household selected on the ith draw and the B_{Ki} and C_{Ki} are this household's indifference-map parameters.[4] Without loss of generality, the C_{Ki} can be assumed to sum to 1. Unsubsidized households are assumed to face the usual linear budget constraint, that is,

Table 3

Price Indices

Good	Price Index	
	Detroit	Minneapolis
Space	.185	1.000
Amenities	.436	1.000
Condition	1.472	1.000
Neighborhood	.508	1.000
Nonhousing	1.031	1.000

$$\sum_K P_{Ki}Q_{Ki} = E_i \tag{14}$$

where E_i is the household's expenditure on observed housing characteristics and nonhousing goods. A household maximizing (13) subject to (14) will spend the following amounts on the five goods.

$$P_{Ki}Q_{Ki}=B_{Ki}P_{Ki}+C_{Ki}(E_i - \sum_K B_{Ki}P_{Ki}) \tag{15}$$

Even though the households used to estimate this indifference map are the same with respect to certain observed characteristics, we do not assume that they have the same preferences. Instead we allow the C_{Ki} to be different for different households. Each individual's parameter can be written as the sum of the population mean value of that parameter C_K and the deviation of the individual's parameter from the mean V_{Ki}.

$$C_{Ki}=C_K+V_{Ki} \qquad K=S,A,C,N,X \tag{16}$$

For simplicity, we assume that each subsistence parameter (e.g., B_{Si}) is the same for all households in the subgroup under consideration.

Substituting (16) into (15) we get

$$P_{Ki}Q_{Ki}=B_K P_{Ki} + C_K (E_i - \sum_K B_{Ki}P_{Ki}) + W_{Ki}$$

$$\text{where } W_{Ki}=V_{Ki}(E_i - \sum_K B_{Ki}P_{Ki}) \tag{17}$$

Since the number of observations from each city was fixed in advance, the P_{Ki} are viewed as fixed in repeated sampling.[5] Since the households in the sample in a particular city were selected at random, E_i and the V_{Ki} are random variables. We assume that the V_{Ki} are independent of E_i.

The definitions of the V_{Ki} insure that their means are zero. Therefore, the $E(W_{Ki})$ are zero. If V_{Ki} is independent of E_i, W_{Ki}, and E_i are uncorrelated.

We want to estimate the mean indifference-map parameters $B_S, B_A, B_C, B_N, B_X, C_S, C_A, C_C, C_N$, and C_X for unsubsidized households with one or two members headed by a white female over 60 years old. Since each of the B_K appears in each of the five equations in (17), we estimate these equations jointly. Since the error terms in these equations sum to zero for each observation, nothing is gained by including all five equations in the estimation. We delete the equation explaining non-housing expenditure. Finally, the utility function is not defined for Q_K less than B_K. Our estimates minimize the sum of squared residuals across all equations and cases subject to the restrictions that the B_K are less than or equal to the sample minima of the corresponding Q_K for subsidized households minus 1.

Table 4 presents the constrained as well as unconstrained estimates of the parameters. Obviously, imposing the restrictions greatly affects the fit of the equations and the signs and magnitudes of some coefficients. However, the unrestricted parameter estimates cannot be used to estimate benefit for 97 percent of subsidized households because these households' estimated consumption of at least one good was less than the unrestricted estimate of the corresponding subsistence parameter. This strongly suggests that our assumption that each subsistence parameter is the same for all households of this type or our assumed functional form for the indifference map is far from the mark. We will eventually make estimates based on alternative utility functions.

The preceding indifference maps are estimated using data on unsubsidized households. We assume that the mean indifference map parameters are the same for subsidized and unsubsidized households of this type. Since recipients of housing subsidies are not selected at random from the entire population, the existence of selection bias is undeniable. Olsen and Barton (1983,

Table 4

Estimates of Parameters of Disaggregated Indifference Map

Coefficient	Estimates (standard errors) Restricted		Unrestricted	
CS	.0191	(.0024)	.0076	(.0024)
CA	.0195	(.0025)	.0152	(.0024)
CC	.0154	(.0026)	.0177	(.0024)
CN	.0027	(.0020)	.0014	(.0024)
BS	2.470	(32.53)*	599.7	(19.83)
BA	517.3	(43.95)*	968.3	(28.31)
BC	-17.51	(34.64)	162.6	(17.65)
BN	-1.000	(44.27)*	58.48	(14.00)
BX	-9912	(1780)	3365	(1146)
SSR	59,438,093		42,468,276	
Cases	301		301	

Note: Asterisk indicates parameter for which restriction was binding.

pp. 314-315) explain why there is no strong a priori reason to believe that the selection bias in estimating the benefit of public housing is in a particular direction. Olsen and Bierman (1982) and Bierman (1985) estimate that the bias is less than 5 percent when a composite utility function is used.

Our estimates of the indifference map parameters of each subsidized household are the estimated means in Table 4. The use of a single indifference map for all families of a particular type combined with variations in tastes among these families results in a type of aggregation bias. Olsen and Caniglia (1981) have shown that the asymptotic bias in our estimator of mean benefit can be in either direction, and Olsen and Agrawal (1982) have estimated the magnitude of the bias for public housing. Using data on the consumption patterns of public housing tenants before they entered public housing and making a range of assumptions about the functional form of their indifference maps, they find that the methods of this paper are likely to overestimate tenant benefit by 10 to 30 percent due to aggregation bias when all goods are divided into two composites. Since this type of aggregation bias is likely to affect estimates of mean benefit in the same direction using the composite and disaggregated utility function, its effect on the difference between these mean benefits is unclear.

4. Formula for Calculating Benefit

Under our assumptions, the equivalent variation measure of the benefit of a housing program to a participant is

$$B = \prod_K [(P_K \cdot Q_K^G - P_K \cdot B_K)/C_K]^{C_K} + \sum_K P_K \cdot B_K - E \tag{18}$$

where K=S,A,C,N,X, the Q_K^G are quantities of goods consumed under the program, and E is expenditure on observed housing attributes and non-housing goods in the absence of the program.

We have already described how we calculate price indices and indifference-map parameters. We now turn to how we predicted the Q_K^G and E.

5. Prediction of Consumption Patterns of Subsidized Households Under the Program

We observe certain attributes of the housing occupied by participants in the housing programs. In subsection 1, we reported an estimated relationship explaining the differences in the rents of unsubsidized units in terms of differences in observed characteristics of these units and their occupants. Substituting the observed characteristics of the subsidized units into the appropriate parts of this equation yields estimates of the market values of particular types of attributes consumed by participants. For example, the market value of the space occupied by a participant is

$$P_{Si}Q_{Si}^G = \sum_{j=1}^{2} \hat{\beta}_{sj} X_{Sji}. \qquad (19)$$

6. Prediction of Expenditure on Nonhousing Goods and Observed Housing Characteristics in the Absence of the Program

To predict how much a subsidized household would spend on observed housing characteristics and nonhousing goods in the absence of the housing program, we subtract from its income a prediction of how much it would spend on unobserved housing characteristics. Based on the discussion in subsection 1, this prediction is

$$(\hat{\alpha}_o + \hat{\beta}_o) + \sum_{j=1}^{m} \hat{\alpha}_j Z_{ji} \qquad (20)$$

where the Z_{ji} are the household characteristics in Table 2.

We have now explained how we have estimated each of the inputs needed to calculate benefit to each subsidized household based on the disaggregated utility function using equation (18).

B. <u>Composite Approach with Unobserved Housing Characteristics</u>

Now that the disaggregated approach with unobserved housing characteristics has been explained in considerable detail, the composite approach can be explained more briefly. To estimate the subutility function defined over a composite of all nonhousing goods and a composite of all observed housing characteristics, we need expenditures on, and price indices for these two composites for unsubsidized families. Expenditure on nonhousing goods is again the excess of a household's income over its rent. Expenditure on observed housing characteristics is gotten by adding expenditures on space, amenities, condition, and neighborhood. Values of an index of the prices of observed housing characteristics are obtained in a manner similar to the price indices for space, amenities, condition, and neighborhood (see equation 12). Its values are .42 for Detroit and 1.0 for Minneapolis. The values of the nonhousing price indices are those in Table 3. Using these price and expenditures for unsubsidized households, we obtain the nonlinear least squares estimates of the parameters of a Stone-Geary utility function from its implied housing expenditure equation. Table 5 reports the results. The predicted market value of all observed housing characteristics of the unit occupied by a subsidized household is the sum of the previous predictions of the market values of space, amenities, condition, and neighborhood. The predicted total expenditure on non-housing goods and observed housing characteristics of these households in the absence of the program is the same as before. Using the formula in equation (18), where K=HO, X and the preceding estimates, we estimate benefit to each subsidized household.

Table 5

Estimates of the Parameters of the Composite Indifference Map Defined over Nonhousing Goods and Observed Housing Characteristics

Coefficient	Parameter Estimates	(standard errors)
CHO	.0776	(.0086)
BHO	176.5	(133.3)
BX	-15834	(2469)
SSR	112,872,640	
Cases	301	

C. Traditional Composite Approach

The traditional composite commodity approach to benefit estimation is based implicitly on the assumption that all housing characteristics are observed. To estimate the utility function defined over a composite of all nonhousing goods and a composite of all housing goods using data on unsubsidized households, expenditure on nonhousing goods is assumed to be the excess of the household's income over its rent, expenditure on all housing characteristics is its rent, and BLS cross-sectional price indices for housing and other goods are assumed to reflect differences in the prices of these composites between the two cities. The values of the BLS housing price index are .738 for Detroit and 1.0 for Minneapolis. Using these prices and expenditures for unsubsidized households, we obtain nonlinear least squares estimates of the parameters of a Stone-Geary utility function from its implied expenditure equation subject to the restrictions that the estimated subsistence parameters B_H and B_X are less than or equal to the sample minima consumption of these two composites by subsidized households minus 1. Table 6 presents the constrained as well as unconstrained estimates of the parameters. To estimate the market rent of the housing unit occupied by a subsidized household, we estimate a hedonic equation identical to that reported in Table 2 except for the exclusion of the demographic variables, and we substitute the characteristics of the subsidized unit into this equation. To estimate this household's expenditure on nonhousing goods, we subtract its rent from its income. Using the preceding estimates and formula (18) where K=H,X, we estimate the benefit to each subsidized household.

V. RESULTS

Table 7 presents the estimated mean benefits for tenants in public housing, other subsidized housing, and both based on a disaggregated and composite commodity approach accounting for

Table 6

Estimates of the Parameters of the Composite Indifference Map

Coefficient	Parameter Estimates (standard errors) Restricted		Unrestricted	
CH	.0848	(.0080)	.0847	(.0080)
BH	527	(268)*	620	(267)
BX	-9966	(2790)	-9150	(2753)
SSR	104,411,150		104,368,600	
Cases	301		301	

Note. Asterisk indicates parameter for which restriction was binding.

Table 7

Mean Annual Benefits

Approach	All Subsidized	Public Housing	Other Subsidized
Disaggregated with unobserved housing characteristics	$538	$565	$471
Composite with unobserved housing characteristics	$797	$843	$681
Traditional composite	$962	$1045	$756
Cases	80	57	23

unobserved housing characteristics and on the traditional composite commodity approach. A comparison of the first two rows answers the primary question considered here. These comparisons show that the composite commodity approach overstates the benefits to recipients of rental housing subsidies by almost 50 percent compared with a disaggregated approach that breaks housing characteristics into four categories--space, condition, amenities, and neighborhood attributes. The bias is approximately the same for public and other subsidized housing. Even this understates the bias because our disaggregated approach involves a substantial degree of aggregation.

A comparison of the last two rows of Table 7 shows that the treatment of unobserved housing characteristics can have a marked effect on estimates of the benefits of housing programs. Which treatment is superior is an open question.

VI. CONCLUSION

The results of this study strongly suggest that previous estimates of the benefits of the types of housing programs prevalent in 1974, namely new construction programs such as public housing and Section 236, greatly overstate the benefits of these programs to recipients. This implies that these programs are less desirable than previously thought compared with programs such as housing allowances that give recipients much more freedom to choose the characteristics of the units occupied. It also suggests the desirability of using a more disaggregated approach in analyzing new construction programs.

Appendix

This appendix reports estimates of the bias in calculating the mean benefit of rent control due to the use of a two-good composite commodity approach. The general procedures used are the same as in the body of the report. For example, the bias is estimated by comparing estimated mean benefit based on a two-good composite utility function where housing is treated as a single composite commodity and based on a five-good composite utility function where housing is disaggregated into four composites--space, amenities, condition, and neighborhood. Unobserved housing characteristics are treated identically in making these estimates. Households with reported rent-income ratios below .05 and above .75 are excluded from the sample.

The analysis is based on data from the 1965 New York City Housing and Vacancy Survey. The estimates are for one and two-person households headed by white males under 40 years old living in Manhattan. This is the largest of 36 family types in uncontrolled housing in this borough and the second largest in controlled housing. Since all of these households live in structures with three or more units, four or more stories, and are categorized as an old law tenement, new law tenement, or multiple dwelling built after 1929, the hedonic equation reported in Table A-1 is estimated using data on apartments in such structures in Manhattan. Since the data are for one place at one point in time, there is no variation in prices across the sample. Therefore, the parameters of the utility function cannot be estimated as in the body. Instead we follow Olsen and Barton's procedure, namely define units of measurement of all goods such that their market prices are one and use the sample minimum expenditure on nonhousing goods as an estimate of subsistence consumption of these goods BX. Tables A-2 and A-3 report estimates of the parameters of the disaggregated and composite utility functions.

The estimated mean benefit to the 151 households of this type living in controlled housing is $568 per year when the two-good utility function is used and $143 when the five-good utility function is used. This suggests that the benefits of rent control are greatly overestimated by the usual approach.

Table A-1

Estimated Relationship Explaining Annual Gross Rent of Unsubsidized Units
(Manhattan 1965)

Regressors	Description of Regressors	Coefficients (standard errors)
Space		
X_{S1}	Number of bedrooms	174.01 (122.27)
X_{S2}	Number of other rooms	163.98 (123.55)
Amenities		
X_{A1}	Number of rooms if unit is on first floor; 0 otherwise	21.57 (107.51)
X_{A2}	Number of rooms if unit is on second or third floor and building has elevator; 0 otherwise	35.62 (114.89)
X_{A3}	Number of rooms if unit is on fourth or fifth floor and building has elevator; 0 otherwise	85.56 (114.02)
X_{A4}	Number of rooms if unit is on fourth or fifth floor and building doesn't have elevator; 0 otherwise	67.49 (138.43)
X_{A5}	Number of rooms if unit is on sixth floor; 0 otherwise	63.46 (115.23)
X_{A6}	Number of rooms if unit is above sixth floor; 0 otherwise	80.86 (113.33)

(X_{A1}=...=X_{A6}=0 if unit is on second or third floor in building without elevator)

Table A-1, Continued

Regressors	Description of Regressors	Coefficients (standard errors)
X_{A7}	Number of rooms if number of units in building is 3 through 19; 0 otherwise	20.04 (127.58)
X_{A8}	Number of rooms if number of units in building is 50 through 99; 0 otherwise	27.51 (46.10)
X_{A9}	Number of rooms if number of units in building is greater than 100; 0 otherwise	12.66 (44.93)
$X_{A7}=X_{A8}=X_{A9}=0$ if number of units in building is 20 through 49)		
Condition		
X_{C1}	Number of rooms if unit is in sound condition; 0 otherwise	118.06 (76.70)
X_{C2}	Number of rooms if building less than 6 years old; 0 otherwise	215.05 (57.89)
X_{C3}	Number of rooms if building 7 through 19 years old; 0 otherwise	24.45 (58.36)
X_{C4}	Number of rooms if building 20 through 65 years old; 0 otherwise	199.88 (60.36)
($X_{C2}=X_{C3}=X_{C4}=0$ if building is more than 65 years old)		
Neighborhood		
X_{N1}	Number of rooms if stories in building less than 6; 0 otherwise	128.84 (118.83)
X_{N2}	Number of rooms if 6 stories in building; 0 otherwise	22.99 (50.23)
($X_{N1}=X_{N2}=0$ if building has more than 6 stories)		

Table A-1, Continued

Regressors	Description of Regressors	Coefficients (standard errors)
Demographic		
Z_1	Annual income in thousands	56.62 (6.34)
Z_2	Annual income in thousands squared	-.15 (.10)
Z_3	Number of persons	24.49 (78.96)
Z_4	Number of persons squared	-24.90 (13.35)
Z_5	1 if head of household is white; 0 otherwise	504.55 (87.73)
Z_6	1 if head of household is male; 0 otherwise	-97.31 (54.11)
Constant		-20.66 (133.96)
R^2		.65
SEE		687.36
F		79.07
Cases		1012

Table A-2

Estimates of Parameters of Disaggregated Indifference Map

Coefficient	Restricted Estimates (standard errors)	
CS	.0303	(.0028)
CA	.0157	(.0028)
CC	.0551	(.0028)
CN	.0029	(.0028)
BS	-1.0000	(39.54)*
BA	-1.0000	(38.87)*
BC	-1.0000	(40.73)*
BN	-37.2348	(38.31)
BX	419.0000	
SSR	72,953,413	
Cases	212	

Notes: Asterisk indicates parameter for which restriction was binding. Estimate of BX is sample minimum of QX.

Table A-3

Estimates of the Parameters of the Composite Indifference Map Defined Over Non-Housing Goods and Observed Housing Characteristics

Coefficient	Parameter Estimates (standard errors)	
CHO	.0847	(.0072)
BHO	291	(105)*
BX	419	
SSR	121,958,190	
Cases	151	

Notes: Asterisk indicates parameter for which restriction was binding. Estimate of BX is sample minimum of QX.

Notes

[1]Minneapolis and Detroit were selected to maximize the variance in the ratio of the price of housing to the price of other goods. This is helpful in making accurate estimates of indifference-map parameters. We divided all subsidized households into 36 groups according to family size and the age, race, and sex of the head of the household. The subsample used here was the largest of these groups, accounting for 21 percent of all subsidized households.

[2]See Olsen and Barton (1983, pp. 301-302) for a discussion of the realism of these assumptions.

[3]Since almost all newspaper accounts of extraordinarily high rent-income ratios of low-income households are based on this method and these data, these stories should be taken with a grain of salt.

[4]We intend to make estimates based on several alternative assumptions about the form of the indifference map, e.g., that underlying Deaton and Muellbauer's almost ideal demand system.

[5]We ignore the possibility that these prices could have been different from their estimated values.

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