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Abstract

The primary goals of the 1937 Housing Act were to provide safe and sanitary housing and to reduce crowding for low-income households. During the nearly 60 years since, the effective goals have expanded to include lowering housing costs, and by extension, to increasing nonhousing consumption. This paper examines the effect these programs have had on the overall consumption behavior of participants.

Using data from the 1987 American Housing Survey (AHS), the results indicate that federal housing programs have little effect on the housing consumption of participants (4.4 percent increase), but an enormous effect on their nonhousing consumption (141 percent increase). Furthermore, the assistance seems to lower the housing consumption of 42 percent of participating households. Finally, substituting cash subsidies for in-kind housing assistance will provide more housing consumption, but with smaller nonhousing consumption, than the current (primarily in-kind) system.

Do Housing Programs for Low-Income Households Improve their Housing?

Introduction

> "The primary purpose of housing assistance has always been to improve housing quality and to reduce housing costs to lower-income households" (U.S. House of Representatives 1992, p. 1673).

Congress passed the Housing Act of 1937 with the specific goals of providing safe and sanitary housing and of reducing crowding (U.S. Congress 1994). During the nearly 60 years since, the perceived goals have expanded to include lowering housing costs, and by extension, to increasing nonhousing consumption. The question—indeed the $18 billion question—is what effect these programs have had on the overall consumption behavior of participants.

Unfortunately, the answers to date appear to reflect the methods employed. Studies that utilize structural models to analyze cross-sectional data tend to find housing assistance is clearly effective in achieving better housing for participants (see Bierman 1985; DeSalvo 1975; Murray 1975; Olsen 1972; Olsen and Barton 1983; Reeder 1985). But, those that examine results of housing experiments are less optimistic about the overall success of housing assistance programs (see Goering, Kamely, and Richardson 1995; Hanushek and Quigley 1981; Kennedy 1983; Friedman and Weinberg 1983; Mayo 1983). Furthermore, the studies are not precisely comparable because none of the studies has accounted for both selection and aggregation biases, although some have accounted for aspects of these problems (see Bierman 1985; Reeder 1985; Hanushek and Quigley 1981; Kennedy 1983; Friedman and Weinberg 1983).

More generally, the recent literature on administrative selection and experimental design has illustrated the myriad problems associated with policy evaluation using either experimental data or cross-sectional data (see Heckman 1989; Heckman and Smith 1995; Roselius 1995 for reviews of this literature). Generally, experimental data is preferred, but the enormous cost of conducting experiments such as the Housing Allowance Demand Experiments of the 1970s has made such efforts infeasible. While cheaper, cross-sectional data often has limited data on participants and their consumption patterns, particularly their consumption choices before they entered the program of interest. The challenge for policy researchers is to get reliable estimates of program effects from less than ideal data.

The goal of this paper is to provide consistent estimates of mean consumption changes for participants in federal rental housing programs and the mean value or benefit of these programs to them. To do so, this paper improves in three ways upon the methods used in many previous studies. First, the methods take into account both self selection by individual households and administrative selection by local housing authorities, who choose among eligible applicants to allocate limited program resources. Second, the computations do not introduce aggregation bias into the estimates of the effects of the programs on participants. These two improvements are sufficient to reconcile the disparity between the experimental-based estimates and the estimates obtained using survey data. Lastly, improvements are made in the econometric specification and the underlying structural model.

Using cross-sectional data from the 1987 American Housing Survey (AHS) Metropolitan Files, the results indicate that federal housing programs have little effect on the housing consumption of participants, but an enormous effect on their consumption of nonhousing goods. The programs increase aggregate consumption of housing about 4 percent, but raise nonhousing consumption by 141 percent. Furthermore, 42 percent of participating households decrease their housing consumption from what they would consume in the absence of any assistance. Finally, substituting cash subsidies for in-kind housing assistance will provide more housing consumption, but with smaller nonhousing consumption, than the current (primarily in-kind) system.

The Analytics of Housing Programs

Housing subsidies currently fall into three basic program categories.[1] The first category covers new construction programs such as Public Housing.[2] These programs provided assistance to 64.2 percent of the more than five million participating households in 1994. The other two categories cover existing housing and are either household-based, such as the Section 8 Certificate and Voucher programs, or project-based.[3] The household-based programs assisted 25 percent of all subsidized households in 1994, with the Certificate program providing the majority of these subsidies.

The analytics of the place-based programs, such as the new construction and project-based existing programs, are straightforward. Under these programs, households are offered a particular housing unit at a below-market rent which is based upon the household's income.[4] The offer is made as an all-or-nothing package, which changes the budget space of an eligible family by adding a single point. Figure 1 illustrates this case for a household that consumes housing services, Q_h, and a composite good, Q_x. In the absence of housing assistance, the household faces market prices P_h and P_x (P_x is set equal to one in the illustration) for the two goods and consumes the bundle *m*. The program offer is denoted by *g*. In the figure, *g* offers the household more housing than it would choose at market prices and is preferred to the market bundle *m*. The amount *B* shown in the figure represents the cash value of the program to participants; it is the amount of money necessary at market prices for the household to achieve the same utility level it enjoys when consuming bundle *g*. The bundle *s* marks the consumption bundle chosen by the family under an equal-value and unrestricted cash subsidy program; the subsidy value is denoted by *S*.

Figure 2 illustrates the possibility that a participating household could decrease its housing consumption under the program. In this scenario, the household chooses to participate because it is made better off through increased ability to consume the non-housing good.

The analytics of the household-based certificate program are illustrated in Figure 3. Households are allowed to rent any private housing unit that the unit meets minimum quality standards, Q_h^{min} in the figure, and rents for less than the locally set FMR ceiling, $P_hQ_h^f$. The household pays a rent equal to 30 percent of its (HUD adjusted) income, regardless of the amount of housing consumed under the program. This program restricts a household's choices under the program to be along the horizontal segment $\overline{ag}$. Under the usual assumption of convex preferences, a household that chooses to participate in this program is induced to consume the maximum allowable amount of housing, so $Q_h^g = Q_h^f$, and the household consumes the bundle *g*. Again, housing consumption may rise or fall. In the figure, the household consumes more housing than the FMR ceiling in the absence of the program, leading it to consume less housing under the program.[5]

Preferences and Selection Effects

The effects of any housing program depend upon the preferences of the participating households. Households with the strongest preferences for housing are usually expected to be attracted to housing programs, complicating the comparison of participants and nonparticipants. While this is certainly true under a program that reduces the price of housing without any restrictions on the household's choices, this need not be the case for current United States housing programs. Figure 4 illustrates the issue for the place-based program in Figure 2.

In this diagram, three families with identical incomes are offered the bundle *g* under a housing assistance program. Their income expansion paths (consistent with Stone-Geary preferences) show that the household with the weakest preferences, denoted γ_h^{weak}, receives the largest benefit from participating (B_{weak} in the diagram). The household with the strongest preference for housing, γ_h^{strong}, values the in-kind housing assistance the least of the three families. In the diagram, B_{strong} is equal to zero.[6]

Because of the relationship between household preferences and a household's valuation of the program, self selection plays an important role in determining the aggregate effects of the programs. However, self selection alone does not determine participation. Households that apply for housing assistance are also subjected to administrative selection because assistance is severely rationed. Since the inception of federal housing assistance, certain types of households have been targeted to receive the bulk of program resources because they have been deemed as having the greatest "need" for housing assistance. For example, in 1983, Congress established priority admission housing programs for "...families that occupy substandard housing (including families that are homeless or living in a shelter for homeless families), are paying more than 50 percent of their family income for rent, or are involuntarily displaced at the time they are seeking assistance under this section..."[7] A low-income family falling into one or more of these categories is said to qualify for federal preferences with respect to admission.[8] Nearly all of the federally subsidized housing programs direct the majority of aid to households that qualify for federal preferences or households whose heads are elderly or handicapped.[9]

Local housing authorities may also set "local" preference criteria for admission, allowing a housing authority to select households which may not have the most severe need for housing but who will provide a more heterogeneous community. In 1987, HUD allowed 10 percent of new admissions to be made solely on these preferences.[10]

The effect of administrative selection on the distribution of participant preferences is ambiguous. For example, consider the case where households with below average tastes for housing sign up for assistance. These households are represented in Figure 5 as those having income-expansion paths between the γ_h^{avg} and $\gamma_h^{weakest}$ lines. Since program resources are severely limited, the housing authority must ration the available units among these applicants.

Suppose the applicants with the strongest tastes for housing are chosen by the program administrators and a small portion of all applicants are served by the program. These households are represented in the shaded area along the γ_h^{avg} line, and the mean of their preferences will be very close to the mean preferences of all nonparticipants. In this case, self-selection bias is negligible. On the other hand, if the applicants with the weakest tastes are selected, these households are represented by the shaded area along the $\gamma_h^{weakest}$ line, the selection bias will be very significant in the parameter estimates because this group is too far from the mean population preferences. An interesting feature of the federal preferences mandated by Congress is that they are directed at households of both seemingly high preferences for housing (those with high rent burdens) and low preferences for housing (those occupying dilapidated units).

The Estimation Problem and Previous Research

Researchers need to obtain estimates of the preferences of participating households in order to estimate accurately the consumption changes and other welfare effects of the programs. This is difficult to do because almost all of the data sets currently available for housing (and other assistance program) studies, including the AHS, consist of a single cross-section in which the private market choices (*m*) of nonparticipants and the program consumption bundles (*g*) of participants are observed. However, the private market choices of participants prior to their entering a housing program, which would provide direct evidence on their preferences, are not observed. To solve the data problem, participants are often assumed to have the same mean preferences as nonparticipants with identical characteristics. Estimates of household preferences are then obtained using data on nonparticipants alone.

The major studies that estimate housing program benefits in this way are Olsen (1972), DeSalvo (1975), Kraft and Olsen (1977), Olsen and Barton (1983). The basic methodologies used in these studies, particularly Olsen and Barton (1983), are hereafter referred to as the "traditional" approach.

Improvements in the traditional approach were introduced by Bierman (1985), Reeder (1985), and Olsen and Bierman (1992), who corrected for self-selection bias.[11] Reeder (1985) had data on participants both before and after they entered the Section 8 Certificate program in 1976, so his estimates of participant preferences are free from self-selection effects. Olsen and Bierman (1992) used the two-step procedure of Heckman (1976, 1979) and found that self selection causes a negative bias of only about 5 percent in the estimation of mean benefit, but they did not compute the change in housing consumption induced by the program. None of the above studies modeled administrative selection, although it is discussed in Olsen and Barton (1983), Bierman (1985), and Olsen and Bierman (1992).

In each of these studies, estimates of mean benefit and consumption changes were calculated by directly substituting the estimated mean preference parameters of these households into the appropriate formulae.[12] However, the benefit formulas are not linear in the preference parameters. Even when consistent mean parameter estimates of participant preferences are substituted, the result is an estimate of the benefit to a family with average preferences. Due to the nonlinearity, this is not the mean benefit over all participating families. It is in this sense that end-stage aggregation bias is present in many previous studies; for the benefit formula used in Olsen and Barton (1983) and Reeder (1985), the bias overstates the benefits of the programs to participants.[13]

The Economic Model

Following many previous studies of housing programs, each household is assumed to have preferences represented by the Stone-Geary utility function. For family *i*, this utility function is

$$U_i = \left(Q_{h,i} - \beta_{h,i}\right)^{\gamma_{h,i}} \left(Q_{x,i} - \beta_{x,i}\right)^{1-\gamma_{h,i}}, \tag{1}$$

where $Q_{h,i}$ and $Q_{x,i}$ are the quantities of housing and other goods consumed. The indifference parameter $\gamma_{h,i}$ is the marginal propensity to spend on housing for a household facing a linear budget constraint. The parameters $\beta_{h,i}$ and $\beta_{x,i}$ are displacement parameters, which are permitted to vary with respect to observed characteristics $X_{\beta,i}$ according to

$$\beta_{h,i} = X_{\beta,i}\,\psi_h, \tag{2a}$$

and

$$\beta_{x,i} = X_{\beta,i}\psi_x . \tag{2b}$$

From the first order conditions of utility maximization subject to a linear budget constraint, the demand equations for housing and all other goods are given by[14]

$$Q_{h,i} = \left[P_h \beta_{h,i} + \gamma_{h,i}\left(Y_i - P_h \beta_{h,i} - P_x \beta_{x,i}\right)\right] / P_h \tag{3a}$$

and

$$Q_{x,i} = \left[P_x \beta_{x,i} + \left(1 - \gamma_{h,i}\right)\left(Y_i - P_h \beta_{h,i} - P_x \beta_{x,i}\right)\right] / P_x . \tag{3b}$$

To capture heterogeneity in preferences across households, $\gamma_{h,i}$ is assumed to vary with observed household characteristics, $X_{1,i}$, and an unobserved disturbance, $\epsilon_{1,i}$. However, for (1) to be a well-behaved utility function, $\gamma_{h,i}$ is restricted to lie in the range [0, 1]. A convenient way to impose this restriction on $\gamma_{h,i}$ without placing severe restrictions on the support of $\epsilon_{1,i}$ is via the relation

$$\gamma_{h,i} = \frac{\exp\left(X_{1,i}\psi_1 + \epsilon_{1,i}\right)}{1 + \exp\left(X_{1,i}\psi_1 + \epsilon_{1,i}\right)} . \tag{4}$$

Inserting the specifications of $\gamma_{h,i}$, $\beta_{h,i}$, and $\beta_{x,i}$ into the housing demand equation (3a) and solving for $\epsilon_{1,i}$ yields

$$\epsilon_{1,i} = \ln\left[P_h \left(Q^m_{h,i} - X_{\beta,i}\psi_h \right)\right] - \ln\left(Y_i - P_h Q^m_{h,i} - X_{\beta,i}\psi_x P_x \right) - X_{1,i}\psi_1 . \tag{5}$$

In the absence of selection effects, the parameter vectors ψ_1, ψ_h, and ψ_x could be estimated from equation (5) by maximum likelihood with an appropriate assumption about the distribution of $\epsilon_{1,i}$. However, the reason some families do not seek assistance is because the expected benefit of participating is less than the expected cost. Specifically, the families' expected benefit of being in the program is less than their expected out-of-pocket application and moving costs and the stigma cost of being in the public assistance program. For family *i*, the net expected benefit of applying for assistance taken over all program units *g* is

$$y_{2,i} = \underset{\{g\}}{E}\left\{\max\left[B\left(Q^g_{h,i},\ Q^g_{x,i}\right) - C_i,\ 0\right]\right\}, \tag{6}$$

where the C_i are the total participation costs for the household.[15] The expectation is taken over all possible program units suitable for this family's size. For those units where the net benefit to the family is negative, the household would choose not to accept the offer, and the benefit would be zero.[16] If $y_{2,i} \geq 0$, the family signs up for assistance.

The household's net benefit from participation is approximated by a linear function of household characteristics $X_{2,i}$ and $\epsilon_{2,i}$, an unobserved disturbance. Specifically,

$$y_{2,i} = X_{2,i}\psi_2 + \epsilon_{2,i}. \tag{7}$$

Once households have applied for assistance, the local housing authorities choose from among the eligible applicants according to a priority-ranked waiting list. A household's priority ranking is determined by the number of points (the priority score) the family receives based on its qualifications for federal and local preferences and specific priority weights for these preferences. By defining W_i as the family's priority score and τ_j as the minimum number of points necessary for family *i* to be offered assistance in location *j*, the family's net priority score is given by

$$y_{3,i} = W_i - \tau_j. \tag{8}$$

If $y_{3,i} \geq 0$, the family is offered assistance.

Although each public housing authority has its own cardinal weighting function for allocating priority on its waiting list, all housing authorities use approximately the same ordinal ranking for federal and local preferences. Therefore, a household's net priority on the waiting list in city *j* is given by

$$y_{3,i} = X_{3,i}\psi_3 - \tau_j + \epsilon_{3,i}, \tag{9}$$

where $X_{3,i}$ is a vector of household characteristics and $\epsilon_{3,i}$ is an unobserved disturbance.[17]

The parameters of interest—housing demand parameter vectors ψ_1, ψ_h, and ψ_x from equation (5), ψ_2 from the self-selection equation (7), and ψ_3 and τ_i from the administrative-selection equation (9)—are estimated via maximum likelihood under the assumption that the unobserved disturbances $\mathrm{E} = (\epsilon_{1,i},\ \epsilon_{2,i},\ \epsilon_{3ii})'$ are independently and identically distributed normally with

$$E(\mathrm{E}) = \mathbf{0}, \quad \text{and} \quad \Sigma = E(\mathrm{E}'\mathrm{E}) = \begin{pmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & 1 & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & 1 \end{pmatrix}.$$

Because $y_{2,i}$ and $y_{3,i}$ are specified as linear functions and the actual values are not observed, only the ratios of the parameters in ψ_2 to σ_{22} and in ψ_3 to σ_{33} are identified. Therefore, without loss of generality, the variances of σ_{22} and σ_{33} are normalized to one.

A household's consumption choice in the private market is observed only if a family is not receiving any housing assistance. This occurs when either $y_{2,i} < 0$ or $y_{3,i} < 0$. If the household does not participate, it is not known which selection decision prevents the family from being in the program.[18] Therefore, let ξ_i denote whether a household participates in a housing program, where $\xi_i = 1$ if a household participates and $\xi_i = 0$ if it does not. If $\xi_i = 1$, it must be true that both $y_{2,i} \geq 0$ and $y_{3,i} \geq 0$.

The likelihood function is composed of two parts, one representing the contributions of participants and the other representing nonparticipants. The likelihood contribution of a household that chooses a unit in the private housing market is the likelihood of observing that particular consumption choice given that the household did not seek assistance or was turned down times the probability the household did not make it through the admittance process. The likelihood contribution for a participating family is the probability that it applied for assistance and was accepted. The full likelihood function for the sample of eligible households is the product of these contributions:

$$\mathfrak{L} = \prod_{i=1}^{n} \left[n_1\left(\epsilon_{1,i} \mid y_{2,i} < 0 \cup y_{3,i} < 0\right) \cdot pr\left(y_{2,i} < 0 \cup y_{3,i} < 0\right)\right]^{1-\xi_i} \times \left[pr\left(y_{2,i} \geq 0 \cap y_{3,i} \geq 0\right)\right]^{\xi_i}, \tag{10}$$

where $n_1(\bullet)$ denotes the unstandardized univariate normal density function.[19]

The integral form for the likelihood contribution for a subsidized household is given by

$$\mathfrak{L}_{\xi_i = 1} = \int_0^\infty \int_0^\infty n_2\left(y_{2,i}, y_{3,i}\right) dy_{2,i}\, dy_{3,i}, \tag{11}$$

and standardizing the arguments results in

$$\mathfrak{L}_{\xi_i = 1} = \int_{\frac{-X_{3,i}\psi_3 + \tau_i}{\sigma_3}}^{\infty} \int_{\frac{-X_{2,i}\psi_2}{\sigma_2}}^{\infty} \phi\left(z_{2,i}, z_{3,i}\right) dz_{2,i}\, dz_{3,i}. \tag{12}$$

For the likelihood contribution of unsubsidized households given in equation (10), Ω_{23} is defined as the region in $\mathbb{R}^2$ where $y_{2,i} < 0$ or $y_{3,i} < 0$. Since $y_{2,i}$ and $y_{3,i}$ are also normally distributed random variables, the integral form of the first term in equation (10) can be written as

$$\mathfrak{L}_{\xi_i = 0} = \frac{\iint_{\Omega_{23}} n_3\left(\epsilon_{1,i}, y_{2,i}, y_{3,i}\right) dy_{2,i}\, dy_{3,i}}{\iint_{\Omega_{23}} n_2\left(y_{2,i}, y_{3,i}\right) dy_{2,i}\, dy_{3,i}} \cdot \iint_{\Omega_{23}} n_2\left(y_{2,i}, y_{3,i}\right) dy_{2,i}\, dy_{3,i}$$

$$= \iint_{\Omega_{23}} n_3\left(\epsilon_{1,i}, y_{2,i}, y_{3,i}\right) dy_{2,i}\, dy_{3,i} \tag{13}$$

However, since $\epsilon_{1,i}$ is not part of the integration, the trivariate density may be written as a bivariate normal density in y_2 and y_3 conditional on ϵ_1 times the marginal density of ϵ_1, which is univariate normal.

$$\mathcal{L}_{\xi_i=0} = n_1(\epsilon_{1,i}) \iint_{\Omega_{23}} n_2(y_{2,i}, y_{3,i} | \epsilon_{1,i}) dy_{2,i}\, dy_{3,i}. \tag{14}$$

For any particular value of $\epsilon_{1,i}$, the conditional density of $y_{2,i}$ and $y_{3,i}$ must integrate to 1 over the support of y_2 and y_3. Therefore, the double integral of the conditional probability over the region Ω_{23} is equal to 1 minus the double integral over the region where $y_{2,i} \geq 0$ and $y_{3,i} \geq 0$. Thus,

$$\mathcal{L}_{\xi_i=0} = n_1(\epsilon_{1,i}) \left[1 - \int_0^\infty \int_0^\infty n_2(y_{2,i}, y_{3,i} | \epsilon_{1,i}) dy_{2,i}\, dy_{3,i} \right]. \tag{15}$$

The means of the conditional distribution of $y_{2,i}$ and $y_{3,i}$ given $\epsilon_{1,i}$ are $M = (\mu_{2,i}, \mu_{3,i})'$ with variance-covariance matrix $\boldsymbol{V}$, where

$$\mathrm{M} = \begin{pmatrix} \mu_{2,i} \\ \mu_{3,i} \end{pmatrix} = \begin{pmatrix} X_{2,i}\psi_2 + \sigma_{12}\epsilon_{1,i} \\ X_{3,i}\psi_3 - \tau_i + \sigma_{13}\epsilon_{1,i} \end{pmatrix}, \quad \text{and}$$

Standardizing the arguments of the integrals results in the final form of the likelihood function:

$$\mathcal{L} = \prod_{i=1}^{n} \left\{ n_1(\epsilon_{1,i}) \left[1 - \int_{\frac{-\mu_{3,i}}{v_{3,i}}}^{\infty} \int_{\frac{-\mu_{2,i}}{v_{2,i}}}^{\infty} \phi(z_{2,i}, z_{3,i}) dz_{2,i}\, dz_{3,i} \right] \right\}^{1-\xi_i} \times \left[\int_{\frac{-X_{3,i}\psi_3 + \tau_i}{\sigma_3}}^{\infty} \int_{\frac{-X_{2,i}\psi_2}{\sigma_2}}^{\infty} \phi(z_{2,i}, z_{3,i}) dz_{2,i}\, dz_{3,i} \right]^{\xi_i}. \tag{16}$$

Maximizing this function with respect to the parameter vectors ψ_1, ψ_2, ψ_3, ψ_h, ψ_x, τ, and the variance-covariance matrix, Σ, of the disturbance vector E produces estimates which are, conditional on $X_{\mathrm{i}} = \{X_{1,i}, X_{2,i}, X_{3,i}, X_{\beta,i}\}$, consistent, asymptotically normally distributed, and asymptotically efficient.

The Data

The primary data source for this study is the 1987 American Housing Survey (AHS) Metropolitan File, which provides data on roughly 4,500 rental units in Atlanta, Baltimore, Chicago, Columbus, Hartford, Houston, Newark, San Diego, Seattle, and St. Louis.[20] About one-fifth of the observations are on subsidized units.

The AHS contains demographic information about the occupants, including the gender, age, race, marital status, and education of household members, the household's labor and total nonlabor income, and the sources of the non-labor income the family receives, including whether someone in the household receives food stamps, welfare, Social Security, or unemployment benefits. With the exception of food stamps, these benefit amounts are included in the reported non-wage income.

Empirical studies suggest that the Food Stamp Program is equivalent to a program of cash grants for almost all of its recipients (Love 1978; Moffitt 1989). For this study, the Food Stamp program is also treated as if it is an unrestricted cash grant by imputing the value of the household's allotment based on program guidelines and the household's reported income and size.[21]

The sample is limited to eligible households using the income eligibility limits set by HUD for each locality. For a family of four, the low-income limit is typically 80 percent of the area median, and the very-low-income limit is set at 50 percent of the area median. Adjustments are made for family size and for locations with very high average rent-to-income ratios.[22] Since the data do not identify the deductions needed to calculate net household income, the total household income is used to determine eligibility based on the low-income criterion.

For each household in the sample, only its current status with regard to program participation is observed. Thus, if a family receives a housing subsidy, its consumption choice in the private housing market is not observed. For the unsubsidized households, no information is provided about whether they have never applied for housing assistance, recently applied and are on a waiting list, or applied in the past and were turned down by the housing authority.

The AHS contains some information on the previous unit occupied by the head of household. Specifically, the primary reason why the household last moved is provided. Among the reasons listed are federal preference categories, such as whether the family was displaced by government action or natural disaster, or if the unit was condemned by a government agency (substandard housing). Thus, it is possible to identify families who may have qualified for federal preferences.

In addition to the data needed for the estimation, it is necessary to know consumption bundles under the program to compute the benefit of the program to participating households and the program's effect on their consumption patterns. Neither the market value of housing services nor of the other goods consumed is directly observed in the AHS. However, both can be imputed. The consumption of nonhousing goods is imputed by taking total household income minus the reported rent paid.[23]

For subsidized households, reported rent does not equal the market rent. Since the amount of the housing subsidy is not reported in the AHS, the market rent must be imputed from a hedonic equation relating unit characteristics to their market value. The estimation of the market rents using data on unsubsidized units is described in Appendix A.[24]

Although it is known whether a household lives in a publicly owned housing project or in an otherwise subsidized unit, the exact program providing the subsidy is not known. Furthermore, nearly all programs use the federal preferences as the major selection criteria. Therefore, in this study all housing subsidies are treated as though they were provided by a single federal program.[25]

Table 1 provides descriptive statistics for all variables used in the parameter estimation and welfare analysis.. In this sample, there are 3,506 observations on eligible families in the ten cities, of which 24 percent live in a federally subsidized unit. The average income of subsidized households in the sample is \$7,682, and the average income of unsubsidized households is \$9,351. In general, subsidized households have a higher proportion of female heads, a higher proportion of unmarried heads, two years less education, and higher participation rates in Food Stamps and welfare than unsubsidized households.

The only information necessary for estimating the preference parameters of the model that is not provided by the AHS directly or by imputation is that on the relative prices of the two composite goods. The price indices data are from the American Chamber of Commerce Researcher's Association (ACCRA) *Cost of Living Index*. The indices include the prices of a composite good and of new two-bedroom apartments. The prices used in this study are taken from the fourth quarter of 1987 and are provided at the end of Table 1.

Estimation Results

Maximum Likelihood Estimates of Model Parameters

Table 2 reports the maximum likelihood estimates of the parameter vectors ψ_1, ψ_2, ψ_3, ψ_h, ψ_x, τ, and the covariance matrix, Σ. The estimates of ψ_1, which describe variation in the marginal propensity to spend on housing, $\gamma_{h,i}$, show that households whose heads are white, Asian, older, or better educated have stronger preferences for housing services, while larger households have weaker preferences. Since housing services encompass both size and quality characteristics, the signs on the parameters do not necessarily indicate the size of apartment the family prefers.

Households with stronger preferences for housing are more likely to self-select into a housing program. This result is shown by the parameter estimates of ψ_1 from equation (5) which are related to housing demand, the parameter estimates of ψ_2 from the self-selection equation (7), and the estimated covariance, between $\epsilon_{1,i}$ and $\epsilon_{2,i}$, σ_{12}. The implied correlation between $\epsilon_{1,i}$ and $\epsilon_{2,i}$ from the estimates of the covariance matrix, Σ, is $\rho_{12} = 0.86$.

The self-selection equation estimates also indicate that multiple program participation has a significant positive effect on whether the household seeks assistance and that elderly households, towards whom a disproportionate amount of resources are targeted, have a higher probability of applying for assistance. Educational attainment and income both have a significant and negative effect on the household's application probability. Better educated households and those with more income may have higher opportunity costs of participation or larger stigma costs, while those who are already participating in assistance programs may have lower costs.

The estimate for the correlation between the self-selection outcome and the housing authority's decision, ρ_{23}, is 0.971, which indicates that households with higher benefits from participating tend to be those that are selected. These are households for whom the program bundle *g* is very close to their income-expansion path, which was illustrated in Figure 4 for households with weak preferences. Also supporting this result is the estimate of the correlation between the household's preferences for housing and the housing authority's decision, ρ_{13}, which is 0.935.

The Preferences for Participants

The estimates from the previous section pertain to the whole population of eligible households. The distribution of participant preferences is obtained by simulating draws from a trivariate normal distribution with means of zero and covariance matrix $\hat{\Sigma}$. These draws are then used to determine whether the simulated households are participants based upon the outcomes of the selection equations (7) and (9).

Specifically, for each observed subsidized household *i*, a draw of $\mathrm{E} \sim N\left(0, \hat{\Sigma}\right)$ is made. The values of $\epsilon_{2,i}$ and $\epsilon_{3,i}$ are used with the maximum likelihood estimates of ψ_2, ψ_3, and τ_i to calculate $\hat{y}_{2,i}$ and $\hat{y}_{3,i}$. If both $\hat{y}_{2,i} > 0$ and $\hat{y}_{3,i} > 0$, the simulated household is considered a participant, and $\hat{\gamma}_{h,i,j}$ is calculated, where $j = 1,\ldots,J$ denotes simulated participating households of type i. For J = 100, the mean value of $\hat{\gamma}_{h,i,j}$ is 0.053, which implies that households spend 5.3 percent of each additional dollar of disposable income on housing services.[26] This value and the values of the other utility function parameters are reported at the end of Table 2, along with the standard deviations of the simulated estimates. The mean value of $\hat{\beta}_h$ is -20.71 and of $\hat{\beta}_x$ is -1241.64; both are statistically different from zero.[27]

The effects of housing assistance are calculated by taking the average of a specific effect, such as the average benefit, over all simulated participating households. Using the simulated distribution of the preferences of participants in this way avoids aggregation bias in the welfare estimates.

The Program Effects and Model Specification Effects

Table 3 shows various measures of the effects of housing programs on participants. Consider the first row which shows that the mean rent paid by participants is $238 per year, the result of a mean subsidy to participants of $4,682. (Hence, the mean market value of the units participants occupy is $4,927.) Referring specifically to the first column of numbers in the table, in the absence of any government housing assistance, participating households would spend an estimated $4,532 on housing. Thus, housing programs lead households to consume more housing. However, the aggregate effect is quite small, since the aggregate increase in housing consumption, measured as the percentage change in the mean consumption of housing services under the program and in its absence, or

$$\%\Delta Q_h^{m,g} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{J} Q_{h,i,j}^{m} - J\sum_{i=1}^{n} Q_{h,i}^{g}}{\sum_{i=1}^{n}\sum_{j=1}^{J} Q_{h,i,j}^{m}} \cdot 100. \qquad (17)$$

is only 4.43 percent. With reference to Figures 1, 2, and 3, this is the percentage change in the average horizontal distance between points m and g. Since equation (17) is based on real consumption rather than expenditures, the aggregate percentage change is not directly calculable from mean expenditure amounts.

If the current system of housing subsidies were replaced with a program of unrestricted cash grants equal to the subsidies currently paid, aggregate housing consumption would actually increase 0.4 percentage points from the current program estimate to 4.85 percent above the level of housing consumption of participants in the absence of assistance.[28] This value is the percentage change in the average horizontal distance between points *m* and *s* in Figures 1, 2, and 3.

The finding that aggregate housing consumption rises when the current system of housing assistance is replaced by with a cash grant program is consistent with the analytics of housing assistance shown in the figures if the income-expansion path for households is to the right of the point *g*. Furthermore, the estimated change in nonhousing consumption implies that the point *g* is vertically higher than both points *m* and *s*. The aggregate increase in nonhousing consumption under current housing programs is 141 percent (a comparison of the vertical distance between points *m* and *g)*. Under the hypothetical unrestricted cash grant program, the increase in aggregate nonhousing consumption is only 107 percent greater than the consumption level in the absence of assistance (a comparison of the vertical distance between points *m* and *s*).

In Figures 2 and 3, it was shown that households may decrease housing consumption under housing assistance programs. Indeed, 42 percent of participants decrease their consumption of housing from what they would choose in the absence of assistance. Thus, even though the aggregate change in housing consumption is positive, a large number of households are induced to consume less housing under programs which were established to do the very opposite.

The estimates of the aggregate effects on housing consumption show clearly that the main effect of housing assistance is increased consumption of nonhousing goods and services. This outcome is consistent with the federal priority established in 1983 of reducing rent burdens but the outcome is inconsistent with the initial federal goals of improving housing conditions for low-income households. Thus, the estimates show, in the terminology of Aaron (1981), that housing assistance programs indeed are not housing programs. To place these estimates in a more general context, of the more than $18 billion in annual expenditures on housing subsidies, only 24 percent is allocated towards increased housing consumption by participants, an amount equal to about $175 per participating household. Yet, the welfare loss for participants from providing housing assistance in-kind is quite small. The value of the program to participants is calculated using an equivalent variation measure of the benefits households receive from participation, which is

$$B\left(Q_{h,i}^{g}, Q_{x,i}^{g}\right) = \left(\frac{P_{h,i}Q_{h,i}^{g} - P_{h,i}\beta_{h,i}}{\gamma_{h,i}}\right)^{\gamma_{h,i}} \left(\frac{P_{x,i}Q_{x,i}^{g} - P_{x,i}\beta_{x,i}}{1 - \gamma_{h,i}}\right)^{1-\gamma_{h,i}} + P_{h,i}\beta_{h,i} + P_{x,i}\beta_{x,i} - \qquad (18)$$

for the utility function specified in equation (1). This is the difference between the expenditure necessary at unsubsidized prices to attain the level of well-being obtained under the housing program and the household's expenditures in the absence of the program. The mean benefit to participating households is $4,338, which, when compared to the mean annual subsidy amount, suggests participating households value the consumption bundle they receive under the program at roughly 91 cents on the dollar.[29]

The second column of numbers in Table 3 shows the results using the traditional model, which does not correct for self or administrative selection or aggregation bias (see Appendix B), on same data. The traditional model overestimates the effects of housing assistance on housing consumption. Under that model, households are shown to increase aggregate housing consumption by 22.94 percent under current housing programs. The traditional model estimate for the increase in housing consumption under an unrestricted cash grant program from what households would consume in the absence of assistance is 29.62 percent. The estimated changes in nonhousing goods consumption are underestimated under the traditional model at 102 percent and 95 percent increases for the current system of housing assistance and the hypothetical cash grant program respectively. In each case, the estimate is statistically different from the corrected estimate.

Interestingly, while the composition is quite different, the mean benefit estimate is not statistically different from the corrected model estimate, although it is larger at $4,500. The nonlinearity of the benefit function with respect to the preference parameters makes it seem as though the selection and aggregation biases are negligible, but, the large disparity shown above in the consumption change estimates between the new model and the traditional model illustrate the impact of model specification. However, the consumption change estimates are not affected by aggregation bias in the preference parameters.[30] The mean benefit to participants when estimated using mean preferences rather than the distribution of preferences changes to $4,851 (showing a bias of 11.8 percent) which is statistically different from the nonaggregated estimate (t-ratio of 2.33) and the traditional estimate (t-ratio of 2.02). Thus while model specification is certainly important, aggregation bias is significant in some estimates of program effects.

Conclusion

Housing assistance programs have the potential for either a positive or adverse effect on the achievement of better housing for participating households. The estimates provided here show adverse effects on housing consumption under the program for some households, but an aggregate positive effect. The current system of low-income housing assistance offers households slightly better housing than they would otherwise choose in the absence of such assistance and attracts households with relatively strong preferences for housing who find the value of participation to be quite large. However, the participation value to households is large not because of the increase in housing consumption but because of the sizeable increase in consumption of other goods and services. That is, the largest effect of housing programs is to provide more of other goods to participants. This result is consistent with the more recent trend in housing policy which is to reduce housing costs, implying that households do not consume enough of other goods.

A policy implication is that the direct public provision of housing is a poor instrument for improving the housing situation of participating families. The provision of subsidies via housing allowances would achieve approximately the same increase in the housing consumption of participating families without, presumably, the production and allocation inefficiencies that exist in the current system. Greater increases in housing consumption could possibly be achieved with stronger restrictions on the minimum quality for the units a household may choose under a voucher type program.

The estimates also demonstrate the importance of model specification. Using a model similar to those employed in many previous studies, selection and aggregation bias were shown to be significant, and that the biases cause an overstatement of program effects on housing consumption and the value of the program to participants and an understatement of the changes in nonhousing consumption. Finally, the model presented here reconciles the disparity in previous studies by providing a method by which reliable estimates may be obtained from nonexperimental data.

Appendix A

The AHS reports extremely detailed information about unit characteristics, such as its rent, size, interior and exterior condition, and neighborhood characteristics. For the hedonic estimates, observations are excluded if the unit is owner-occupied, rented for noncash rent, has a reported rent of zero, is subsidized by a federal, state, or local housing assistance program, or under rent control. Observations are also excluded if any of the characteristic variables are missing for the unit.

The optimal functional form for the hedonic rent equations is widely debated in the housing hedonics literature. Linneman (1980), Halvorsen and Pollakowski (1981), and Blackley, Follain, and Ondrich (1984) recommend using variations of the Box-Cox transformation to find a "best" fit in the sense of both minimum mean squared error over a large class of functional forms and ease of estimation. The most commonly used model in housing studies is the semi-log transformation where the log of rent is regressed against untransformed characteristic variables (for example, see Butler 1982; Thibodeau 1989, 1992; and Linneman 1980). However, while this method generally provides the smallest mean squared error among the limit cases of the Box-Cox model, the mean inverted rent estimates, conditional on unit characteristics, are biased (Cassel and Mendelsohn 1985; Goldberger 1968; Thibodeau 1989, 1992). Goldberger suggests a correction for the bias at the mean under the assumption of normally distributed error terms. The imputed rent estimates in this paper use the semi-log specification with Goldberger's correction.

Separate hedonic regressions are estimated for the ten cities and are available from the author upon request.

Appendix B

The Traditional Model of Housing Demand

As was noted in the description of the data, the market choices of subsidized households in the absence of program assistance are not observed. The traditional approach to estimating the indifference map parameters solves this data problem with the assumption that the distribution of preferences for subsidized and unsubsidized households are identical, conditional on their observed characteristics. This assumption means that both the self and administrative selection may be ignored. The estimation problem is thus reduced to how to estimate the parameters of the housing demand equation. The model described below is that of Olsen and Barton (1983) slightly modified to take advantage of data from multiple MSAs.

Explanation of the Econometric Model

With the assumption above, household preferences can be estimated using the observed behavior of nonparticipants to estimate the housing demand equation given in (3a). The implied rent-to-income ratio (RIR) from equation (3a) is

$$RIR_i = \frac{P_{h,i} Q^m_{h,i}}{Y_i} = \gamma_{h,i} + \left(1 - \gamma_{h,i}\right)\frac{\beta_{h,i} P_{h,i}}{Y_i} - \gamma_{h,i} \frac{\beta_{x,i} P_{x,i}}{Y_i} . \tag{B1}$$

The displacement parameters $\beta_{h,i}$ and $\beta_{x,i}$ are assumed to vary only with respect to observed household characteristics so that conditional on these characteristics,

$$\beta_{h,i} = \beta_h \tag{B2a}$$

and

$$\beta_{x,i} = \beta_x . \tag{B2b}$$

The parameter $\gamma_{h,i}$ is assumed to vary with observed characteristics and an unobserved disturbance according to

$$\gamma_{h,i} = \gamma_h + \epsilon_i , \tag{B3}$$

where $E(\epsilon_i) = 0$ and $V(\epsilon_i) = \sigma_{\epsilon\epsilon}$. It is also assumed that ϵ_i is independent of Y_i, $P_{h,i}$, and $P_{x,i}$. Inserting the specifications of $\gamma_{h,i}$, $\beta_{h,i}$, and $\beta_{x,i}$ into equation (B1) produces the regression equation

$$RIR_i = \gamma_h + \left(1 - \gamma_h\right)\frac{\beta_h P_{h,i}}{Y_i} - \gamma_h \frac{\beta_x P_{x,i}}{Y_i} + \left[1 - \frac{\beta_h P_{h,i}}{Y_i} - \frac{\beta_x P_{x,i}}{Y_i}\right]\epsilon_i . \tag{B4}$$

If α_0, α_1, and α_2 are defined such that $\alpha_0 = \gamma_h$, $\alpha_1 = (1\text{-}\gamma_h)\beta_h$, and $\alpha_2 = \text{-}\gamma_h\beta_x$, and

$$u_i = \left[1 - \frac{\beta_h P_{h,i}}{Y_i} - \frac{\beta_x P_{x,i}}{Y_i}\right]\epsilon_i , \tag{B5}$$

where $E(u_\mathrm{i}) = 0$ and $V(u_\mathrm{i}) = \sigma_{uu,i}$, then, for simplicity, (B4) can be rewritten as

$$RIR_i = \alpha_0 + \alpha_1 \frac{P_{h,i}}{Y_i} + \alpha_2 \frac{P_{x,i}}{Y_i} + u_i . \tag{B6}$$

Using least squares estimation on (B6) provides consistent estimates of the three preference parameters, but due to the interaction of income and prices with the disturbance in (B4), the estimates are inefficient. The fact that the variance of u_i is not constant leads to biased estimates of the standard errors of the estimated parameters. However, this bias is corrected easily using weighted least squares. The variation in preferences by observed household characteristics is introduced by estimating a separate regression for each household type. For this study, 20 family types are used based on race, marital status, and age of the household head and the household size. Table B1 presents the results of the weighted least squares estimation for the family groups.

Letting s_j denote the standard deviation of α_j, j=0,1,2. The reported standard errors for the model parameters γ_h, β_h, and β_x are calculated according to the formulas

$$s_{\gamma_h} = s_0 , \tag{B7}$$

$$s_{\beta_h} = \left[\left(\frac{1}{1 - \hat{\alpha}_0} \right)^2 s_1^2 + \left(\frac{\hat{\alpha}_1}{(1 - \hat{\alpha}_0)^2} \right)^2 s_0^2 + \frac{2\,\hat{\alpha}_1}{(1 - \hat{\alpha}_0)^3} cov\left(\hat{\alpha}_0,\ \hat{\alpha}_1\right) \right]^{1/2}, \tag{B8}$$

and

$$s_{\beta_x} = \left[\left(\frac{-1}{\hat{\alpha}_0} \right)^2 s_2^2 + \left(\frac{\hat{\alpha}_2}{\hat{\alpha}_0^2} \right)^2 s_0^2 - \frac{2\,\hat{\alpha}_2}{\hat{\alpha}_0^3} cov\left(\hat{\alpha}_0,\ \hat{\alpha}_2\right) \right]^{1/2}. \tag{B9}$$

The estimates of program effects presented in Table 3 are calculated by substituting the values of γ_h, β_h, and β_x for each household directly into the appropriate formulae. Even though different parameters are used for different households, depending on their type, aggregation bias is still present since within each group there still exists unobserved heterogeneity. The resulting estimates of mean program effects are therefore the mean effects of the program on households with the mean preferences of households within their respective groups.

Table B-1. Estimates of Model Parameters from Traditional Model

Family Characteristics[a]	$\alpha_0 = \gamma_h$	α_1	α_2	$\beta_h = \alpha_1/(1-\gamma_h)$	$\beta_x = -\alpha_2/\gamma_h$	R^2 # obs
	0.115	13.986	17.933	15.801	-156.145	0.397
W - M - A1 - S1	(0.045)	(6.413)	(7.570)	(1.968)	(15.589)	87
	0.152	0.198	33.430	0.234	-216.342	0.373
W - M - A1 - S2	(0.046)	(7.478)	(8.707)	(2.635)	(16.952)	69
	0.213	5.833	15.536	7.413	-72.924	0.211
W - M - A2 - S1	(0.061)	(9.836)	(11.730)	(1.585)	(24.151)	49
	0.149	-17.049	52.065	-20.029	-349.853	0.433
W - M - A2 - S2	(0.041)	(6.182)	(8.793)	(1.290)	(18.455)	70
	0.276	6.162	10.396	8.514	-37.633	0.232
W - M - A3 - S3	(0.039)	(4.518)	(6.492)	(1.989)	(7.845)	102
	0.318	10.752	4.326	15.772	-13.594	0.231
W - S - A1 -S1	(0.021)	(3.156)	(3.626)	(0.879)	(6.057)	322
	0.338	5.374	9.036	8.122	-26.708	0.107
W - S - A1 -S2	(0.066)	(13.529)	(15.477)	(1.122)	(25.652)	38
	0.313	11.583	2.080	16.866	-6.640	0.244
W - S - A2 -S1	(0.025)	(3.471)	(4.084)	(2.370)	(8.001)	202
	0.259	13.430	7.311	18.135	-28.184	0.173
W - S - A2 -S2	(0.068)	(8.767)	(11.056)	(2.501)	(23.417)	57
	0.312	0.961	14.147	1.396	-45.416	0.193
W - S - A3 - S3	(0.024)	(1.989)	(2.941)	(1.662)	(6.015)	343
	0.179	11.382	10.073	13.864	-56.268	0.477
NW - M - A1 - S1	(0.047)	(4.773)	(5.897)	(2.551)	(12.388)	43
	0.112	11.268	17.980	12.688	-160.601	0.435
NW - M - A1 - S2	(0.040)	(4.725)	(5.746)	(1.824)	(11.681)	62
	0.174	5.892	14.063	7.135	-80.697	0.174
NW - M - A2 - S1	(0.078)	(7.147)	(10.023)	(4.596)	(28.452)	24
	0.074	-3.663	40.683	-3.957	-547.405	0.418
NW - M - A2 - S2	(0.045)	(5.112)	(7.115)	(1.911)	(15.421)	69
	0.201	5.414	17.250	6.776	-85.824	0.116
NW - M - A3 - S3	(0.050)	(3.818)	(6.088)	(1.223)	(11.684)	46
	0.245	7.122	10.831	9.430	-44.257	0.432
NW - S - A1 - S1	(0.025)	(2.514)	(3.245)	(0.918)	(8.451)	155
	0.202	-0.935	25.037	-1.172	-123.830	0.275
NW - S - A1 - S2	(0.069)	(7.039)	(10.004)	(1.447)	(21.556)	48
	0.228	2.789	14.797	3.612	-64.952	0.343
NW - S - A2 - S1	(0.029)	(3.130)	(4.104)	(1.010)	(9.212)	135
	0.188	2.848	24.047	3.509	-127.598	0.410
NW - S - A2 - S2	(0.041)	(3.852)	(6.715)	(2.141)	(11.985)	87
	0.235	4.072	11.630	5.324	-49.439	0.290
NW - S - A3 - S3	(0.038)	(3.022)	(3.959)	(0.971)	(10.338)	117

[a]Family Characteristics are shown by categories A - B - C - D, where A denotes race of household head (W = white, NW = nonwhite), B denotes marital status of household head (M = married, S = not married), C denotes age group of household head (A1 = younger than 31 years, A2 = 31 -50 years, and A3 = 51 years or older), and D denotes household size (S1 = 1-3 persons, S2 = 4 or more persons, and S3 = all households). Standard errors of parameter estimates are given in parentheses.
Source: Author's calculations.

Appendix C

The Variance for Testing the Statistical Significance of the Difference Between Two Point Estimates

In this appendix, the formulae for the variance of the program effects provided in Table 3 are provided. These formulae are based on White (1982).

The Asymptotic Variance of a Particular Point Estimate

The point estimates in question are each a function of the $(1{\times}M)$ vector of household characteristics X_j, $j=1,\ldots,n$, and the estimated $(p{\times}1)$ parameter vector $\hat{\theta}$. Letting $g(X_j,\ \theta)$ be the function of interest (e.g., the benefit formula) for household j, and letting $\underline{g}(X,\ \theta)$ denote the $(n{\times}1)$ vector of the values of g, the estimate of the mean of this function over households is calculated as

$$E\left(g\left(X_j,\ \theta\right)\right) = \frac{1}{n}\, i^{\prime}\underline{g}\left(X,\ \hat{\theta}\right), \tag{C1}$$

where $i^{\prime}$ is an $(n{\times}1)$ vector of 1s. The likelihood function used to estimate the vector θ is denoted

$$\mathcal{L}_n^f(X,\ \theta) = \frac{1}{n}\sum_{j=1}^{n} \log f\left(X_j,\ \theta\right), \tag{C2}$$

and $\hat{\theta}$ is defined as the parameter vector that solves the problem

$$\max_{\theta \in \Theta}\ \mathcal{L}_n^f(X,\ \theta). \tag{C3}$$

According to White (1982), the variance of the mean of the function of interest is given by

$$V\left[E\left(g\left(X,\ \hat{\theta}\right)\right)\right] = i^{\prime}\underline{g}_{\theta}(X,\ \theta^{*})\,C\left(\hat{\theta}\right)\underline{g}_{\theta}(X,\ \theta^{*})^{\prime}\, i, \tag{C4}$$

where, defining the matrices

$$A(\theta) = plim\left(\frac{1}{n}\sum_{j=1}^{n} \partial^2 \log f\left(X_j,\ \theta\right)/\partial\theta\partial\theta'\right) \quad \text{and} \tag{C5}$$

$$B(\theta) = plim\left[\frac{1}{n}\sum_{j=1}^{n} \left(\partial \log f\left(X_j,\ \theta\right)/\partial\theta\right)\left(\partial \log f\left(X_j,\ \theta\right)/\partial\theta\right)'\right], \tag{C6}$$

the matrix $C(\theta)$, which is the asymptotic covariance matrix of the parameter vector θ, is defined by

$$C(\theta) = A(\theta)^{-1} B(\theta) A(\theta)^{-1}. \tag{C7}$$

Under six general assumptions, White (1982) shows that $\sqrt{n}\left(\hat{\theta}_n - \theta^*\right) \overset{A}{\sim} N\left(0,\ C(\theta^*)\right)$, and $C_n\left(\hat{\theta}_n\right) \overset{a.s.}{\rightarrow} C\left(\theta^*\right)$ element by element. However, if the underlying model is correctly specified, θ^* converges to the true value of θ, and the variance of $\hat{\theta}$ given by $C\left(\hat{\theta}\right)$ converges to $-A\left(\theta^*\right)^{-1}$. If the model is misspecified, then the appropriate variance of $\hat{\theta}$ is given by $C(\hat{\theta})$ in (C7). The reported standard errors for the estimates of θ in Table 2 are calculated using $-A\left(\hat{\theta}\right)^{-1}$ under the assumption that the primary model of the paper is correctly specified.

The Asymptotic Variance of the Difference of Two Point Estimates

As above, the likelihood contribution by household j is denoted by $f\left(X_j,\ \theta\right)$ in (C2) and the corresponding function of interest is denoted by $g\left(X_j,\ \theta\right)$. For the second specification, the likelihood contribution by household j is denoted by $h\left(X_j,\ \xi\right)$ and $\hat{\xi}$ is defined to be the $(r\times 1)$ parameter vector that solves the problem

$$\max_{\xi \in \Xi} \mathfrak{L}_n^h(X,\ \xi), \tag{C8}$$

where

$$\mathfrak{L}_n^h(X,\ \xi) = \frac{1}{n}\sum_{j=1}^{n} \log h\left(X_j,\ \xi\right). \tag{C9}$$

The function $k\left(X_j,\ \xi\right)$ denotes a second specification of the function of interest (*e.g.* again the benefit formula from the theoretical specification of the model). Then the difference in the point estimates of the means of $g\left(X_j,\ \theta\right)$ and $k\left(X_j,\ \xi\right)$ is given by

$$E\left[g\left(X_j,\ \theta\right) - k\left(X_j,\ \xi\right)\right] = \frac{1}{n} i'\left[\underline{g}(X,\ \theta) - \underline{k}(X,\ \xi)\right]. \tag{C10}$$

Then from White (1982) the asymptotic variance of this difference is given by

$$\begin{aligned} V\left(g\left(X,\ \hat{\theta}\right) - k\left(X,\ \hat{\xi}\right)\right) = i'\Big[& \underline{g}_\theta(X,\ \theta^*) C\left(\hat{\theta}\right) \underline{g}_\theta(X,\ \theta^*)' \\ & + \underline{k}_\xi(X,\ \xi^*) C\left(\hat{\xi}\right) \underline{k}_\xi(X,\ \xi^*)' + \underline{g}_\theta(X,\ \theta^*) D\left(\hat{\theta},\ \hat{\xi}\right) \underline{k}_\xi(X,\ \xi^*)' \\ & + \underline{k}_\xi(X,\ \xi^*) D\left(\hat{\xi},\ \hat{\theta}\right) \underline{g}_\theta(X,\ \theta^*)' \Big] i, \end{aligned} \tag{C11}$$

where the matrix $D(\xi,\theta)$ is the covariance matrix for the two parameter vectors. The function $\mathcal{L}_j^i(\bullet)$ is defined to be the log likelihood contribution for observation j, corresponding to the model specification with contribution function i ($i = f, h$), and $\mathcal{L}_{j,\eta}^i(\bullet)$ to be the first derivative of that contribution with respect to η, $\eta = \theta,\xi$. The second derivative of the likelihood function is similarly denoted as $\mathcal{L}_{j,\eta\eta}^i(\bullet)$. Using the notation above, the asymptotic covariance matrix between θ and ξ is given by

$$\begin{aligned} D\left(\hat{\theta},\ \hat{\xi}\right) = plim \Bigg\{ n & \left[\frac{1}{n} \sum_{j=1}^{n} \mathcal{L}_{j,\theta\theta'}^f\left(X_j,\ \theta^*\right)\right]^{-1} \left[\frac{1}{n} \sum_{j=1}^{n} \mathcal{L}_{j,\theta}^f\left(X_j,\ \theta^*\right)\right] \\ & \bullet \left[\frac{1}{n} \sum_{j=1}^{n} \mathcal{L}_{j,\xi}^h\left(X_j,\ \xi^*\right)\right]' \left[\frac{1}{n} \sum_{j=1}^{n} \mathcal{L}_{j,\xi\xi'}^h\left(X_j,\ \xi^*\right)\right]^{-1} \Bigg\}. \end{aligned} \tag{C12}$$

The terms $\text{plim}\,[\frac{1}{n}\sum_{j=1}^{n} \mathcal{L}_{1j\theta\theta'}(X_j,\ \theta^*)]$ and $\text{plim}\,[\frac{1}{n}\sum_{j=1}^{n} \mathcal{L}_{1j\xi\xi'}(X_j,\ \xi^*)]$ in (C12) are equal to $A(\hat{\theta})^{-1}$ and $A(\hat{\xi})^{-1}$ defined in equation (C5), and by independence of vector X across observations, the middle product of the sums of the first derivatives reduces such that

$$\left[\frac{1}{n}\sum_{j=1}^{n} \mathfrak{L}_{1j\theta}\left(X_j,\ \theta^*\right)\right]\left[\frac{1}{n}\sum_{j=1}^{n} \mathfrak{L}_{2j\xi}\left(X_j,\ \xi^*\right)\right]' = \frac{1}{n^2}\sum_{j=1}^{n} \mathfrak{L}_{1j\theta}\left(X_j,\ \theta^*\right)\mathfrak{L}_{2,j,\xi}\left(X_j,\ \xi^*\right). \tag{C13}$$

Then the covariance matrix between the estimated values of θ and ξ becomes

$$D\left(\hat{\theta},\ \hat{\xi}\right) = A\left(\hat{\theta}\right)^{-1} plim\left[\frac{1}{n^2}\sum_{j=1}^{n} \mathfrak{L}_{j\theta}^{f}\left(X_j,\ \hat{\theta}\right)\mathfrak{L}_{j\xi}^{h}\left(X_j,\ \hat{\xi}\right)\right]A\left(\hat{\xi}\right)^{-1}. \tag{C14}$$

Table 1. List of Variables Used in Model Estimation

Variable	Description[a]	Unsubsidized Households		Subsidized Households	
		Mean[b]	Standard Deviation	Mean[b]	Standard Deviation
INCOME	Annual household income from all sources. [c]	$9,351	$4,544	$7,691	$3,639
INCOME RATIO	Proportion of income that comes from low-income assistance programs.	0.3986	0.4497	0.7349	0.3938
RENT	Total annual market value of housing + utilities (imputed for subsidized households).	$4,939	$1,814	$4,923	$1,236
X EXPENDITURE	Expenditure on nonhousing goods	$4,412	$3,510	$7,451	$3,575
CARS	Number of cars owned by household.	0.6646	0.4722	0.3816	0.4863
FOODSTAMP	Household receives Food Stamps assistance.	0.1854	0.3887	0.4794	0.4999
WELFARE	Household receives Welfare assistance.	0.1552	0.3622	0.4746	0.4997
UNEMPLOYMENT	Household receives unemployment benefits.	0.0403	0.1967	0.1005	0.3008
SOCIAL SECURITY	Household receives Social Security benefits.	0.2466	0.4311	0.3777	0.4851
ASIAN	Head of household is Asian.	0.0272	0.1628	0.0182	0.1336
BLACK	Head of household is black.	0.2489	0.4324	0.4395	0.4966
HISPANIC	Head of household is Hispanic.	0.1041	0.3055	0.1847	0.2787
AGE	Age of the head of household.	41.572	19.269	48.516	20.649
ELDERLY	Head of household is elderly.	0.2063	0.4048	0.3402	0.4741
FEMALE	Head of household is female.	0.5560	0.4970	0.7942	0.4045
EDUCATION	Education completed by head (0 to 26 years).	13.919	6.300	11.748	5.0940
MARRIED	Head is married or has a live-in partner.	0.2604	0.4390	0.1404	0.3477
HOUSEHOLD SIZE	Size of household.	2.4709	1.4988	2.4843	1.5327
YOUNG KIDS	Number of children under six years old.	0.3090	0.6793	0.4031	0.7696
SCHOOL KIDS	Number of school children (6-12 years old).	0.2791	0.6601	0.3983	0.7659
HIGH RENT MOVE	Household’s last move was to lower rent.	0.0623	0.2418	0.1102	0.3133
DILAPIDATED	Household’s previous unit was dilapidated.	0.0653	0.2471	0.0847	0.2787
DISPLACED	Household's last move was because of displacement by government.	0.0769	0.2664	0.0557	0.2295
BEDMIN	Minimum size of unit (by bedrooms) for household under HUD standards. [d]	1.4664	0.8512	1.5993	0.9148
BEDMAX	Maximum size of unit (by bedrooms) for household under HUD standards. [d]	2.4724	1.1446	2.7349	1.2966
ATLANTA	Household lives in Atlanta.	0.0675	0.2510	0.0981	0.2976
BALTIMORE	Household lives in Baltimore.	0.0996	0.3000	0.1404	0.3476
CHICAGO	Household lives in Chicago.	0.1153	0.3194	0.1065	0.3087
COLUMBUS	Household lives in Columbus.	0.1041	0.3054	0.0908	0.2875
HARTFORD	Household lives in Hartford.	0.0743	0.2622	0.1659	0.3722
HOUSTON	Household lives in Houston.	0.1265	0.3325	0.0375	0.1902
NEWARK	Household lives in Newark.	0.0826	0.2751	0.1042	0.3056
SANDIEGO	Household lives in San Diego.	0.1093	0.3121	0.0944	0.2926
SEATTLE	Household lives in Seattle.	0.1138	0.3176	0.0654	0.2473
STLOUIS	Household lives in St. Louis.	0.1071	0.3093	0.0968	0.2959

Table 1. Continued

City	P_h	P_x	City	P_h	P_x
Atlanta	116.04	114.89	Houston	80.57	107.81
Baltimore	107.43	105.75	Newark	197.91	123.19
Chicago	170.27	110.55	San Diego	108.21	101.06
Columbus	98.31	100.73	Seattle	112.91	107.49
Hartford	151.76	113.47	St. Louis	113.69	108.93

[a]Unless otherwise stated, all variables are dummy variables. There are 3,506 observations: are 826 program participants, 2680 are nonparticipants.

[b]Observations are excluded from the sample if: (1) The unit is owner occupied, rented for non-cash oe zero rent; (2) any of the demographic variables for the head of household or of the household are missing, or information for imputing the rent value of a subsidized unit is missing; (3) the variables indicating the household receives a rent subsidy or lives under rent control are missing; (4) the unit is under rent control; or (5) household income is higher than the 1987 low-income limit for eligibility.

[c]Includes the imputed cash value of food stamps.

[d]HUD standards require an ample number of bedrooms in the unit so that two members of opposite sex, other than the head and spouse, or very young children, should not have to share. No more than two persons are allowed to occupy a bedroom in a HUD subsidized unit. See U.S. Department of Housing and Urban Development, Office of Public and Indian Housing (1987).

Source: Author's calculations

Table 2. Maximum Likelihood Estimates of ψ_h, ψ_x, ψ_1, ψ_2, ψ_3 and Σ[a]

Variable	Coefficient	Standard Error
Estimates of ψ_h where $\beta_h = \boldsymbol{X}_\beta \psi_h$ (Equation (5))		
CONSTANT*100	-1.1972**	0.1728
ASIAN*100	-0.5211	1.4445
BLACK*100	0.2586*	0.1436
HISPANIC*100	0.4241**	0.1704
AGE*100	-0.0107**	0.0036
HOUSEHOLD SIZE*100	0.0267	0.0305
Estimates of ψ_x where $\beta_x = \boldsymbol{X}_\beta \psi_x$ (Equation (5))		
CONSTANT*100	5.2718	7.4984
ASIAN*100	1.5981	19.4457
BLACK*100	1.8492	5.1222
HISPANIC*100	4.3378	7.6779
AGE*100	-4.0213**	0.2778
HOUSEHOLD SIZE*100	-4.8164**	1.8966
Estimates of ψ_1 where $\gamma_{h,i} = \frac{\exp\left(\boldsymbol{X}_{1,i}\psi_1 + \varepsilon_{1,i}\right)}{1 + \exp\left(\boldsymbol{X}_{1,i}\psi_1 + \varepsilon_{1,i}\right)}$ (Equation (5))		
CONSTANT	-3.2553**	0.0397
ASIAN	0.1887	0.5110
BLACK	-0.2354**	0.0699
HISPANIC	-0.2677**	0.0952
AGE	-0.0373**	0.0007
AGE SQUARED/100	0.0216**	0.0011
ELDERLY	-0.0269	0.0224
FEMALE	0.0023	0.0107
EDUCATION	0.0034**	0.0008
MARRIED	0.0104	0.0137
HOUSEHOLD SIZE	0.0007	0.0192
HOUSEHOLD SIZE SQUARED	-0.0032**	0.0016
YOUNG KIDS	-0.0277**	0.0077
SCHOOL KIDS	-0.0210**	0.0071
Estimates of ψ_2 where $y_{2,i} = \boldsymbol{X}_{2,i}\psi_2 + \varepsilon_{2,i}$ Equation (7))		
CONSTANT	-1.7063**	0.3268
INCOME/1000	0.0992**	0.0263
INCOME SQUARED/100000	-0.0035**	0.0012
INCOME RATIO	0.4004**	0.0894
CARS	-0.1884**	0.0477
FOODSTAMP	0.0325	0.0658

Table 2. Continue

Variable	Coefficient	Standard Error
Estimates of ψ_2 where $y_{2,i} = \boldsymbol{X_{2,i}}\boldsymbol{\psi_2} + \varepsilon_{2,i}$ Equation (7)) (continued)		
WELFARE	0.1849**	0.0703
UNEMPLOYMENT	0.0144	0.0247
SOCIAL SECURITY	-0.0347	0.0761
ASIAN	0.2390	0.2119
BLACK	0.4119**	0.0640
HISPANIC	-0.0380	0.0936
AGE	-0.0012	0.0086
AGE SQUARED/100	0.0006	0.0087
ELDERLY	0.2221*	0.1261
FEMALE	0.2483**	0.0670
EDUCATION	-0.0074	0.0050
MARRIED	-0.0352	0.0832
HOUSEHOLD SIZE	-0.0046	0.0667
HOUSEHOLD SIZE SQUARED	-0.0004	0.0082
Estimates of ψ_3 where $y_{3,i} = \boldsymbol{X_{3,i}}\boldsymbol{\psi_3} - \tau_i + \varepsilon_{3,i}$ (Equation (9))		
ASIAN	0.2134	0.4879
BLACK	0.4735**	0.0934
HISPANIC	-0.0131	0.1673
ELDERLY	0.3477**	0.1095
HIGH RENT MOVE	0.0588	0.1137
DILAPIDATED	0.0470	0.1319
DISPLACED	0.0447	0.1824
BEDMIN	-0.0578	0.1286
BEDMAX	0.0957	0.0892
Estimates of τ_j where $y_{3,i} = \boldsymbol{X_{3,i}}\boldsymbol{\psi_3} - \tau_j + \varepsilon_{3,i}$ (Equation (10))		
ATLANTA	0.9848**	0.1686
BALTIMORE	0.9471**	0.1605
CHICAGO	0.3775	1.4849
COLUMBUS	1.0943**	0.1509
HARTFORD	0.4471	0.7793
HOUSTON	1.7194**	0.1452
NEWARK	0.2547	0.9745
SANDIEGO	0.9514**	0.1789
SEATTLE	0.8190**	0.2115
STLOUIS	0.9275**	0.1650

Table 2. Continued

Variable	Coefficient	Standard Error
Estimates of Σ		
σ_{11}	0.0673**	0.0206
σ_{12}	0.2226**	0.1003
σ_{13}	0.2426**	0.0097
σ_{23}	0.9741**	0.2461
Simulated Mean Utility Function Parameter Estimates[b]		
$\gamma_{h,i}$	0.0533	0.0177
$\beta_{h,i}$	-20.7055	71.2129
$\beta_{x,i}$	-1241.6380	200.5669

[a]The number of observations = 3506 ; $\ln(\mathcal{L}(\hat{\theta})) = -1{,}223.37$

[b]100 households are simulated for each observed participating household. Standard errors are calculated using equation C6 from Appendix C.

*denotes significance at the 10-percent level. **denotes significance at the 5-percent level.

Source: Author's calculations.

Table 3. Some Aggregate Effects of Existing Federal Housing Programs and a Hypothetical Program of Unrestricted Cash Grants (in dollars)

Effect on Housing Consumption: Current Programs[a]	Corrected Estimate[b]	Traditional Estimate[c]
Mean annual rent paid by participating families	238 (163)	238 NA[d]
Mean annual subsidy for participating families	4,682 (41)	4,682 NA
Mean annual market rent of their susidized unit [e]	4,927 (43)	4,927 NA
Mean annual housing expenditure in the absence of these programs	4,532 (266)	3,997 (194)
Percentage change in aggregate consumption of housing services [f]	4.43 (0.52)	22.94 (1.46)
Effect on Housing Consumption: Unrestricted Cash Grant Programs		
Mean annual housing expenditure under a program of unrestricted cash grants	4,757 (272)	5,178 (188)
Percentage change in aggregate housing consumption under a program of unrestricted cash grants [f]	4.85 (1.06)	29.62 (2.08)
Effect on Nonhousing Consumption: Current Programs		
Mean annual expenditure on other goods in the absence of these programs	3,109 (271)	3,694 (220)
Mean annual expenditure on other goods under these programs	7,443 (256)	7,443 NA
Percentage change in aggregate consumption of other goods under these programs[f]	141.12 (12.69)	101.52 (10.62)
Effect on Nonhousing Consumption: Unrestricted Cash Grant Programs		
Mean annual expenditure on other goods under a program of unrestricted cash grants	7,545 (287)	8,608 (221)
Percentage change in aggregate consumption of other goods under a program of unrestricted cash grants [f]	107.79 (16.74)	94.58 (13.23)

Table 3. Continued

	Corrected Estimate[b]	Traditional Estimate[c]
Participant Valuation and Deadweight Loss		
Mean annual benefit to participating families	4,338 (473)	4,500 (97)
Value of program assistance to participants per dollar of subsidy	0.91 (0.03)	0.96 (0.02)

[a]There are 826 participating families in the sample; 100 families are simulated for each obs. under the corrected model.

[b]Standard errors are given in parentheses and are calculated using equation C6 from Appendix C.

[c]Standard errors given in parentheses are for the difference between the corrected estimates and the traditional model estimates. The formula for their calculation is given in equation C12 in Appendix C.

[d]Standard errors not applicable; the value is independent of the model chosen.

[e]Imputed from hedonic rent regressions described in Appendix A.

[f]These percentage change values are calculated for real consumption, whereas mean annual expeditures take into account local market prices. Thus, the percentage change values are not directly calculable from the expenditures values.

Source: Author's calculations.

Figure 1. See author for this figure at: Amy_Crews@freddiemac.com

Figure 2. See author for this figure at: Amy_Crews@freddiemac.com

Figure 3. See author for this figure at: Amy_Crews@freddiemac.com

Figure 4. See author for this figure at: Amy_Crews@freddiemac.com

Figure 5. See author for this figure at: Amy_Crews@freddiemac.com

Endnotes

1. A more detailed summary of housing programs is given in Olsen (1993) and Cage (1994).

2. Under Public Housing—the oldest and the largest program—new units for low-income households are built with federal money. These projects, the majority of which were constructed in the 1940s and 1950s, are owned and operated by local housing authorities. Other new construction programs subsidize selected private suppliers to build and operate housing for low-income households.

3. The Section 8 Vouchers and Certificates are household-based programs for existing rental housing that allow selected eligible households to live in any affordable private unit meeting certain minimum standards for space, amenities, and condition. The certificate program imposes the additional restriction that the rent be no greater than a ceiling, inappropriately called the Fair Market Rent (FMR), that varies with the locality and size of the unit. The subsidy under the voucher program and the maximum subsidy under the certificate programs is calculated as the difference between the relevant FMR and 30 percent of the household's adjusted income.

   There are two types of programs in the project-based category for existing rental housing. The first offers subsidies to households who live in a housing project acquired or in danger of being acquired by HUD through default on government loan guarantees. The other is rehabilitated housing for which the government provides subsidies to selected private organizations to rehabilitate and maintain projects and to rent them to low-income tenants at below-market rents.

4. The rent charged to a household living in a subsidized unit under one of these programs is typically 30 percent of the household's net income as determined by the local housing authority or, if the household participates in AFDC, the AFDC housing allowance.

5. Reeder (1985, p. 366) reports that 20 percent of his sample of participants in the Section 8 Certificate program selected housing under the program that rented for less than the housing they inhabited prior to joining the program.

6. The example is deliberately extreme. More generally, households that are offered consumption bundles close to their income-expansion paths will have the largest benefits from participation.

7. Section 8(d) (1) (A) of the U.S. Housing Act of 1937, as amended in 1983. These preferences for admission were put into effect in 1987. Some of the preferences have been in effect for a longer time. See U.S. House of Representatives (1987) for more details.

8. The definition of a low-income family of four is one which has an income less than or equal to 80 percent of the area median income. Very-low-income households have incomes below 50 percent of the area median. Adjustments to both categories are made for household size.

9. A disproportionate number of the units in projects are limited to elderly or handicapped individuals. Roughly 36 percent of the very-low-income elderly and disabled renters lived in subsidized housing units, compared to an assistance rate of 22 percent for all other very-low-income households. Elderly and disabled renters comprise 44 percent of all very-low-income households. See U.S. Department of Housing and Urban Development, Office of Policy Development and Research (1991).

10. The National Affordable Housing Act of 1990, also known as the Cranston-Gonzalez Act, changed the local preference allowance to 30 percent of new admissions.

11. Bierman (1985) also examined the effect of rent control on a household's housing consumption choice.

12. Mayo (1983) estimates the deadweight loss of the assistance programs in the Housing Allowance Demand Experiment. His estimate also suffers from aggregation bias, but in his case, because it is based on estimates of mean elasticities.

13. This is shown in the results section of the paper. Also see Crews (1995) for more on the effects of model specification and bias.

14. Implicitly, it is assumed that households do not save and that all households in the same locality face the same prices for the two goods. The subscripts on prices denoting locality are omitted for simplicity of exposition.

15. There are also significant costs associated with waiting for an offer of admission. For example, in June 1992, the Housing Authority of the City of Los Angeles (HACLA) had 20,478 families on the waiting list for an initial interview. It is common for families on the list to wait for more than two years for an offer of admission. HACLA had 8,605 units under its control in 1991. Sources: Telephone interview with Duane Walker, Director of Admissions, Housing Authority of the City of Los Angeles, July 17, 1992, and Housing Authority of the City of Los Angeles (1991).

16. Technically, the family also incurs some application costs even if it does not ultimately participate in the program. In this specification, these costs are assumed to be negligible.

17. The difference in cardinal weighting function across cities suggests that the ψ_3 should be different for different cities. However, the fact that the ordinal rankings are similar allows the differences to be captured in the fixed effect parameters τ which define the acceptance thresholds.

18. Although theoretically the selection events occur in sequence, only the final outcome of the whole application process is observed. Therefore, the two selection processes are treated as separate but correlated decisions. A third selection decision is ignored. Households that are offered a unit may turn down the offer and return to the waiting list with a penalty. The data are not rich enough to identify this third stage of self selection separately.

19. Similarly $n_2(\bullet)$ is defined as the unstandardized bivariate normal density function and $n_3(\bullet)$ as the unstandardized trivariate normal density. See Johnson and Kotz (1972, Chs. 35-6) for

a detailed discussion of the properties of the bivariate and trivariate normal distributions.

20. Due to the potential problem of market distortions caused by rent control, New York City is not included in this study.

21. Food Stamp allotments are based on a family's countable income. Countable income is the household's earned income plus unearned income minus applicable deductions. For this study, the deductions used are a 20-percent tax allowance and the standard deduction amount (see U.S. House of Representatives 1987). Eligibility for the work-related or medical deductions is not observed in the AHS.

22. See U.S. Department of Housing and Urban Development, Office of Policy Development and Research (1987a) for the upper income limits for eligibility.

23. Imputing the household's consumption of other goods in this way implicitly assumes households do not save nor do they receive other subsidies in-kind. Medicaid is benefits are not included in this calculation, however, Moffitt and Wolfe (1992, p.616, footnote 2) report that AFDC and Medicaid participation are strongly correlated. The high participation rates in AFDC by very-low-income households imply that true household consumption of other goods in this sample is underestimated due to the omission of Medicaid benefits. Omitting in-kind transfers biases the benefit estimates downward.

24. The hedonic estimates are available from the author upon request.

25. The effect on the parameter estimates of treating all programs the same is minimal since the consumption patterns under the programs are not used in that stage of the estimation.

26. The simulation exercise had 29.1 percent of simulated households passing the self-selection criterion. Of those households, 92 percent passed the administrative selection criterion, with a total of 27.6 percent of the simulated households being selected.

27. The implication of the negative signs on β_h and β_x and their relative magnitudes is that the income elasticity of demand is less than 1; in fact the point estimate is 0.14. This is consistent with previous research indicating that the elasticity is much smaller than 1. See Follain (1979), who reports estimates between 0.3 and 0.6, and Hanushek and Quigley (1981), who estimate the elasticities to be between 0.1 and 0.3.

28. This exercise assumes that the market prices of housing and other goods remain unchanged and that taxes, public services, and household income from sources other than the housing program also are unchanged.

29. This estimate is higher than the estimate in Olsen and Barton (1983) of 77 and 75 cents on the dollar for New York City residents in 1965 and 1968, respectively, and Reeder's (1985) estimate of 83 cents on the dollar for Section 8 Certificate participants in 1976, but is similar to some of the estimates obtained by Mayo (1983), who used a consumer surplus measure with data from the Housing Allowance Demand Experiment..

30. Equation (17) is unaffected by aggregation bias because the demand equations are linear in $\gamma_{h,i,j}$ for each household of type *i*.

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