Economic Impacts of Subsidized Housing Location

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Abstract:

A popular scheme for providing affordable housing involves the use of rental vouchers given directly to families who choose their own market-rate housing. In this paper we present a methodology for calculating localized economic benefits and costs to various groups affected by a hypothetical move from inner-city public housing to suburban Section 8 rental housing. Such a move might occur as part of a program similar to the Gautreaux Assisted Housing Program. Benefits and costs derived from this move can then be used in an optimization model to compare impacts of alternative allocations of families to certain areas in which to search for rental housing. We apply this benefit/cost methodology to metropolitan Chicago data and report computational results.

Keywords:
Housing, benefit-cost analysis, public sector, welfare economics, location

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I. Introduction

In the United States, racial segregation of low-income minority families in subsidized housing has been noted by Warren (1986), Fischer (1994) and the U.S. Department of Housing and Urban Development (1994) and others. Residential segregation of minorities is not limited to those in subsidized housing: Massey and Denton (1993) have extensively documented the widespread nature of racial segregation and have argued that it is a root cause of black poverty in the United States. Jargowski (1997) has explored the process of neighborhood segregation and has shown that isolation of poor minority communities has grown significantly in the past thirty years. This segregation has also been characterized as a "spatial mismatch" between majority nonwhite and economically depressed areas (where much subsidized housing lies) and those areas with highest job growth rates, usually suburban municipalities (Leadership Council for Metropolitan Open Communities, 1991; Fernandez, 1994).

A pioneer effort to increase racial integration in subsidized housing while addressing the spatial mismatch between jobs and housing is the Gautreaux Assisted Housing Program in Chicago, Ill. The Gautreaux Program has dispersed more than 7,000 minority families in, or on the waiting list for, CHA public housing to good quality market-rate rent-subsidized housing in integrated communities in the city of Chicago and surrounding suburbs through the Section 8 housing subsidy program (Warren, 1988; Rosenbaum, 1995). HUD has recently initiated a nationwide series of housing dispersion programs similar in spirit to the Gautreaux Program called the Moving to Opportunity Program (HUD, 1995a). However, research attempts to model potential impacts of programs such as MTO for purposes of planning have been scarce. Our research goals are to estimate the potential economic impacts of a hypothetical program similar to the Gautreaux Program and MTO that uses Section 8 subsidies, and to use these impacts, as well as other, non-economic impacts, in a mathematical optimization model to evaluate alternative location patterns for participants in this program. In this context, use of management science modeling techniques could assist decisionmakers to: (1) assist families to look for rental housing in areas where they could enjoy the greatest benefit; (2) establish estimates of impacts for use in negotiations with potential host communities, and (3) allocate resources among agencies to administer subsidized housing programs.

In this paper we develop a methodology to evaluate some of the economic benefits and costs of a hypothetical housing program, modeled after the Gautreaux Program, in which low-income minority families relocate from public housing in the inner city to existing private-market rental housing in suburban areas whose rent is subsidized with Section 8 certificates or vouchers.

We concentrate on existing subsidized housing rather than new construction primarily because the contentiousness and expense of such projects would require a multi-period analysis. Our analysis focuses on two groups affected by location of subsidized housing: the residents of subsidized housing themselves and society as a whole, represented by taxpayers who pay the cost of the subsidized housing program. Though there is a substantial literature on the neighborhood impacts of subsidized housing (see, e.g. Warren *et al.*, 1983; Guy, *et al.*, 1985; Goetz *et al.*, 1996), the techniques necessary to study these effects are quite dissimilar from those used to study tenant and societal impacts. Thus, in this work, we ignore economic impacts on occupants of owner-occupied housing close to the new units of subsidized housing. In addition, though it can be argued that suburban employers benefit economically from having a stable pool of potential entry-level employees in relatively close proximity to the job site, we defer examination of this group to the math optimization model, in which non-economic employer impacts are measured (see Johnson and Hurter, 1997).

Using two cross-sectional datasets from the Chicago metropolitan area, we estimate that the average total cost of relocating a family from public housing in the city of Chicago to Section 8-subsidized housing in the far Chicago suburbs is $88.71. Tenant benefits and subsidy levels show significant spatial variation: regression results show that they increase in distance from the CBD, tract median income, tract housing density, and percent Hispanic tract population; they decrease in the amount of entry-level employment. Family size is a significant parameter: larger families enjoy lower benefits and require greater subsidies than smaller families. Monthly income and housing expenditures are strongly and negatively correlated with benefits; if program funds are limited, this may justify a policy in which eligibility in the housing subsidy program is limited at family income rises. Tenant benefits are less strongly associated than tenant subsidy with the contract rent of housing consumed. In spite of negative benefit estimates for a hypothetical move from public housing to Section 8 housing, we believe that long-term benefits arising from investments in social capital such a move represent could outweigh short-term net costs. We feel confident that the benefits and subsidy model we have developed can be applied to estimate tenant benefits and costs in parts of the Chicago metropolitan area that lie outside the study area used in this paper. We plan to apply these estimated benefit and cost measures to an optimization model for subsidized housing[1].

[1]The reader may be curious as to why potentially negative benefit values would be used in an optimization model. Many optimization models in management science attempt to allocate resources in such a way to minimize costs, subject to constraints which define a feasible solution. In our case, we seek the allocation of families to regions in which the families could search for rent-subsidized housing which has the greatest positive (or least negative) total benefit measure, subject to the consideration that some number *F* of families must be allocated. For more details, refer to (Johnson and Hurter, 1997).

In Section 2 of the paper, we review the literature on family economic impacts of subsidized housing. Section 3 presents the economic model for estimating impacts of a move from public housing to market-rate rent-subsidized housing. Section 4 presents the data used to estimate economic impacts. Section 5 contains benefit-cost calculations for a hypothetical public housing-to-section 8 housing. Section 6 summarizes the methodology and findings, and presents possible research extensions.

II. Literature Review

Researchers have investigated the effects of subsidized housing, and of racial segregation in the broader housing market, for over 30 years. The work on subsidized housing has focused on the effects of subsidized housing on three groups: residents of subsidized housing, taxpayers who pay the administrative costs of subsidized housing programs, and residents of nonsubsidized housing in close proximity to subsidized housing. Economic impacts on the first and second groups are the primary focus of this paper.

We focus first on minority residents (in all types of housing) who live in racially segregated neighborhoods with limited employment opportunities and ask what kinds of economic benefits such individuals might enjoy by moving to less segregated communities with greater employment opportunities. Borjas (1995) models the transmission of employment skills from one generation to the next as a process in which parental earnings, mean earnings of the ethnic group of the parent's generation and neighborhood fixed effects are transformed into the earnings of children. He demonstrates that ethnicity has an influence above and beyond neighborhood effects and parental influence--specifically, that racial segregation has a special negative impact on children's earnings, and that residence in ethnically integrated neighborhoods results in the highest rate of convergence of skills across ethnic groups. Fernandez (1995), in a survey of the spatial mismatch literature, concludes that the recent scholarly evidence supports the spatial mismatch hypothesis: that is, that residential segregation in housing has greatly limited the access of minorities to entry-level employment in higher-growth suburban areas. The policy implication of these works is that if low-income minority families could relocate to more affluent, majority white communities in high job-growth areas, the parents might enjoy greater labor market participation and the children could develop greater employment skills.

This type of spatial and intergenerational argument is very different, however, from the literature on economic impacts of a move from nonsubsidized housing to subsidized housing. Here, researchers have focused on tenant benefits as a function of the value of the housing occupied. That is, they have assumed that all benefits from living in certain housing are capitalized into the contract rent of that unit. They have also assumed that families moving to subsidized housing remain within the local housing market. The early work of DeSalvo (1971, 1975) uses comparative statics with the Cobb-Douglas utility function to calculate benefits to households living in middle-income subsidized housing in New York City as the equivalent variation of consumer surplus. He shows that subsidized housing, as an in-kind transfer of benefits, is inefficient; he estimates that tenant benefits are 54 percent of the total subsidy. In a review of the housing demand literature, Mayo (1981) concludes that price and income elasticities of demand for housing are less than one, implying that the Cobb-Douglas utility function is unsuitable for estimating housing demand. In place of the Cobb-Douglas, Mayo recommends the Stone-Geary utility function, which has the advantage that the demand function can be derived directly from it, and that price and income elasticities vary with price and income.

Clemmer (1984) evaluates economic effects of public housing using various types of utility functions as well as measuring EV directly using compensated demand curves. Based on a nationwide sample of residents of public housing, he concludes that demand function-based approaches allow for more flexibility in the form of housing demand functions than utility function-based approaches, and that EV estimates for an nonsubsidized-to-public housing move based on the explicit utility functional forms overestimate tenant benefits relative to demand function benefit measures. Olsen and Barton (1983) use the Stone-Geary utility function to estimate benefits of New York City public housing to residents of that housing and detailed estimates of interest rates to calculate short-term resource costs of public housing. They show that one of the parameters of the Stone-Geary utility function, the estimated housing minimum consumption level, is consistently negative, a counter-intuitive result that might indicate that utility functions should be estimated for multiple time periods. They estimate that the ratio of tenant benefits to housing cost ranges from 42.44 percent to 54.70 percent if the housing cost includes explicit measures of financing and administration, and 73.19 percent to 77.30 percent if housing cost is equal to the difference between market rent and tenant contribution.

DeBorger (1986) extends the tenant benefits methodology by assuming that housing has multiple attributes that different families may value differently, even if two distinct housing units have the same rent. Applying this technique to Belgian data on public housing, he finds that the ratio of tenant benefits to housing subsidy is 40.55 percent. In (DeBorger, 1987), the author shows that when residents of subsidized housing are prevented from consuming their most preferred combination of housing and nonhousing (as would be expected in a public housing program), the "standard" composite commodity approach overestimates tenant benefits as measured by the multi-attribute commodity method. However, when tenants can choose their most preferred combination of housing and nonhousing under a rental subsidy program (e.g. a rental voucher program), the composite and multi-attribute methods result in identical utility measurements. DeBorger also compares the level of tenant benefits as measured by the composite and multi-attribute approaches arising from a transition between alternative housing policy regimes, for example, from no subsidy to restricted consumption of subsidized housing. He shows that the composite commodity method underestimates actual benefits arising from a move from a restricted-consumption housing regime (e.g. public housing) to an unrestricted-consumption housing regime (e.g. a pure price-subsidy or housing allowance program).

Reeder (1983) has done a comprehensive economic analysis of the Section 8 program. Essentially, he applies the comparative statics analysis developed for public housing tenant benefits to examine benefits to residents of housing under the Section 8 program. Using national data, he finds that the monthly subsidy to Section 8 families, $100.20 in 1976 dollars, is about 33% of the average monthly income of participant families. He also finds that the ratio of tenant benefits to housing subsidy is 92 percent, if the subsidy is measured as contract rent minus tenant contribution, and is 66 percent, if the subsidy includes the full housing provision cost. As for all other researchers examining benefits of subsidized housing, he finds that housing consumption increased under the subsidized housing program. Similar results have also been reported in Olsen and Reeder (1981).

Rosenbaum (1995) and Rosenbaum and Popkin (1991) are among the few researchers who have examined the impact of a move from inner-city public housing to rent-subsidized housing in more affluent communities. They have examined family outcomes under the Gautreaux Program using descriptive sociological methods rather than formal behavioral models. Rosenbaum's surveys of over 400 participants in the Gautreaux program in 1982 and 1989 have indicated that families who relocate from public housing in inner-city Chicago to Section 8 rent-subsidized housing through the Gautreaux program enjoy average increases in hourly wages of $1.16 for families who relocate to rental housing in the city of Chicago, and $1.04 for families who move to the Chicago suburbs. In addition, respondents who relocate to the suburb as opposed to the city are have higher employment rates, whether or not they were employed pre-move. Rosenbaum also notes that children of Gautreaux families attending suburban schools had higher educational outcomes than those attending school in the city of Chicago. Suburban movers interviewed identified a number of benefits without direct economic measures, as well: increased feelings of personal safety and more access to role models. Rosenbaum's research design does not allow comparison of Gautreaux family benefits to those of families who have remained in public housing, however, so it is not clear what the *incremental* benefit of a Gautreaux move would be.

Still, his employment benefit measures provide some support for the ethnic capital and spatial mismatch hypotheses presented above.

Much of the work on tenant benefits using economic models assumes that all benefits to tenants arising from residence in subsidized housing is capitalized into housing rents, that calculating the equivalent variation of consumer surplus adequately measures these benefits and this calculation can be reliably done using utility functions. All relevant studies find that, in the absence of tangible externalities or evidence that residents of subsidized housing systematically undervalue housing, subsidized housing programs are inefficient, and that cash transfers would better allow families to consume goods that reflect their preferences. The literature also indicates that the Section 8 housing subsidy program is relatively more efficient than the public housing program. Very few researchers have examined the economic impacts of such a family's move from public housing in a low-income inner-city area to rent-subsidized housing in more affluent environments. And no researchers, to our knowledge, have tried apply models of such a residential transition to actual housing data.

III. Modeling Economic Impacts of Subsidized Housing to Tenants and Taxpayers

Recent results on the Gautreaux program, as well as the ethnic capital and spatial mismatch models, raise questions as to whether consumer surplus measures really capture the extant of short-term tenant benefits. On the other hand, negative impacts on property values due to proximity to subsidized housing may well reduce total net benefits. In the face of this uncertainty, we will concentrate strictly on EV measures of tenant benefit in this paper. DeBorger (1987) shows that use of a composite housing commodity, in the context of a move from public housing to Section 8 subsidized housing, will underestimate actual tenant benefit measures relative to use of multi-attribute commodity measures. Therefore, we will regard the public housing-to-Section 8 housing benefit measures we calculate based on a composite housing commodity as a lower bound to the true values. Reeder (1983) has calculated that the cost of housing provision under the Section 8 program is about 38% higher than the direct subsidy for 1976 data, and Olsen and Barton (1985) have estimated public housing provision costs between 20% and 22% in excess of direct subsidy costs. For simplicity, we will assume that the cost of housing provision is equal to the market price of that housing. Thus, the subsidy measures we use are also a lower bound to the true values. We suspect that the benefit measures we use understate other, longer-term impacts, such as those measured by Rosenbaum, that might capture improvements in education, employment opportunities and increased safety arising from residence in more affluent and more integrated communities.

In this section we illustrate calculation of tenant benefits from a move to subsidized housing graphically, formally solve an optimization model of tenant behavior, and indicate how traditional models might be modified to account for a move from public housing to rent-subsidized housing. This material is based on presentations in DeSalvo (1971), Olsen and Barton (1983) and Reeder (1983). We also comment on the use of descriptive economic models of consumer behavior in an explicitly normative planning model.

Tenant Benefit Illustration

Our goal is to calculate the equivalent variation form of consumer surplus accruing to families who live in subsidized housing (either public housing or privately-managed, rent-subsidized housing) and who previously lived in nonsubsidized market-rate rental housing. Families are assumed to consume only two goods: "housing", H, at a cost of p_h per unit, and "nonhousing", X, at a cost of p_x per unit. Housing is measured by a single attribute, "quantity", e.g. number of rooms. Without loss of generality, assume $p_x = 1$. The value of the family's total consumption is given by the Stone-Geary utility function $U = (H - \theta_h)^{\beta_h}(X - \theta_x)^{\beta_x}$, which the family maximizes subject to the constraint that total expenditures not exceed available income Y_0. Displacement parameters θ_h and θ_x are often referred to as "subsistence parameters"; parameters β_h and β_x measure the family's propensity to consume housing and nonhousing above their respective subsistence levels. Family income and the market price of housing are assumed to remain constant as a result of participation in the subsidized housing program, while the effective price of housing paid by the family decreases from p_h to $\alpha \cdot p_h$, $0 < \alpha < 1$. Families do not save or invest excess income. The model's time horizon is short, a year or so. All markets are in competitive equilibrium, supply is completely inelastic and information is free.

Consider first a public housing program. In Figure 1, the family's consumption bundle in the absence of a housing subsidy, (H_0, X_0) , is represented by point *a*, which is the tangent of the total expenditures line and the highest possible indifference curve. At *a*, family enjoys utility I_0. Now assume the family enters a public housing program in which the housing consumption is determined exogenously as H_s; the family has moved from point *a* to another point *b* where nonhousing consumption is constrained by income to be X_s and new utility $I_s > I_0$. Although available income Y_0 has not changed, the slope of expenditure line has increased from $-p_h$ to $-\alpha \cdot p_h$ due to a decrease in the effective price of housing. However, this consumption bundle is not the tangent of the indifference curve which passes through it and the expenditure line. This is because families are required to spend the entire subsidy on housing, rather than other, possibly more preferred goods. Then the theory of the consumer says that there exists another bundle of housing and nonhousing goods (H^*, X^*) at point *c*, purchased at market prices, which gives the same satisfaction as the first bundle with respect to a new income $Y_s > Y_0$. Moreover, there is a third income level, denoted Y_m and represented by the income line (Y_m/p_x - Y_m/p_h) that would permit the family to purchase on the open market the housing they now occupy at a subsidized rate.

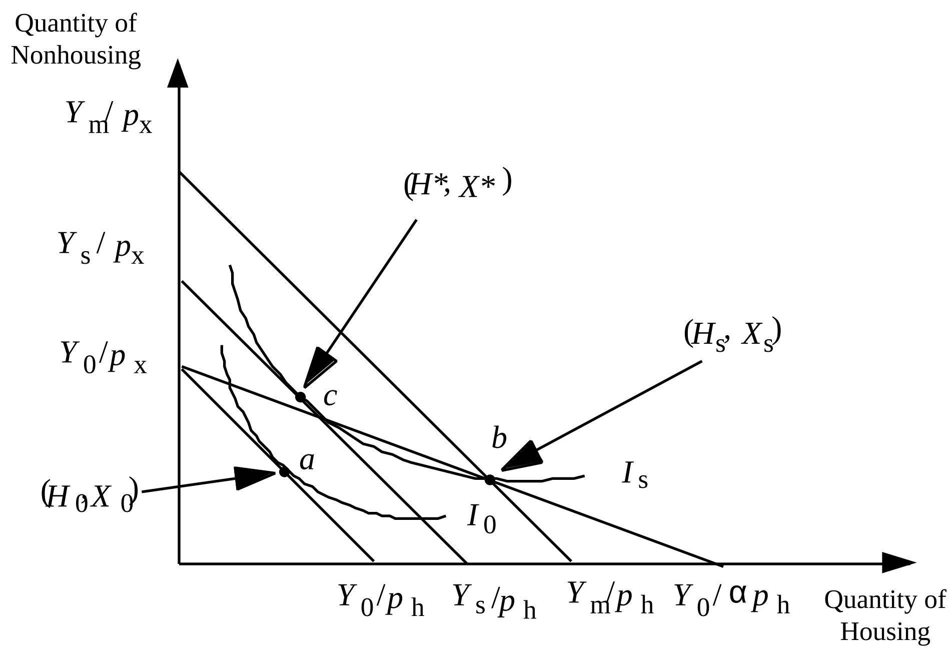

Figure 1: Consumption of Subsidized Housing With Quantity Constraints

The *subsidy* represented by the public housing program is the increase in income that would be required to allow the family, currently in nonsubsidized housing, to purchase at market rates the housing they would consume under the public housing program. This quantity, $Y_m - Y_0$, is equal to the difference between the market value of the public housing purchased at subsidized prices and the family's actual expenditure on public housing. The *benefit* of the program to the family is extra income necessary to enjoy the same benefit from housing, at market prices, as they would enjoy at subsidized prices with their current income. The benefit $Y_s - Y_0$ is defined as the Hicks price equivalent variation of consumer surplus (EV). Because public housing tenants are constrained to consume a bundle of housing and nonhousing which does not represent a tangency between a utility curve and an income line, the subsidy is greater than the tenant benefit, and the amount of this difference is $Y_m - Y_s$. That is, the move from nonsubsidized housing to public housing is not justified on benefit-cost grounds, unless some sort of benefit of at least $Y_m - Y_s$ can be measured.

Now suppose that the family moves from nonsubsidized housing to market-rate rental housing purchased with the assistance of a certificate or voucher. If this certificate or voucher is used in accordance with the Federal Section 8 subsidized housing program, then, in principle, the family has considerable flexibility in choosing the type, size, location and market value of subsidized housing. Indeed, the family can choose housing whose market rate is as high as a Federally-defined ceiling called the Fair Market Rent (45 percent of the market rent of apartments of a similar size in a certain region). The family can also spend as much as 30% of their income on housing. If the FMR allows families to rent more housing than they would were they in public housing, then the effective housing cost under the Section 8 program, $\alpha' \cdot p_h$, would be less than the relative price of housing under the public housing program. An example of this situation is Figure 2, below.

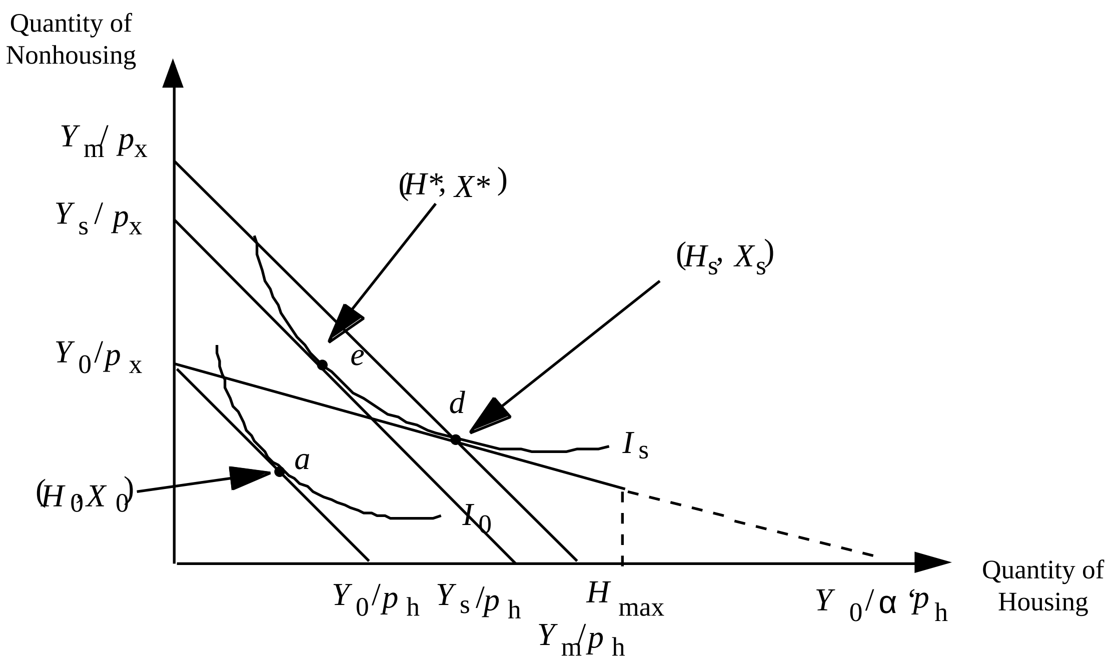

Figure 2: Consumption of Subsidized Housing Using Certificates or Vouchers

The vertical line through H_{max} represents the maximum housing the family can consume and remain within FMR limits. Assume the family consumes the bundle (H'_s, X'_s) under the Section 8 program at point d, enjoying utility I'_s. This new utility level, associated with greater choice in consumption of housing and nonhousing, is now closer to the utility I_m the family would enjoy if it had the income to consume at market prices the housing it now consumes with a subsidy: Y_m - Y_s is fairly small. Therefore, while the certificate/voucher program, considered alone, also fails on benefit-cost grounds, it comes closer than public housing to "breaking even".

In contrast to the moves illustrated above, the move from public housing directly to Section 8-type housing cannot be displayed graphically in a straightforward way. This is because the starting point is not an equilibrium point: families in public housing are not consuming their most-preferred bundle of housing and non-housing. However, suppose that the family moving from public housing to Section 8 housing makes two imaginary moves: from nonsubsidized housing to public housing, and from nonsubsidized housing to Section 8-type housing. Using project analysis, the Section 8-type housing move would be the "incumbent" project and the public housing move would be the "status quo" project. Then the net benefit of a move from public housing to Section 8-type housing would equal the net benefit of the public housing move subtracted from the net benefit of the Section 8-type housing move.

This decomposition approach assumes that housing and nonhousing prices (p_h and p_x), family income and preferences all remain constant during each of the three states: nonsubsidy, public housing and Section 8 housing. However, in the case of a program such as Gautreaux, many families would move to regions in the Chicago metropolitan area quite far from their from their original homes. In a metropolitan area as large as Chicago, it is not reasonable to assume that housing prices remain constant. Assume that p_h increases to $\gamma . p_h$ post-move. As well, assume that H_{max} increases to H'_{max}, i.e. that the FMR in the new region is greater than the FMR in the original region. Thus, the effective price of housing post-move could be biased upward (due to the increase in p_h) as well as downward (due to the increase in H_{max}). Write the new effective price of housing as $p'_h = \alpha' \cdot \gamma p_h$. It is not clear *a priori* if the new effective price of housing is less than, equal, or greater than the original effective price of housing. We graph one outcome of such a move, where $p'_h < p_h$:

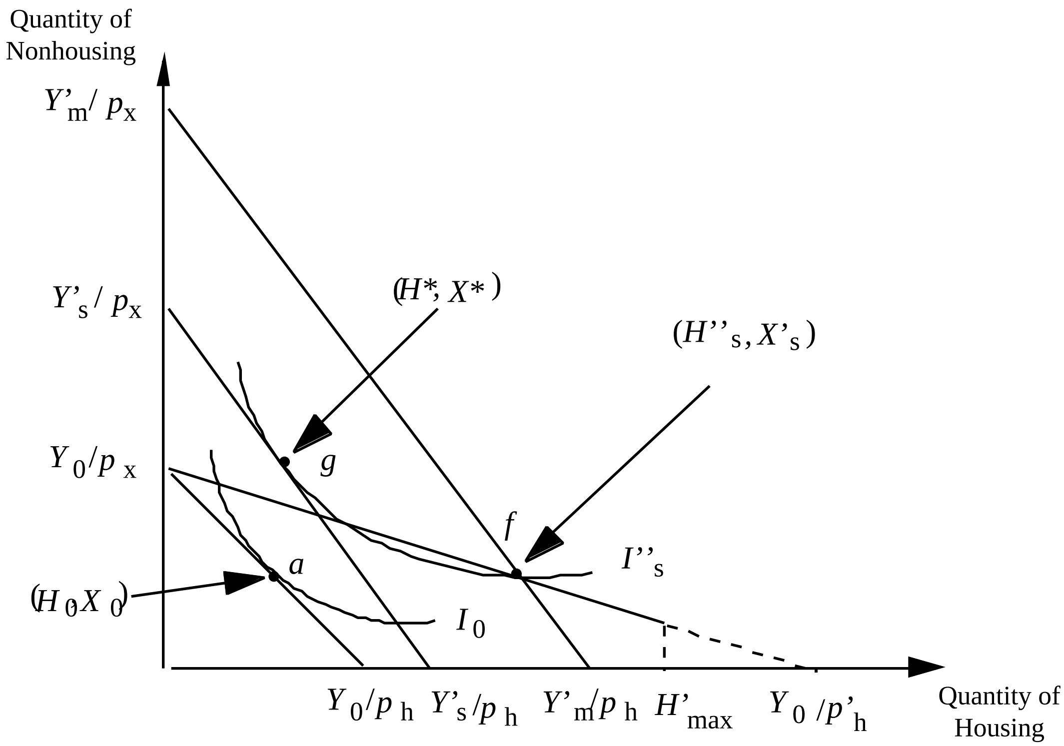

Figure 3: Consumption of Subsidized Housing Using Certificates or Vouchers (Increase in p_h)

The pre-move consumption bundle remains (H_0, X_0), but the post-move bundle at point f is now (H''_s, X''_s). If $p'_h > p_h$, then this bundle lies on an indifference curve of utility $I''_s < I'_s$ in Figure 2. Moreover, there is a new equivalent income Y'_s with which the family may purchase housing and nonhousing that give the same satisfaction as (H''_s, X''_s), and a new equivalent income Y'_m with which the family can purchase on the open market the same housing H''_s that they currently purchase at subsidized prices. As we have assumed that $p'_h > p_h$, the slope of the two effective income lines (Y'_s/p_x - Y'_s/p'_h) and (Y'_m/p_x - Y'_m/p'_h) are more negative than equivalent lines in the case of no price change in Figure 2. So in this case, the subsidy increases by $Y'_m - Y_m$, the benefit increases by $Y'_s - Y_s$, but program efficiency is now $\frac{Y'_m\text{-}Y_s}{Y'_m\text{-}Y_0} < \frac{Y'_m\text{-}Y_s}{Y'_m\text{-}Y_0}$. However, proving the direction of bias in benefit and program efficiency in the general case is more difficult. We simply assert here that a bias will exist as a result of a move between housing markets.

Let Y_m(PH) denote the income necessary to consume public housing at market rates and Y_s(PH) the income necessary to purchase at market rates housing which gives the same satisfaction as public housing purchased at subsidized prices; Y_m(S8) and Y_s(S8) are defined similarly for market-rate rent-subsidized rental housing. Then the net benefit of a move from public housing to Section 8-type housing is[2]

$$[Y_{\mathrm{m}}\ (\mathrm{S8}) - Y_{\mathrm{s}}\ (\mathrm{S8})] - [Y_{\mathrm{m}}\ (\mathrm{PH}) - Y_{\mathrm{s}}\ (\mathrm{PH})]. \quad (1)$$

The sign of quantity (1) could be positive or negative, depending on market housing prices, the contract rent of Section 8-type housing and the equivalent contract rent of public housing. For market housing prices constant pre-move and post-move, and Section 8 contract rents within a reasonable range of equivalent public housing contract rents, we would expect (1) to be positive because the efficiency of the Section 8 program, is greater than that of a public housing. If market housing prices are significantly higher post-move than pre-move, then even if the Section 8 program is more efficient in general, the dollar-valued net benefit of a move from public housing to Section 8 housing could be negative.

Solution of the Economic Model

We state and solve the optimization problem the family solves to consume housing (DeBorger, 1985; Reeder, 1983):

$$\max U = (H - \theta_h)^{\beta_h}(X - \theta_x)^{\beta_x} \quad (2)$$

$$\text{s.t. } Y_0 = p_h H + p_x X \quad (3)$$

where:

H, X = amount of housing and nonhousing consumed;

Y_0 = current income;

p_h, p_x = market price of housing and nonhousing goods;

θ_h, θ_x = minimum consumption levels of housing and nonhousing;

β_h, β_x = mean marginal propensity to spend on housing and nonhousing above minimum consumption levels;

$\beta_h + \beta_x = 1$.

We will solve (2) - (3) for optimal values of housing and nonhousing consumption H_0 and X_0 in the absence of a housing subsidy, and use these optimal values to derive measures of

[2] It is possible that we cannot observe individual families moving from public housing to Section 8 housing. In this case, we would assume that families in public housing originate from a point source, then subtract from $[Y_{\mathrm{m}}$ (S8) - Y_{s} (S8)] values for each family in Section 8 housing the average value of $[Y_{\mathrm{m}}$ (PH) - Y_{s} (PH)] for all families in public housing.

consumer surplus when a housing subsidy is introduced. Using Lagrangian relaxation, re-write (2) - (3) as

$$\max L = (H - \theta_h)^{\beta_h}(X - \theta_x)^{\beta_x} + \lambda(Y_0 - p_h H - p_x X) \ . \tag{4}$$

The first-order optimality conditions of (4) are:

$$\frac{\partial L}{\partial H} = \beta_h(H - \theta_h)^{\beta_h - 1}(X - \theta_x)^{\beta_x} - \lambda p_h = 0 \tag{5}$$

$$\frac{\partial L}{\partial X} = \beta_x(H - \theta_h)^{\beta_h}(X - \theta_x)^{\beta_x - 1} - \lambda p_x = 0 \tag{6}$$

$$\frac{\partial L}{\partial \lambda} = Y_0 - p_h H - p_x X = 0 \tag{7}$$

We solve first-order conditions (5) - (7) for demand functions for housing and nonhousing:

$$H_0 = \theta_h + \frac{\beta}{p_h}(Y_0 - p_h\theta_h - p_x\theta_x) \tag{8}$$

$$X_0 = \theta_x + \frac{1-\beta}{p_x}(Y_0 - p_h\theta_h - p_x\theta_x) \ . \tag{9}$$

We compute the consumer surplus associated with the consumption of subsidized housing as follows. In the absence of a housing subsidy, a family consuming the bundle (H_0, X_0) at prices $\boldsymbol{p} = (p_h, p_x)$ and income Y_0 would receive benefit

$$U = (H_0 - \theta_h)^{\beta}(X_0 - \theta_x)^{1-\beta} \ , \tag{10}$$

or

$$U = \left[\frac{\beta}{p_h}(Y_0 - p_h\theta_h - p_x\theta_x)\right]^{\beta}\left[\frac{1-\beta}{p_x}(Y_0 - p_h\theta_h - p_x\theta_x)\right]^{1-\beta} \ . \tag{11}$$

This quantity is referred to as the *indirect utility function* $v(\boldsymbol{p}, Y_0)$. When participating in a subsidized housing program, the family consumes a bundle of housing and nonhousing goods (H_s, X_s), receiving utility $U^s = (H_s - \theta_h)^{\beta}(X_s - \theta_x)^{1-\beta}$. Define the *expenditure function* $e(\boldsymbol{p}, U^s)$ as the income Y_m required to purchase (H_s, X_s) at prices $\boldsymbol{p}$ and giving satisfaction U^s; define Y_s as the income needed to purchase another bundle (H^*, X^*) which achieves the same utility U^s and is located at the tangency of the indifference curve and the equivalent income line. By setting equation (11) and U^s equal, we can express Y_s as:

$$Y_s = \left[\frac{p_h(H_s - \theta_h)}{\beta}\right]^{\beta}\left[\frac{p_x(X_s - \theta_x)}{1-\beta}\right]^{1-\beta} + p_h\theta_h + p_x\theta_x \ . \tag{12}$$

Note that $p_h H_s$ is the market price for housing H_s purchased with a rental subsidy. We denote this value as R^m and the actual housing expenditure by the family as R^s; $R^m \geq R^s$. Also, $p_x X_s = X_s = Y_0 - R^s$ is the family's expenditure on nonhousing goods. The income equivalent variation of consumer surplus (EV) is equal to the *additional* income required to purchase, at market prices, housing and nonhousing goods which produce the same satisfaction as those currently consumed in the subsidized housing program. We denote this quantity (Y_s - Y_0 in Figs. 1 - 3) as B^f:

$$B^f = \left[\frac{R^m - p_h\theta_h}{\beta}\right]^{\beta}\left[\frac{Y_0 - R^s - \theta_x}{1-\beta}\right]^{1-\beta} + p_h\theta_h + \theta_x - Y_0. \tag{13}$$

Assume that the administrative cost of the subsidized housing program is zero. Then the only cost taxpayers incur for each family's move is the cost of the subsidy, denoted by B^s:

$$B^s = R^m - R^s. \tag{14}$$

The net total cost of a family's move from nonsubsidized housing to subsidized housing is then $B^s - B^f$ or

$$NTC = R^m - R^s - \left\{\left[\frac{R^m - p_h\theta_h}{\beta}\right]^{\beta}\left[\frac{Y_0 - R^s - \theta_x}{1-\beta}\right]^{1-\beta} + p_h\theta_h + \theta_x - Y_0\right\} \tag{15}$$

and the incremental total cost of a family's move from public housing to rent-subsidized market rental housing is NTC[S8] - NTC[PH].

If a family moves from an area where the housing price is p_h to an area with a higher housing price $p'_h = \gamma p_h$, then the bias in the estimate of tenant benefits is difference between the expression (15) evaluated for housing price = γp_h and (15) evaluated for housing price = p_h. This value, which we denote as ΔNTC, is given by

$$\Delta NTC = R^m(\gamma - 1) + \left[\frac{R^m - p_h\theta_h}{\beta}\right]^{\beta}\left[\frac{Y_0 - R^s - \theta_x}{1-\beta}\right]^{1-\beta}(1 - \gamma^{\beta}) + p_h\theta_h(1 - \gamma). \tag{16}$$

Again, although there is bias in the estimate of tenant benefits, the direction of the bias is unclear.

Using the Net Total Cost Function in a Location Model

Given our analysis of the net total cost of a move from public housing to Section 8 subsidized housing, it is useful to consider how this cost measure could be used in an optimization model. For any set of parameters which represent economic and non-economic impacts of a move from public housing to Section 8 housing and which define feasible moves, the optimization model will select regions in a metropolitan area in which families could search for subsidized housing which minimize multiple economic and non-economic objectives. For a collection of objective function weights, the set of alternative optima generated represent program efficiency benchmarks. From an economic perspective, this location problem is non-trivial, i.e. there is potentially a great variety of spatial variation in the net total cost measures (15) for different destination regions.

To see this, note that if the housing program imposed no constraints at all, for example if it offered families an unrestricted cash grant, then the theory would predict that two families with identical preferences, initial consumption bundles and initial incomes would choose new and identical housing and nonhousing bundles. Thus, since the contract rents of housing chosen under this unrestricted cash grant program are identical, from a location perspective there would be nothing to distinguish the two housing choices in terms of family benefit.

On the other hand, each of the two conceptual moves a family makes which comprise the actual move from public housing to Section 8 housing represents a transition from an equilibrium position (consumption of the preferred bundle of housing and non-housing) to a non-equilibrium position (consumption of housing and non-housing constrained by public housing or Section 8 program rules). Thus, it is possible that two families with identical preferences, initial consumption bundles and incomes could decide to consume different bundles of housing and nonhousing under a housing subsidy program. This is because unmeasured parameters such as a family's preference to be closer to its home neighborhood, or to live in neighborhoods with greater transit/pedestrian accessibility could influence the family's decision when the housing program imposes constraints. As a result, we expect to observe significant variation in consumption choices by families in housing subsidy programs and significant spatial variation in calculated benefit measures.

IV. Data Sources

We will estimate expression (15) for a sample of residents that live in public housing units in Chicago's inner city and privately-managed, rent-subsidized units in the Chicago suburbs. The quantities needed to calculate NTC fall into three categories:

(a) Publicly available data:

- Y_0 - income of family living in public housing and rent-subsidized housing;
- R^s - housing expenditure of family living in public housing and rent-subsidized housing;
- R^m - contract rent for rent-subsidized units;

(b) Data to be estimated:

- R^m - contract rent of public housing unit;
- p_h - relative market price of housing;

(c) Parameters to be estimated:

- θ_h, θ_x - minimum consumption level of housing and of nonhousing;
- β - marginal propensity to spend on housing.

(A single set of parameters apply to families in public housing *and* to similar families in rent-subsidized housing.)

In the absence of observations of families who have actually moved from public housing to Section 8-subsidized housing, we use data from a variety of sources.

The American Housing Survey (AHS) provides in-depth information about U.S. families, the homes they live in and some information about the neighborhoods they live in. Besides a national sample of about 50,000 families done every other year, the AHS also does in-depth surveys of major metropolitan areas every four years or so (Abt Associates, 1990). We use the 1991 AHS for the Chicago metropolitan area (Bureau of the Census, 1991) to select observations of families in rental housing in the city of Chicago (to estimate the utility function parameters θ_h, θ_x and β), and to select observations of families in public housing in the city of Chicago (to predict R^m for public housing residents and to calculate NTC[PH]). To ensure a robust range of neighborhood-level variables for predicting the R^m of public housing residents, we also use data from the 1990 Census of Population and Housing as recorded in a dataset published by Datamocracy, Inc. (Datamocracy, Inc., 1996).

Because the AHS provides relatively few observations of families, particularly minority families, in rent-subsidized, non-public housing in Chicago's suburbs, we used observations of families in the Section 8 program provided by the Lake County (Ill.) Housing Authority to observe R^m, R^s and Y_0, and to compute NTC[S8] (Lake County Housing Authority, 1997). In order to focus on nonwhite families in the LCHA's Section 8 program who are similar to those in the Gautreaux program, we used data from the Leadership Council for Metropolitan Open Communities (Leadership Council for Metropolitan Open Communities, 1995) to determine income limits for families of various sizes and to cull observations accordingly.

To test the hypothesis that families in the Section 8 program choose housing that costs as much as the local Fair Market Rent, we used FMR figures published by the U.S. Department of Housing and Urban Development (U.S. Department of Housing and Urban Development, 1997) as well as special "exception" FMR levels used in parts of Lake County (U.S. Department of Housing and Urban Development, 1995b) and other exception FMRs used in parts of Cook County (Leadership Council for Metropolitan Open Communities, 1995).

Regressions that estimate the effect of various socioeconomic variables on tenant benefits, subsidy, income, housing expenditure and benefits include a number of special variables. A measure of the number of entry-level jobs in each Census tract is derived from the 1990 Census Transportation Planning Package Urban Element for Illinois, Table 2-2: Sex by Occupation of Workers. We omitted job categories that could be classified as "professional", as well as occupations presumably unavailable to poor urban residents, such as farming (U.S. Department of Transportation, 1995; U.S. Department of Transportation, 1996). The number of families in the Gautreaux program who first choose new housing in each Census tract is derived from a data file of Gautreaux program participants provided by the Leadership Council for Metropolitan Open Communities to Prof. James Rosenbaum and coded by the first author. Finally, the percent of a tract's housing stock which is subsidized is derived from a data file of subsidized housing throughout the Chicago metropolitan area collected by Dr. Elizabeth Warren and coded by the first author.

V. Computational Results: Estimated Subsidies and Benefits

Market-Rate Rents for Public Housing and Section 8-Subsidized Housing

To estimate the market rent of a unit of public housing, we create an hedonic property-value model that relates the market rent of nonsubsidized rental units to a set of explanatory variables.

One set of explanatory variables might include household attributes, such as number of bedrooms, building age and so on. Another set would include characteristics of the household, such as sex, age, race and educational level attained. A third set would be neighborhood attributes, such as neighborhood or geographical region, per-capita income, and percentage minority population. We can write this hedonic model as:

$$p = \alpha + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + \varepsilon \qquad (17)$$

where p is the rental value of non-subsidized housing, α is a constant, β_1 through β_n are marginal values of an additional unit of attribute i, $i = 1, \ldots, n$, x_1 through x_n are actual values of the explanatory variables and ε is a normally-distributed error term.

In spite of the fact that the Federal Government has set uniform Fair Market Rents for a large region of metropolitan Chicago, including the city of Chicago (see Table 1), we found that average relative housing expenditures (contract rent divided by number of bedrooms) varies significantly by geographic region and by tenant family classification (see Table 2). Therefore, we decided to use the city of Chicago alone as the dataset from which public housing rents are estimated.

FMR Region[3] [No. of tracts]	0 BR	1 BR	2 BR	3 BR	4 BR	5+ BR
ChiMetroGeneral [604]	$492	$591	$704	$881	$985	$1,133
Chicago [866]	$492	$591	$704	$881	$985	$1,133
CookNWNS [196]	$566	$680	$810	$1,013	$1,133	$1,303
LakeExcep [78]	$590	$709	$845	$1,057	$1,182	$1,360

Table 1: Chicago Metropolitan Area Fair Market Rents
Source: U.S. Department of Housing and Urban Development.

[3]These regions are based on published FMR and exception FMR levels published by HUD, with the exception of Chicago, which is not considered separately from the rest of the metropolitan area with respect to FMRs.

ChiMetroGeneral	- Suburban Cook County with the exception of the north and northwest suburbs, the North Chicago-Waukegan-Zion corridor in Lake County, McHenry, Will, Kane and Du Page Counties;
Chicago	- City of Chicago;
CookNWNS	- North and northwest suburban Cook County;
LakeExcep	- Lake County outside of the North Chicago-Waukegan-Zion corridor.

FMR Region [No. of AHS Obs.]	WH, ≤ 3 Per.	WH, > 3 Per.	NW, ≤ 3 Per.	NW, > 3 Per.
ChiMetroGeneral [418]	$126.81	$95.25	$112.82	$101.66
Chicago [751]	$145.64	$89.10	$114.28	$77.14
CookNWNS [107]	$167.56	$114.31	$168.97	$161.04
LakeExcep [39]	$160.85	$108.84	$76.80	$134.38*

Table 2: Chicago Metropolitan Area Relative Housing Expenditures
Source: American Housing Survey, 1991 tabulation for Chicago metropolitan area
*Based on just 2 observations; value set to $76.80 in all computations

Variables used in the regression are listed in Table 3 below:

Variable Name	Meaning	Range	Average Value
BUILTA80	Building constructed after 1980	1/0	0.03
FLOORS	Number of stories in building	1 to highest value	5.31
BATHS	Number of bathrooms in unit	1 to highest value	1.05
PCINC	Per-capita income of population in sample region	0 to highest value	$12,107.96
SPANC	Household respondent is Hispanic	1/0	0.15
RENT	Monthly contract rent	1 to highest value	$446.22
INCMONTH	Monthly income of respondent and relatives in dwelling	0 to highest value	$2,051.06

Table 3: Variable definitions for estimation of public housing market rent
Source: American Housing Survey, 1991 tabulation for Chicago metropolitan area; 1990 Census.

The variable that refers to a "sample region" is a product of the fact that the American Housing Survey reports sample data. Thus, the lowest geographic detail available is a variable called ZONE, which represents a "socio-economically homogeneous area of more than 100,000 people" (Abt Associates, 1990). ZONE is aggregation of census tracts though not necessarily corresponding to other geographic boundaries. In order to capture neighborhood attributes we identified all census tracts corresponding to each ZONE in Chicago and aggregated various census measures to the ZONE level.

652 observations of the variables in Table 1 were used in an hedonic regression. Regression results using SPSS for Power Macintosh Version 6.1 (1996) are below (t-statistics are in parentheses):

$$RENT = 116.0289 + \underset{(5.039)}{.0171}*PCINC + \underset{(14.455)}{4.341}*FLOORS + \underset{(3.583)}{57.303}*BATHS + \quad (3.180) \tag{18}$$

$$160.552*BUILTA80 + 0.0191*INCMONTH - 34.942*SPANC$$
(4.730) (5.271) (-2.490)

N = 652; Adjusted R-squared = .52029; Standard error of estimate = 33827.33817; F-statistic = 118.67720.

All coefficient estimates are significant at the .01 level except for SPANC, which is significant at the .05 level. The F-statistic represents that the hypothesis that all coefficients are equal to zero can be rejected at the .01 level.

This regression demonstrates that the coefficients for the variables included have appropriate signs and magnitudes. For example, renters pay a premium for buildings constructed after 1980, to be in a taller building, and to be in a unit with more rather than fewer bathrooms. Renters pay a premium to be on a higher floor in a building (FLOORS), but this premium is less than that to occupy a larger apartment (ROOMS). Monthly tenant income and per-capita neighborhood income positively influence contract rent, while the proportion of the population which is Hispanic negatively influences contract rent.

To estimate market rents for public housing, we multiply the estimated coefficients of equation (18) by the values of the corresponding variable values for each of the 48 American Housing Survey samples of residents who live in public housing in the city of Chicago; the result is an estimate of the market rent for that unit of public housing. Assume that the estimated market rent represents all costs of providing public housing at market prices. Then the difference between the estimated market rent and the actual rent paid by respondents in public housing is the subsidy enjoyed by families in this sample. The results are below in Table 4.

Family Type	Subsample Size	Avg. Est. Market Rent	Avg. Housing Exp.	Avg. Est. Subsidy	Avg. Monthly Income
White, ≤ 3 persons	1	$493.66	$495.00	-$1.34	$610.00
White, > 3 persons	N/A	N/A	N/A	N/A	N/A
Nonwhite, ≤ 3 persons	26	$414.26	$128.69	$285.57	$448.20
Nonwhite, >3 persons	21	$396.92	$94.05	$302.87	$441.13
All Families	**48**	**$408.33**	**$121.17**	**$287.16**	**$448.48**

Table 4: Estimated Market Rents and Subsidies for Families in Public Housing in Chicago
Source: American Housing Survey, 1991 tabulation for Chicago metropolitan area

These results indicate that public housing provides an average subsidy of 64% of monthly income, more than twice as much as average total housing expenditure. Since 98 percent, or 47, of the 48 AHS observations of families in public housing in the city of Chicago are nonwhite, we can assume that, based on the American Housing Survey data, the "typical" family who would relocate to rent-subsidized housing under our hypothetical program is nonwhite. On average, this family has 3.38 members.

Market rents for Section 8 housing is simply the contract rent for each unit. Using data provided by the Lake County Housing Authority, we have extracted observations for tenant families whose incomes and family sizes would qualify them for the Gautreaux Program. We have excluded from consideration utility allowances paid by the Lake County Housing Authority to tenant families for utility expenses not included in the contract rent. Summary statistics are contained in Table 5, below.

Family Type	Subsample Size	Avg. Contract Rent	Avg. Housing Exp.	Avg. Est. Subsidy	Avg. Monthly Income
White, ≤ 3 persons	624	$634.18	$141.95	$492.23	$716.80
White, > 3 persons	256	$749.83	$156.36	$593.47	$879.78
Nonwhite, ≤ 3 persons	297	$630.07	$150.60	$479.47	$810.11
Nonwhite, >3 persons	196	$744.84	$140.83	$604.01	$924.43
Nonwhite Families	**493**	**$675.70**	**$146.72**	**$528.98**	**$855.56**
All Families	**1373**	**$670.65**	**$146.35**	**$524.30**	**$797.01**

Table 5: Market Rents and Subsidies for Section 8 Housing in Lake County, Ill.
Source: Lake County Housing Authority, 1997.

These statistics show that white and nonwhite tenant families in the Section 8 program in Lake County who would qualify for the Gautreaux program differ little in average contract rent, average housing expenditure or average monthly income. In fact, on average, white families have lower monthly income than nonwhite families. Two statistics of interest for the Section 8 program data used here is the extant to which tenant families choose the most expensive housing possible, i.e. housing whose contract rent is equal to the Fair Market Rent, and the percentage of monthly income spent on rent. Data results in Table 6, below, indicate that on average families choose housing whose rent is less than the FMR, and pay on average less than 30 percent of their income on rent. These results indicate that, for this data set, it is not correct to assume that contract rent is equal to the FMR and that housing expenditure is equal to 30 percent of monthly income.

Family Type	Avg. FMR - Contract Rent	Avg. Percentage of Income Spent on Rent
White, ≤ 3 persons	$182.28	19.8%
White, > 3 persons	$223.18	17.8%
Nonwhite, ≤ 3 persons	$138.51	18.6%
Nonwhite, >3 persons	$154.92	15.23%
Nonwhite Families	**$145.03**	**17.15%**
All Families	**$176.53**	**18.36%**

Table 6: FMR-Contract Rent and Housing Expenditure Comparisons
Source: Lake County Housing Authority, 1997.

One possible explanation as to why families in the Lake County Housing Authority Section 8 program generally occupy housing which costs less than the FMR is that, given low-quality housing occupied before entering the Section 8 program, families do not, or cannot, look for new housing very far from their previous, nonsubsidized housing. Thus, they foreclose on the possibility of renting higher-quality, and more expensive housing. Comparing income and housing expenditures of Section 8 families administered by the Lake County Housing Authority who would qualify for the Gautreaux Program to renters in the Lake County Housing Authority's administrative area and to Lake County as a whole gives the following results in Table 7:

Attribute	LCHA Section 8*	LCHA Service Area (nonsubsidized)**	Lake County (nonsubsidized)**
Average Monthly Income	$797.01	$2,790.37	$2,767.20
Average Contract Rent	$670.65	$547.76	$549.98

Table 7: Comparison of Subsidized and Nonsubsidized Residents in Lake County, Ill.
Source: *Lake County Housing Authority, 1997, **American Housing Survey, 1991.

These results indicate that low-income families who participate in the LCHA Section 8 program have average incomes that are just 28.5% of average monthly income for renters in nonsubsidized housing. However, the average contract rent for the apartments they occupy is greater than that of families without rental subsidies. Even accounting for the fact that the LCHA data are measured in 1997 dollars while the AHS data are measured in 1991 dollars, the size of contract rents for Section 8 families relative to families in nonsubsidized housing is surprising. One possible reason for this outcome is that low-income families who lack resources to move to housing that gives best quality for dollar are constrained to pay higher rent to those landlords who accept Section 8 vouchers and certificates[4]. Such an outcome is reasonable if LCHA Section 8

[4]Landlords are not required to accept Section 8 certificates and vouchers, although if they rent to any Section 8 tenants, they cannot reject a priori any particular class of potential Section 8 tenants.

families procure housing on their own, without access to the search assistance given to families in the Gautreaux program. Another possibility, though, is that LCHA families, who have an average of 3.01 persons as compared to 1.88 for Lake County renters overall, require larger housing units--and, not having the income to purchase single-family homes, must rent large apartments or homes which are scarce in Lake County. The 1991 AHS data show that households in Lake County with 4 or more persons whose yearly income is less than $15,000 are about 5 percent of all families in rental units, while vacant 4- and 5-bedroom apartments whose contract rent falls below the FMR account for only 2 percent of all vacant apartments.

Parameters of the Stone-Geary Utility Function

To estimate the parameters of the Stone-Geary utility function, the housing demand equation (8) can be put in a form suitable for regression:

$$R = -\beta\,\theta_x + \beta Y_0 + \theta_h (1 - \beta) p_h + \varepsilon \qquad (19)$$

where:

R	$= p_h H$ = household expenditures on housing;
Y_0, p_h	= income, relative price of housing (explanatory variables);
β, $\theta_h (1 - \beta)$	= coefficients of explanatory variables;
$-\beta\theta_x$	= constant;
ε	= IID error term.

While utility functions are unique for each individual, for this analysis we assume that certain groups of individuals have identical preferences and that the Stone-Geary parameters β, θ_h and θ_x reflect these preferences. We have defined these groups as "White/three or fewer family members," White/more than three family members," "Nonwhite/three or fewer family members," and "Nonwhite/more than three family members." Moreover, these parameters are independent of the family's type of residence. Since we analyze a hypothetical housing program, we feel our test population should reside in nonsubsidized rental housing. Thus, to estimate Stone-Geary utility function parameters we use the universe of nonsubsidized renters in the city of Chicago according to the 1991 AHS .[5]

[5]Various researchers have used different populations to estimate utility function parameters. Reeder (1983) used Section 8 residents themselves, knowing that most of them previously lived in nonsubsidized units. Olsen and Barton (1983) used nonsubsidized renters living in New York City. DeBorger (1986; 1987) used residents of Belgian public housing.

As written, equation (19) assumes that there is significant variation in p_h across observations. But since we have assumed that p_h is uniform across a geographic area for a particular time period, this can happen only if: observations are cross-sectional, covering various metropolitan areas, or if they are time-series. Although Table 2 shows some price variation across the Chicago metropolitan area, there is no real price variation in the city of Chicago, for which we estimate the Stone-Geary utility function parameters. There are two ways to address this problem. Mayo (1983) simply treats (19) as a univariate regression:

$$R = (\theta_h (1 - \beta) p_h - \beta\, \theta_x) + \beta Y_0 + \varepsilon, \tag{20}$$

where θ_h and θ_x can be estimated in any convenient fashion, for example by measuring the sample minimum consumption levels of housing and nonhousing. Barton and Olsen (1983) set $p_h = p_x = \$1$ and transform the dependent variable to percent of income spent on housing by dividing both sides of (21) by Y_0. We also define $\beta = \beta_0 + w$, where β_0 is the mean value of β for all families in a particular demographic category and w has mean zero. Substituting these values in (19), the equation to estimate becomes:

$$\frac{R}{Y_0} = \beta_0 + \gamma \frac{1}{Y_0} + z, \tag{21}$$

where $\gamma = (\theta_h (1 - \beta_0) - \beta_0\, \theta_x)$ and the transformed error term $z = w \cdot \left\{ 1 - \frac{\theta_h + \theta_x}{Y_0} \right\}$. If we assume, as Olsen and Barton do, that the variables Y_0 and w are uncorrelated, then $\frac{1}{Y_0}$ and z are uncorrelated, and the weighted least squares estimates of β_0 and $(\theta_h (1-\beta_0) - \beta_0 \theta_x)$ are consistent. Having estimated β_0 and γ for a particular category of observations, we estimate θ_h as the sample minimum housing expenditure and calculate $\hat{\theta}_x = \left\{ \frac{(\hat{\gamma} - \hat{\theta}_h (1 - \hat{\beta}))}{\hat{\beta}} \right\}$. We report computational results for formulation (20) (called "Mayo") and formulation (21) (called "O-B").

Household expenditures are represented by contract rent paid by an AHS respondent; income is the monthly income of the respondent and relations living in the same household[6]. An asterisk in the columns representing estimates of explanatory variable coefficients represents significance at the .05 level; a double asterisk represents significance at the .01 level. A plus sign in

[6]We omitted observations in which the family's monthly income was less than the contract rent, in the assumption that through family support, or in-kind rent payments, the observation did not represent a completely market transaction.

the column representing the F-statistic represents that the hypothesis that all coefficients are equal to zero can be rejected at the .01 level.

Categories		Coeff of Y_0	Const	Est. β	Est. θ_h	Est. θ_x	N	Adj. R^2	F-Stat.
Race = White	# persons [1,3]	0.0623**	362.146**	0.0623	50	21.67	282	0.222	81.154+
	# persons > 3	0.364**	388.760**	0.0364	250	100	28	0.0810	5.660
Race = Nonwhite	# persons [1,3]	0.363**	323.481**	0.363	35	10	269	0.0895	27.352+
	# persons > 3	0.293**	310.720**	0.293	10	11	128	0.0597	9.0648+

Table 8: Estimating Stone-Geary Utility Function Parameters: "Mayo" Formulation
Source: Calculations by authors

Categories		Coeff of $1/Y_0$	Const	Est. β	Est. θ_h	Est. θ_x	N	Adj. R^2	F-Stat.
Race = White	# persons [1,3]	277.139	0.107**	0.107	50	-2,174.804	282	0.600	422.689+
	# persons > 3	345.0526	0.0585*	0.0585	250	-1,874.719	28	0.810	116.330+
Race = Nonwhite	# persons [1,3]	250.135**	0.0876 **	0.0876	35	-2,491.411	269	0.698	620.429+
	# persons > 3	275.844	0.0510**	0.0510	10	-5,219.256	128	0.705	304.330+

Table 9: Estimating Stone-Geary Utility Function Parameters; "O-B" Formulation
Source: Calculations by authors

The results of Tables 8 and 9 indicate that the estimates for β lie between 0 and 1, as expected. β decreases in family size, perhaps because larger families have responsibilities related to children or elderly relatives that take priority over additional shelter expenses. In addition, β is larger for white families than for nonwhite families, possibly because white families generally have more disposable income than nonwhite families and can afford to purchase better-quality housing. For both models, estimates for θ_h lie between \$10 and \$250, plausible quantities for minimum housing expenditures. However, in the O-B model, the estimates for θ_x are large and negative.

Olsen and Barton (1983) and Reeder (1983) have also computed negative values for θ_x. According to Reeder, negative values for θ_x can be interpreted as "current subsistence expenditure on nonhousing goods minus the present value of future income in excess of future subsistence expenditures" (Reeder, 1983, p.105). In other words, because our model covers only a single time period, θ_x measures minimum nonhousing expenditures if a family pays for these expenditures by borrowing against future earnings. θ_x decreases in family size for white families but increases in family size for nonwhite families. In addition, θ_x is greater for nonwhite families than for white families for either family size category. These results are counterintuitive, as we would expect future income measures to be greater for white families than for nonwhite families, in general. In any case, Table 9 indicates that our assumption that families neither save nor borrow current income may be too restrictive and that it may be necessary to estimate utility functions over multiple periods.

Adjusted R-squared values for the "Mayo" model in Table 8 are quite low; despite the fact that the coefficient estimates are statistically significant, we believe the models that use this formulation have very limited explanatory power compared to the models in Table 9. In addition, the O-B model's assumptions about p_h and p_x result in estimates for θ_x that describe family consumption better than the Mayo model. Thus, we have used the results for the O-B model in all computations of tenant benefit.

Tenant Benefits and Subsidies For Residents of Public Housing and Section 8 Housing

To compute the benefits and subsidies associated with a hypothetical move from no subsidy to subsidized housing, substitute the appropriate Stone-Geary function parameters, income, nonhousing expenditure and estimated market rent for the subsidized housing unit currently occupied into the equivalent variation formula (13) and subsidy formula (14). In accordance with the O-B model assumptions, $p_h = p_x = \$1$. In this and subsequent sections, we omit reference to benefits to white families in subsidized housing. This is because the small number of white families in public housing will make it difficult to estimate reliable benefit measures of a hypothetical move to Section 8 housing. Also, all family observations have the property that monthly income is greater than monthly housing expenditure. Results for families in public housing in the city of Chicago, based on observations from the 1991 AHS, are contained in Table 10. Results for families in Section 8 subsidized housing in Lake County, based on observations of LCHA data, are contained in Table 11.

Nonwhite Family Type	N	Average Subsidy	Average Benefit	Average Net Cost	Benefit as % of Subsidy
Three or Fewer Members	26	$285.56	$262.36	-$23.21	91.88%
More Than Three Members	20	$305.66	$288.98	-$16.68	94.54%
All Families	46	$294.30	$273.93	-$20.37	93.08%

Table 10: Estimated benefits for families in public housing in the city of Chicago
Source: Calculations by authors, American Housing Survey, 1991 tabulation for Chicago metropolitan area

Nonwhite Family Type	N	Average Subsidy	Average Benefit	Average Net Cost	Benefit as % of Subsidy
Three or Fewer Members	297	$479.47	$393.22	-$86.25	82.01%
More Than Three Members	195	$604.03	$459.53	-$144.50	76.08%
All Families	492	$528.84	$419.50	-$109.34	79.32%

Table 11: Estimated benefits for families in Section 8 Subsidized Housing in Lake County
Source: Calculations by authors, 1997 LCHA Observations

Tables 10 and 11 demonstrate that benefit, subsidy and efficiency measures depend strongly on the size of the family: larger families incur larger subsidies and enjoy larger benefits. The public housing program is also more efficient for larger families as opposed to smaller families. Estimated efficiency for a no subsidy-to-public housing move of about 93% overall are significantly higher than those estimated by Olsen-Barton (1983) and Clemmer (1984) using similar methodology. One possible reason for this might be the fact that subsidized housing in Chicago is highly segregated, thus when hedonic models predict market rents based on neighborhood values rather than regional variables (e.g., dummy variables for the New York borough, in Olsen and Barton, and for central city location, in Clemmer), these rents are likely to be lower than those based on regional variables. It may also be that since nonwhite family incomes are less than white family incomes, calculated benefits will be higher than for white families of similar size.

Estimated benefits of a no subsidy-to-Section 8 subsidy move are 79%, rather lower than those predicted by Reeder (but nearly double that predicted by DeBorger (1986), who used a vector of housing service attributes). Recall that average incomes for families in LCHA Section 8 housing are nearly double those for families in Chicago public housing; this violates the assumption that family income remains the same pre-move as post-move. Housing prices are higher in LCHA's service area than in Chicago: Fair Market Rents are greater in the LCHA service area than in Chicago (see Table 2) and average contract rents are 65% higher for families in LCHA Section 8 housing than those in Chicago public housing (see Tables 4 and 5), violating the assumption of uniform housing prices across the study area. Also, the bulk of LCHA Section 8 families have not relocated from Chicago, in contrast to the assumption of our hypothetical housing program. If the utility maps of LCHA residents are actually different from the residents of Chicago public housing, then we cannot say that the housing choices of families in Chicago public housing would be similar to those currently in LCHA Section 8 housing. These results may be evidence that higher housing prices bias equivalent variation measures of tenant benefit downward.

The Net Benefit of a Move from Public Housing to Rent-Subsidized Housing

The benefit-cost methodology presented in section 2 requires us to subtract the value of the status quo--the net benefit of a move from no subsidy to public housing--from the value of the incumbent project--the net benefit of a move from no subsidy to rent-subsidized housing. Because families in Chicago public housing are assumed to originate from a point source, we subtract the average value of the benefit and subsidy for all Chicago public housing families in a given size category from calculated benefit and subsidy values for each LCHA Section 8 family observation. Results are below in Table 12:

Nonwhite Family Type	N	Δ Average Subsidy	Δ Average Benefit	Δ Average Net Cost	Δ Benefit as % of Δ Subsidy
Three or Fewer Members	297	\$193.81	\$130.86	-\$63.04	67.5%
More Than Three Members	195	\$298.37	\$170.55	-\$127.82	57.1%
All Families	492	\$235.31	\$146.59	-\$88.71	62.3%

Table 12: Estimated Benefits and Subsidies Of Hypothetical Move From Chicago Public Housing To LCHA Section 8 Housing
Source: Calculations by authors

Given the limitations of our data as detailed above, we suspect that these results--both dollar values and efficiency measures--are a lower bound to net benefits of an actual move. However, higher housing prices and a limited supply of rental housing in the suburbs would make positive measures of net benefits difficult to achieve in the short term.

Analysis of Estimated Benefit Values and Subsidy Levels

In this section we examine the influences of various variables on tenant benefit and subsidy measures. The data for this analysis are 492 observations of nonwhite families participating in the Section 8 and Moderate Rehab subsidized housing programs of the Lake County Housing Authority, selected variables from the 1990 Census of Population and Housing and spatial measurements. At the family observation level, correlations between incremental tenant benefit and subsidy measures and the variables that are inputs to the net total cost expression *NTC* are as follows:

	BENEFIT	SUBSIDY	INCMONTH	HSGEXP	CONTRENT
BENEFIT	1.0	0.938	-0.741	-0.896	0.259
SUBSIDY		1.0	-0.653	-0.751	0.540
INCMONTH			1.0	0.878	0.153
HSGEXP				1.0	0.148
CONTRENT					1.0

Table 13: Correlations Between Tenant Benefit, Subsidy and Input Variables
Source: Calculations by authors

These correlations show that benefit measures are more sensitive to changes in income and housing expenditures than are subsidy measures and that rising incomes make the housing subsidy program increasingly inefficient. Thus, as the income of new families in the Section 8 program increases over time (consistent with Rosenbaum's findings for families in the Gautreaux program), the amount of benefits from the program may decrease. A possible policy implication of these results is that where housing subsidy funds are limited, subsidy payments could be decreased in a sliding fashion as incomes increase and tenant participation becomes increasingly inefficient. Note also that the amount of contract rent, while fairly strongly correlated with gross subsidy, is only weakly associated with tenant benefit. This suggests that increasing Fair Market Rent levels alone, as a means to make more rental housing available and affordable, may result in housing subsidy programs becoming more inefficient.

To determine how certain Census tract-level socioeconomic and spatial variables are associated with calculated tenant benefits and rental subsidy levels, we regressed incremental tenant benefits and subsidy measures[7] upon the explanatory variables defined in Table 14, below.

Variable	Definition	Mean Value	Standard Deviation
CBDDIST	Distance between tract centroid and Chicago central business district	40.176	3.37
FAMSZIND	1, if tract observation describes families with more then three members 0, otherwise	0.396	0.49
GATFAM	Number of families in Gautreaux Assisted Housing Prgram who have located in tract since 1990 per sq. km.	0.290	0.433
INC_MEDN	Median family income	34,513.644	6,671.257
ENTRYEMP	Number of entry-level jobs per sq. km	186.068	135.444
PCTPTRAN	Percent of employed persons who take public transit to work	0.027	0.011
PCT_HISP	Percentage of population which is Hispanic	0.076	0.048
HSG_DENS	Number of housing units per sq. km.	525.550	245.117

Table 14: Explanatory Variables for Tenant Benefit/Subsidy Regressions[8]
Source: 1990 Census, Mapinfo 3.0

Our regression results (Table 15) indicate that the both the size of tenant benefits and subsidies is positively and significantly influenced by distance from the CBD, family size, tract median income, transit accessibility, housing density, the percent of population which is Hispanic and the density of Gautreaux program participants. Tenant benefits and subsidy levels are negatively influenced by the amount of entry-level employment. Also, the coefficient of the entry-level employment variable with respect to tenant subsidy is no longer significant at the 5% level[9]. All coefficients have the expected signs except for the employment availability coefficient. This

[7]Because the only location information given is the Census tract (to protect the privacy of the families), there are multiple observations per tract. We combined the observations by averaging the values of dependent variables of observations sharing the same Census tract and family size. These aggregated observations were then weighted by the number of observations per aggregated sample. Thus, $N = 51$ (unweighted) and 493 (weighted).
[8]We defined independent variables as percentages rather than counts in order to predict tenant benefit and subsidy values at the Census block group level as part of the larger location optimization model.
[9]Tract median rent, a variable which might be expected to influence benefit and subsidy measures, had very low correlation with the dependent variables (-0.002 w.r.t. tenant benefit and 0.0453 w.r.t. subsidy) ; including median rent in the regressions of Table 15 did not increase the models' explanatory power, and the variable was not significant at the 5% level.

t Dep. Var.	(const.)	CBD_DDI	FAMSZIN	PCT_HISP	INC_MED	PCTPTRA	ENTRYEM	HSG_DEN	GATFAM	Adj. R^2	F	SE
Benefit	279.548	5.526	25.713	230.709	0.00318	483.750	-0.0356	0.106	27.0232	.437	48.567 †	34.766
	(-5.042)	(6.271)	(7.685)	(4.306)	(5.898)	(2.681)	(-2.984)	(8.472)	(5.892)			
Subsidy	365.741	6.410	85.453	275.0135	0.00512	795.118	-0.0157	0.153	44.950	.698	142.602 ††	40.53
	(-5.656)	(6.237)	(21.901)	(4.402)	(8.140)	(3.779)	(-0.748)	(10.501)	(8.404)			

**

††

might be because, among LCHA Section 8 families themselves, higher monthly income (arising, presumably, from employment wages) is strongly and negatively correlated with tenant benefits.

Overall, the values of the coefficients that influence tenant benefit and subsidy variables would be consistent with location in older, denser, more-distant industrial "satellite cities" in the Chicago metropolitan area such as Elgin, Aurora, Joliet and Waukegan. These municipalities are relatively well-served by public transit, have higher-than average Hispanic populations and have higher-than-average unemployment rates (Datamocracy, 1995). However, one consideration for the Gautreaux program, and for other programs with desegregation as a policy objective, is that families not relocate to areas with high proportions of nonwhite residents. Since nonwhite population size is negatively correlated with many socioeconomic measures of affluence in the Lake County dataset, and since some of these measures have been shown to positively affect tenant benefit levels, an optimization model which identifies regions in which families could search for rental housing would have to select candidate areas from a subset of the most desirable *and* eligible areas for nonwhite Section 8 families. This could make the public housing-to-Section 8 housing transition more expensive, in the short term, than if residential segregation were not a concern.

V. Conclusion and Extensions

In this working paper we have presented some of the theory and computational results related to estimation of economic models of benefit and cost of subsidized housing location. Using the American Housing Survey 1991 dataset for the Chicago metropolitan area and individual observations of families in subsidized housing in Lake County, Ill., we have demonstrated a methodology for estimating economic impacts of a hypothetical move from public housing in the city of Chicago to rent-subsidized housing in the Chicago suburbs. This methodology involves calculating the difference between an approximation to the housing subsidy and the Hicks equivalent variation measure of consumer surplus associated with Chicago public housing as well as suburban rent-subsidized housing and subtracting the former from the latter. Estimated incremental net benefits for a nonwhite family's hypothesized move from public housing in Chicago to rent-subsidized housing in a suburban area compared to the status quo equal -$63.04 for a family of three or fewer members and -$127.82 for a family with more than three members, or -$88.71 overall. We believe that this figure is a lower bound to net benefits of an actual move estimated using EV because of the very different profiles of tenants in Section 8 subsidized housing in a portion of the Chicago suburbs versus tenants in public housing in the city of Chicago: Section 8 families tend to earn more and live in more expensive housing than their public housing counterparts. These short-term economic measures also do not incorporate family benefits measured by increased feelings of security and perception of better educational and employment opportunities. We have found that benefit and subsidy values are strongly and positively associated with distance from the CBD, transit accessibility, housing density, population percent Hispanic, tract median income, and the number of participants in the Gautreaux program who have settled in a region since 1990. Tenant benefit and subsidy values are negatively associated with the level of entry-level employment. All of these measures except the tract median income are associated with location in older, denser and less affluent "satellite" towns located in the outer ring of Chicago's suburbs.

We have stated that these results will ultimately be used in an optimization model to identify locations in which minority families could search for subsidized housing after moving from public housing, and that this model has an explicit focus on housing integration. In this context, if families are only allowed to consider more affluent areas with lower minority populations, the cost of any particular location scheme would be higher than one where families could choose housing more consistent with revealed preferences of minority families already living in subsidized suburban housing.

One could conclude that, based on our data, the move from public housing to Section 8 housing is not justified on benefit-cost grounds and that a location model that maximizes net benefits is unnecessary. We have two responses to this objection. First, all studies of tenant benefits that we have examined have found that the nonsubsidized housing-to-subsidized housing is also unjustified on strict benefit-cost grounds. One would be hard-pressed to find any public-sector program focused on poor families that is justified based on short-term benefit-cost measurements; the example of job-training for low-income single mothers comes to mind. Programs such as these are the result of a decision by society that the positive (and mostly unmeasured) externalities outweigh the negative economic impacts. In this case, society's desire to further housing integration and provide low-income families with enhanced educational and employment opportunities yielding longer-term benefits could justify the large cost of program development. Second, given potential negative benefits, location models can still be useful inasmuch as they can determine locations of facilities that minimize total costs. Such models, which usually have a short-term orientation as well, can be used to evaluate tradeoffs between various groups affected positively and negatively by a particular location pattern.

The immediate extension to this work is to actually predict tenant benefits and subsidy levels at the block group level for the Chicago metropolitan area, given the benefit and subsidy regression results in Section 5. Another extension to this work lies in addressing neighborhood impacts of subsidized housing. There is an extensive literature on property value impacts of subsidized housing, and though we suspect that neighborhood impacts of Gautreaux-type housing, as opposed to standard Section 8 housing, are quite small, we wish to estimate these impacts for a small number of Census tracts in the Chicago metropolitan area. Other costs and benefits our model does not address, which it should at a later point, are associated with alternative uses of land on which high-rise public housing currently sits, or at least estimates of demolition or renovation costs. Chicago's Cabrini-Green controversy (see, e.g. Chicago Sun-Times 10/24/96) illustrates that a number of groups look to profit from the conversion of some land beneath public housing to commercial and upscale real estate uses. Another possible extension of this work is examination of tenant benefits and subsidies for new housing construction, as well as existing rental housing. We also wish to more carefully examine the issue of bias in tenant benefit measurements given a change in housing price or tenant income.

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References

Abt. Associates Inc. 1990. Codebook for the American Housing Survey. Cambridge: Abt Associates Inc.

Borjas, G. J. 1995. Ethnicity, Neighborhoods and Human Capital. *Journal of Economic Literature* **85**, 365 - 390.

Bureau of the Census. 1991. American Housing Survey, Chicago Metropolitan Area, 1991: [Compact Disk]. Washington, D.C.: U.S. Department of Commerce, Data User Services Division, Bureau of the Census.

---------------------------. 1990. Census Population and Housing: Summary Tape File 4, 1990: [Mainframe Tape]. Washington, D.C.: U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census.

Clemmer, R. B. 1984. Measuring Welfare Effects of In-Kind Transfers. *Journal of Urban Economics* **15**, 46-65.

Datamocracy, Inc. 1996. Streets and Tracts: Chicago Metropolitan Area [Compact Disk]. Berkeley, CA: Datamocracy, Inc.

DeBorger, B. 1986. Estimating the Benefits of Public-Housing Programs: A Characteristics Approach. *Journal of Regional Science* **26**, 761 - 773.

-----------------. 1987. Composite Commodities, Housing Characteristics and the Hicksian Surplus Measures of Welfare Change. *Regional Science and Urban Economics* **17,** 475 - 494.

DeSalvo, J. S. 1971. A Methodology for Evaluating Housing Programs. *Journal of Regional Science* **11**, 173 - 185.

-----------------. 1975. Benefits and Costs of New York City's Middle-Income Housing Program. *Journal of Political Economy* **83**, 791 - 805.

Fernandez, R. M. 1994. "Spatial Mismatch: Housing, Transportation and Employment in Regional Perspective." Presented at Metropolitan Assembly on Urban Problems, September 1994, Northwestern University.

Fischer, P. B. 1994. "Racial and Locational Patterns of Subsidized Housing in the Chicago Suburbs". *Georgetown Journal on Fighting Poverty* **1**, 384 - 416.

Gillis, M. "Cabrini Group Sues to Stop Redevelopment Plan." Chicago Sun-Times, October 24, 1996, p. 12.

Goetz, E. G., Lam, H. K. and A. Heitlinger. 1996. There Goes the Neighborhood? The Impact of Subsidized Multi-Family Housing on Urban Neighborhoods. Minneapolis: Neighborhood Planning for Community Revitalization and the Center for Urban and Regional Affairs.

Guy, D. C., Hysom, J. L. and S. R. Rath. 1985. The Effect of Subsidized Housing on Values of Adjacent Housing. *AREUEA Journal* **13**, 378 - 387.

Jargowski, P. A. 1997. Poverty and Place: Ghettos, Barrios and the American City. New York: Russel Sage Foundation.

Johnson, M. P. and A. P. Hurter. 1997. "Location of Locally Objectionable Facilities: Subsidized Housing", in Proceedings of the Sixth Industrial Engineering Research Conference (to appear).

Lake County Housing Authority. 1997. Dataset of families in the Section 8 rental subsidy program. Grayslake, Ill.: Lake County Housing Authority.

Leadership Council for Metropolitan Open Communities. 1991. "Jobs, Housing and Race in the Chicago Metropolitan Area (A Geographic Imbalance)". Chicago.

--. 1994. "Gautreaux Assisted Housing Program." Chicago: Leadership Council for Metropolitan Open Communities.

--. 1996. Dataset of families in the Gautreaux Assisted Housing Program, 1982 - 1996. Chicago: Leadership Council for Metropolitan Open Communities.

Luenberger, D. G. 1984. Linear and Nonlinear Programming, Second Edition. Reading, Mass.: Addison-Wesley Publishing Company.

Mapinfo Corporation. 1994. Mapinfo 3.0 for Macintosh User's Guide. Troy, N.Y.: Mapinfo Corporation.

Massey, D. S. and N. A. Denton. (1993). *American Apartheid: Segregation and the Making of the Underclass*. Cambridge, MA: Harvard University Press.

Mayo, S. K. 1981. Theory and Estimation in the Economics of Housing Demand. *Journal of Urban Economics* **10**, 95 - 116.

Olsen, E. O. and D. M. Barton. 1983. The Benefits and Costs of Public Housing in New York City. *Journal of Public Economics* **20**, 299 - 332.

Olsen, E. O. and W. J. Reeder. 1981. Does HUD Pay Too Much for Section 8 Existing Housing? *Land Economics* **57**, 243 - 251.

Reeder, W. J. 1983. An Economic Evaluation of the Section 8 Existing Housing Program. Unpublished doctoral dissertation. University of Virginia.

Rosenbaum, J. E. 1995. Changing the Geography of Opportunity by Expanding Residential Choice: Lessons From the Gautreaux Program. *Housing Policy Debate* **6**, 231 - 267.

----------------------. and Popkin, S. J. 1991. "Employment and Earnings of Low-Income Blacks Who Move to Middle-Class Suburbs," in The Urban Underclass, Christopher Jencks and Paul E. Peterson (eds.), p. 342 - 56. Washington, DC: The Brookings Institution.

SPSS Inc. 1996. SPSS Graduate Pack Standard Version, Version 6.1.1 for Power Macintosh. Chicago: SPSS Inc.

U.S. Department of Housing and Urban Development. 1994. The Location and Racial Composition of Public Housing in the United States. Washington, D.C.: Office of Policy Development and Research, U.S. Department of Housing and Urban Development.

--. 1995a. Promoting Choice in HUD's Rental Assistance Programs. Washington, D.C.: Office of Policy Development and Research, Department of Housing and Urban Development.

--. 1995b. Communication between Edwin Eisendrath, HUD Secretary's Representative and Alon Jeffrey, Executive Director of the Lake County Housing Authority.

U.S. Department of Transportation. 1995. CTPP Handbook: An Instructional Guide to the 1990 Census Transportation Planning Package. Washington, DC: Federal Highway Administration, U.S. Department of Transportation.

---. 1996. TransVU-CTPP Edition [Compact Disk]. Washington, DC: Bureau of Transportation Statistics, Federal Highway Administration, U.S. Department of Transportation.

Warren, E. 1988. The Legacy of Judicial Policy-Making: *Gautreaux v Chicago Housing Authority*-The Decision and Its Impacts. Lanham, MD: University Press of America.

-------------. 1986. The Dispersal of Subsidized Housing in Chicago: An Index for Comparisons. *Urban Affairs Quarterly* **21**, 484 - 500.

-------------, Aduddell, R. M. and R. Tatalovich. 1983. The Impact of Subsidized Housing on Property Values: A Two-Pronged Analysis of Chicago and Cook County Suburbs. Chicago: Center for Urban Policy, Loyola University of Chicago.

---------------. 1997. Dataset of locations of subsidized housing throughout the Chicago metropolitan area (collected from various housing authorities).