USING HEDONIC INDEXES TO MEASURE HOUSING QUANTITY

C. LANCE BARNETT

R-2450-HUD

OCTOBER 1979

HOUSING ASSISTANCE SUPPLY EXPERIMENT

Sponsored by

The Office of Policy Development and Research
U.S. Department of Housing and Urban Development

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PREFACE

This report was prepared for a conference on housing choices of low-income families sponsored by the Office of Policy Development and Research, U.S. Department of Housing and Urban Development (HUD). The conference was held in Washington, D.C., on 8-9 March 1979. The data presented here draw on research conducted by Rand as part of the Housing Assistance Supply Experiment (HASE).

The author wishes to thank the many individuals on the HASE staff who contributed directly or indirectly to the collection and processing of the data used in this analysis. Special acknowledgments are due to Daniel A. Relles, who provided consistently sound advice on statistical issues; to Ira S. Lowry, Kevin F. McCarthy, Charles W. Noland, and C. Peter Rydell, who reviewed an earlier draft and offered excellent suggestions for its improvement; to Dennis deTray and William McNaught, who reviewed the draft and provided detailed comments; to Judy Bartulski and Jan Newman, who typed the successive drafts; and to Judy Rasmussen, who edited the report.

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SUMMARY

A major problem faced by any researcher studying the characteristics of the rental housing market and the behavior of its participants is that although rent is directly observable, the services a dwelling supplies and the prices of those services are not. Hedonic indexing is one way to overcome that problem. A hedonic index for housing (or any other complex good) is most easily described as a regression equation that relates the attributes of dwellings and locations to gross rent, the sum of tenants' payment to landlords and for utilities. If the market for housing is perfectly competitive and in equilibrium, the regression coefficients can be interpreted as market prices that clear the market for each attribute individually and all attributes jointly. Weighting the attributes of dwellings by those prices, disparate attributes such as the number of rooms, type of heating system, and quality of the neighborhood can be summed to yield measures of services supplied by dwellings that are comparable across dwellings and over time.

This report presents a hedonic index fit to data that describe Brown County, Wisconsin's rental housing stock in 1974. The data were collected as part of the Housing Assistance Supply Experiment (HASE), funded by the U.S. Department of Housing and Urban Development (HUD). HASE's purpose is to help HUD judge the desirability of using housing allowance programs to enable low-income families to afford safe, decent, and sanitary housing without spending more than a quarter of their income. The data come from surveys that address the owners, occupants, buildings, and neighborhoods of a marketwide probability sample of residential rental properties. The data are an exceptionally rich source of information with which to fit a hedonic index: For each of 1,736 dwellings, more than 200 attributes were compiled from over 400 survey items.

The index presented here consists of 17 attributes that describe the interiors and exteriors of dwellings and 6 that describe the location of the dwellings. In addition, the regression equation used to fit the index includes four variables that adjust gross rents for price

discounts some tenants received. If the relative importance of variables is measured by how much those variables contribute to the accuracy with which the regression predicts gross rent, location attributes and price adjustments are least important. Excluding them reduces the index's accuracy by only about 9 percent. The most important attributes are those measuring the interior quality of dwellings, followed by those measuring the spaciousness of dwellings and those describing exterior quality.

The regression fits the data well. It predicts the gross rent of individual dwellings with a standard error of $20 or 15 percent of average monthly gross rent ($137). With only one exception, the estimated attribute prices and price adjustments have signs that agreed with logical expectations. When external evidence on attribute prices is available, it confirms that their estimated magnitudes are roughly correct.

Most of the housing attributes in the index refer to structural features that are unlikely to change over the life of the dwelling except by substantial remodeling or rehabilitation. Since the allowance program rarely engenders such actions, the index will probably not be sensitive to allowance-induced changes. On the other hand, the index will be valuable for studying housing markets, household choices, and landlord behavior.

To demonstrate that the index will be a useful analytical tool for HASE, the report first confirms that the estimated prices satisfy the conditions necessary for dwellings to be treated as if they provide homogeneous and comparable flows of services (i.e., that the attributes of dwellings are a composite commodity). It then presents two ways the index can be used to study households' housing choices. The first is to determine whether alternative search strategies enable households to find bargains (dwellings renting at significant discounts compared with their hedonic rents).* The evidence indicates that the most effective way to find bargains is through tips from friends.

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*Alternative search strategies for finding bargains are only outlined here. See Kevin F. McCarthy, *Housing Search and Residential Mobility*, The Rand Corporation, R-2451-HUD, September 1979, for a complete presentation of the analysis and its implications.

The second use is to show the effects of renters' income on their consumption of four summary attributes: space, interior quality, exterior quality, and location. The findings are plausible. The consumption of space varies less with income than does the consumption of interior and exterior quality. Higher income renters tend to buy "better" rather than "more" housing. Although the consumption of location does not vary with income, its composition does. Higher income renters live farther from the center of town, preferring better neighborhoods to access.

Overall, the evidence presented here indicates that the index for Brown County will be a valuable tool for studying the characteristics of its housing market and the behavior of participants in that market.

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TABLES

I. INTRODUCTION

This report presents and appraises the usefulness of a hedonic index for measuring services of rental dwellings in Brown County, Wisconsin.* Its appraisal shows that the index will be a valuable tool in analyzing that housing market. An excellent data base allowed me to test numerous specifications and thus obtain a good statistical fit and plausible estimated prices. Because of Brown County's market characteristics, the index can measure differences in the services supplied by dwellings in different markets or from the same dwellings at different times. Even though the index will probably not distinguish small changes caused by the allowance program from zero, it is capable of distinguishing differences in the prices paid for dwellings as well as the composition of services supplied by them. The work presented here will be extended to include fitting a similar index with data for rental housing in St. Joseph County, Indiana, and with data for owner-occupied dwellings in both counties.

The remainder of this section briefly reviews the theory of hedonic indexing and its implications for the choice of variables and functional form. It then describes the Brown County data base and presents evidence that shows it meets the requirements for estimating valid attribute prices. Finally, it previews the characteristics of the fitted index.

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*Brown County is one of two housing markets (the other is St. Joseph County, Indiana) being studied by the Housing Assistance Supply Experiment (HASE) to help the U.S. Department of Housing and Urban Development assess the desirability and feasibility of using housing allowances to enable low-income families to afford safe, decent, and sanitary dwellings. HASE was explicitly undertaken to measure the price effects of a fullscale housing allowance program. The work presented here was initially begun in the hope that the index could be used to measure those price effects. See C. Lance Barnett, *Using Hedonic Indexes to Measure Supply Response to Housing Allowances*, The Rand Corporation, WN-8686-HUD, August 1976 (forthcoming as N-1069-HUD).

THEORY OF HEDONIC INDEXING

To compare the services of dwellings in different markets or services of the same dwelling at different times, one needs a cardinal unit of account that is invariant under different market conditions. Hedonic index numbers, if properly estimated, provide such a unit of account. They are weighted sums of directly observable attributes of dwellings and locations that are not themselves directly commensurable but that jointly account for the services dwellings provide. The weights are chosen so that within at least one housing market, index numbers for different dwellings approximate market rents.

Many attempts have been made to specify the attributes that should compose a hedonic index for housing service and to estimate their coefficients.* Specifying attributes has usually been narrowly constrained by the descriptive data available for an adequate sample of dwellings. Estimating coefficients has consistently been done by regressing a measure of each dwelling's market value on the values of its attributes, testing alternative specifications for goodness of fit. The regression coefficients are then interpreted as prices for the attributes to which they pertain. The validity of that interpretation rests on a theory of market transactions in multidimensional commodities.

Here, to index housing and location services, it is assumed that consumers value the attributes of dwellings (such as number of rooms, ceiling height, plumbing facilities, and neighborhood quality) rather than dwellings per se. It is also assumed that consumers have weakly separable utility functions,** with one branch of those functions containing all and only the attributes of dwellings. Consequently, their

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*See, for example, Robert F. Gillingham, *Place-to-Place Rent Comparisons Using Hedonic Quality Adjustment Techniques*, U.S. Bureau of Labor Statistics, Staff Paper 8, 1975.

**For a discussion of separable utility functions and their implications for demand analysis, see Robert H. Strotz, "The Empirical Implications of a Utility Tree," *Econometrica*, Vol. 25, 1957, pp. 269-280; William M. Gorman, "Separable Utility and Aggregation," *Econometrica*, Vol. 27, 1959, pp. 469-481; and Steven M. Goldman and Hirofumi H. Uzawa, "A Note on Separability in Demand Analysis," *Econometrica*, Vol. 32, 1964, pp. 387-398.

choice of attributes depends only on attribute prices and how much they want to spend on housing.

Although landlords offer such housing attributes in bundles, they can and do alter what the bundles include. Ordinary market transactions can therefore produce a consensus on the attribute prices. If a housing market has many participants, competition among the buyers and sellers will clear the market for each attribute individually and all attributes jointly. If a perfectly competitive housing market is in equilibrium, attribute prices are the solution to the simultaneous equation system composed of many individual demand and production functions. Attribute prices are marginal prices facing both consumers and suppliers and thus represent the market's consensus about marginal rates of substitution among the attributes.

Current theory is not powerful enough to indicate what functional form the index should have.* There is widespread agreement, however, that if the attributes composing the index are measured in natural units (e.g., number of rooms), the index is likely to be nonlinear. If so, marginal prices will not equal average prices--a troublesome result because regressions yield estimated coefficients that are best interpreted as averages. In this study, attributes are transformed as needed, so that their marginal and average prices will be equal. The functional form consistent with such prices is linear:

$$R_i = x_i\beta + z_i\gamma, \tag{1}$$

where R_i = rent for dwelling i,

x_i = $1 \times k$ vector of housing attributes for dwelling i,

β = $k \times 1$ vector of housing attribute prices,

z_i = $1 \times g$ vector of location attributes for dwelling i,

γ = $g \times 1$ vector of location attribute prices.

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*See, for example, Sherwin Rosen, "Hedonic Prices and Implicit Markets," *Journal of Political Economy*, Vol. 82, 1974, pp. 34-55.

Equation (1) defines a hedonic index for residential services, which are composed of housing and location services. The term $x_i\beta$ measures housing service; $z_i\gamma$ measures location service. The two services are distinguished here to measure changes in the quantity of housing service. Because attribute prices will not vary in the market when it is in equilibrium, differences in expenditure must be due to differences in the quantity of attributes consumed. Arbitrarily defining the unit of quantity so that the price of a unit of housing or location service equals one causes the total quantity to equal expenditure.

Intertemporal changes in the quantity of housing service for a given dwelling equal the changes in the dwelling's housing attributes weighted by the attributes' prices:

$$\Delta q_h = (x_t - x_s)\beta_s, \tag{2}$$

where Δq_h = the change in the quantity of housing service between times t and s ($s < t$),

x_t , x_s = $1 \times k$ vectors of attributes for a given dwelling at times t and s,

β_s = $k \times 1$ vector of attribute prices for time s.*

Equation (2) can also be used to measure cross-sectional differences in the quantities of housing services by substituting x_i and x_j for x_t and x_s, where x_i and x_j are the vectors of attributes for dwellings i and j. Moreover, equations that are similar to Eq. (2) can be used to measure cross-sectional or intertemporal differences in the quantity of location services supplied or consumed. Such equations, then, can be combined to measure differences in residential services.

The index is a linear function of the attributes,** which affects the interpretation of an attribute's price. First, its price does not

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*Any price vector can be used to measure intertemporal changes. Equation (2) uses base period prices, so it is a Laspeyers quantity index. If it used end period prices, it would be a Paasche quantity index. The use of either period can lead to well-known ambiguities; see Barnett, *Using Hedonic Indexes to Measure Supply Response.*

**Hedonic indexes are frequently specified with log-linear form; see, for example, Sally Merrill, *Draft Report on Hedonic Indices as a Measure of Housing Quality*, Abt Associates, Cambridge, Mass., Report 76-96R, 23 December 1977.

vary with the quantity of the attribute consumed. For example, if a bathroom is added to a dwelling and if bathrooms are worth $18 per month, then adding one bathroom increases the quantity of housing service by 18, regardless of the original number of bathrooms. Second, the price of an attribute does not vary with the quantity of other attributes. The increase in quantity of housing service provided by an extra bathroom does not depend on the location of the dwelling or on other attributes such as the number of other rooms in the dwelling.

Equation (1) readily converts to a regression equation,

$$R_i = x_i\beta + z_i\gamma + \varepsilon_i, \qquad (3)$$

where ε_i = a random error term. At this level of generality, the error term represents random variation in the price of residential services.* Such variation in rents for similar dwellings should be present because the buyers and sellers of housing are unlikely to have complete knowledge of the housing market. As long as it is truly random and reasonably small, such variation does not adversely affect the estimated prices.

BROWN COUNTY DATA BASE

The data needed for hedonic indexing were assembled by combining parts of the baseline household, residential building, and neighborhood and landlord surveys.** The household survey provided counts

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*In the actual regression, the error term also contains excluded attributes.

**Those surveys, fielded mostly in 1974 (before the allowance program began), provide a benchmark for assessing the program's effect. The landlord survey was addressed to the owners of a marketwide probability sample of residential rental properties. The household survey solicited information from the occupants of dwellings on those properties. The residential building survey used trained fieldworkers who examined each building on those properties and reported on its characteristics. The neighborhood survey collected facts from local public sources about the 108 neighborhoods into which Brown County had been divided. It also used trained fieldworkers who observed each blockface in the county and reported on its characteristics.

of rooms and bathrooms, ratings of interior quality, indicators of whether attributes such as steam heat or thermostats are present in the dwelling, and tenant characteristics such as length of stay and satisfaction with a dwelling. The residential building survey furnished ratings of exterior quality, indicated type of exterior construction material (e.g., composition siding), and described the blockface where the dwelling is located. The neighborhood survey gave details of the neighborhood's quality, characteristics, and location. The landlord survey indicated whether the property had a resident landlord and also gave the landlord's assessment of building quality.

The data base was constructed in several steps. First, 2,573 rental dwellings on properties whose occupants, landlords, and buildings we survey annually were identified. That set of dwellings excluded mobile homes and dwellings occupied by roomers or lodgers because they presented special analytical problems. All dwellings that lacked a complete interview for either the household, residential building, or landlord survey were dropped from the data base, leaving 2,014 records.

The second step entailed linking data from the four surveys. Because the household survey has the same unit of observation (the dwelling) that is used to fit the index, each record in the data base contains data from only one household record. Two or more dwellings may occupy the same building, so data from one residential building report may be repeated in the records of several dwellings. Similarly, data from one landlord or neighborhood may be included in the records of several dwellings.

Next, about 200 analysis variables were compiled for each record and were used to trim the data base. Records were then excluded from the data base if they satisfied one or more of the following conditions: (a) data were incomplete, (b) tenant was related to the landlord, (c) tenant stated that he paid less than full market rent, or (d) dwelling was located on a property that was also used for farming. After those exclusions, 1,736 records remained in the data base.

In addition to the requirements just presented, the data must also have come from a market that is in equilibrium or from one that divides into a few submarkets that are in equilibrium. In the absence of

equilibrium, attribute prices might vary greatly among dwellings and could not be accurately estimated. On the other hand, attribute prices that fit poorly might indicate that the market divides into submarkets supporting different attribute prices. If so, Eq. (3) could be separately fit for each submarket,* assuming the individual submarkets were in equilibrium.

A study of rent inflation in Brown County provides the best available evidence that its rental housing market was in equilibrium at baseline.** That study computed the inflation rates of contract and gross rent (contract rent plus tenant-paid utilities), using longitudinal data that cover a period of 54 months beginning slightly before baseline.

If the rental market were much out of equilibrium, rates of change in gross rents would vary greatly among dwellings, since individual landlords would be adjusting both prices and quantities as they searched for the equilibrium values. That did not occur in Brown County. During the 54-month period mentioned earlier, the average annual rate of inflation was 6.64 percent with a standard error of .19. The annual rates for 1974, 1975, and 1976 have similarly small standard errors of about .37. When average annual rates are computed for dwellings grouped by number of rooms, the range of values is uncomfortably wide--from 5.82 percent for one- or two-room dwellings to 9.01 percent for six- or more room dwellings. However, the standard errors are reassuringly small, never exceeding .6. The wide range is probably due to the differential use of fuel for space heating combined with the rapid inflation of fuel prices following the 1973 oil embargo. Although that event could easily disrupt a market, it could not have influenced Brown County's rental market in early 1974 when the data used here were collected.

PREVIEW OF FINDINGS

A hedonic index was fitted to data drawn from surveys of rental properties in Brown County before the experimental allowance program

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*Section III investigates whether Brown County's housing market at baseline divides into submarkets.

**James P. Stucker, *Rent Inflation in Brown County, Wisconsin: 1973-78*, The Rand Corporation, WN-10073-HUD, August 1978 (forthcoming as N-1134-HUD).

began. In its final specification, the regression used to fit the index contains 27 variables, of which 17 are housing attributes, 6 are location attributes, and 4 are price adjustments (see Table 1). These variables are a subset of about 200 (derived from over 400 survey items) that were tested. The coefficient of each included variable is

Table 1

DETAILED COMPONENTS OF THE HEDONIC INDEX FOR RENTAL DWELLINGS: BROWN COUNTY, WISCONSIN, 1973

Summary Attributes	Detailed Components
	Housing Attributes
Space	Number of rooms (ln) Number of bathrooms
Interior quality	Composite rating of interior quality Window rating Wall and ceiling rating Floor and floor covering rating Building rating Number of appliances supplied by landlord Storage space[a] Central or steam heat[a] Thermostat[a] Subdivided residential space[a]
Exterior quality	Composite rating of exterior quality Roof rating Wall rating Window rating Storm window rating Sidewalk and driveway rating Exterior repair rating Overall cleanliness rating Overall condition rating Construction quality rating Building rating Composite rating of comparative building quality Landlord's rating Tenant's rating Fieldworker's rating Lot size per dwelling (sq ft) Wood or composition siding[a]

Table 1 (continued)

Summary Attributes	Detailed Components
	Housing Attributes (continued)
Exterior quality (continued)	Garage or carport[a] Single-family[a] Duplex[a] 5-9 dwellings on property 10+ dwellings on property
	Location Attributes
Access to employment	Logarithm of neighborhood employment inversely weighted by airline distance
Neighborhood quality	Composite rating of neighborhood quality Building rating Yard rating Cleanliness rating Fraction of neighborhood that is open space
Blockface quality	Consumer shops[a] Institutions[a] Above average landscaping[a]
	Other
Price adjustments	Number of years since current tenant moved in: length of stay Tenant's satisfaction with dwelling Resident landlord[a]
Constant term	Correction for incorrect zero points on attribute scales
Error term	Missing attributes; random price variation

SOURCE: Compiled by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

[a]Variable indicates whether attribute is present.

significantly different from zero at the 67 percent confidence level, and most are significant at the 95 percent level.

The equation's standard error of estimate is $20, or about 15 percent of the mean monthly gross rent. In goodness of fit, it compares

well with other fitted indexes for housing. All its variables have coefficients whose signs and magnitudes can be reasonably explained and which in some cases are roughly confirmed by independent evidence.

Fourteen of the 17 housing attributes in the index are structural features that are unlikely to change over the life of a dwelling except by major remodeling or rehabilitation. Therefore, the index will be insensitive to the kinds of housing improvements likely to result from a housing allowance program. Such improvements would be reflected primarily in three composite quality ratings whose standard deviations in the baseline data are small (.34 to .51) and whose price coefficients are all under $6. On the other hand, if receiving allowances induced households to add rooms or install masonry siding, the index would reflect those improvements.

I do think the index will be useful for studying the factors that affect landlords' maintenance and repair expenditures. When residential prices differ across markets or submarkets (because of location or different supply-demand relationships), the index will enable us to distinguish housing service values from location values and thus normalize expenditures per unit of housing service.

The index will also be a valuable tool for studying the characteristics of Brown County's housing market and the behavior of its participants because it converts disparate measurements on individual attributes into comparable measures of services. Section III verifies that the index can be used in this way. It then shows two ways that the index can be used to better understand renters' housing choices: to determine whether some search strategies are better than others at locating bargains, and to describe renters' marginal propensities to consume space, interior quality, exterior quality, and location.

II. A HEDONIC INDEX FOR BROWN COUNTY

Attribute prices cannot be directly observed because transactions between landlords and tenants concern bundles of attributes. However, the composition of those bundles varies, allowing individuals to determine the approximate prices of attributes by comparing rents of dwellings that closely resemble one another. Such determinations can also be made by using regression analysis.

This section presents a hedonic index for rental dwellings in Brown County in 1974. It begins by explaining why monthly gross rent is the appropriate dependent variable for the regression used to fit the index.* It then shows the importance of the independent variables (attributes and price adjustments) for determining monthly gross rent. Next, it details the construction of those variables and, when possible, assesses the magnitudes and signs of their coefficients. The section closes by appraising the likelihood of serious specification error.

DEPENDENT VARIABLE

Gross rent per month (contract rent plus tenant-paid utilities) is the dependent variable used here. It is the appropriate variable because competition among tenants and landlords should equate the gross rents of dwellings offering comparable services. Consider, for example, two identical dwellings located in the same neighborhood. Competition would equate their gross rents. Consider also two identical dwellings located in different neighborhoods but the same market. Competition would again force their gross rents to differ by an amount proportional to the difference between the location services supplied. Similarly, for dwellings offering the same location services but different housing services, competition would force their rents to differ by an amount proportional to the difference in housing services supplied.

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*Because price adjustment variables are included among the independent variables, the regression equation is not identical to the hedonic index. I do, however, occasionally use the terms *regression* and *index* synonymously.

INDEPENDENT VARIABLES

Variables composing the hedonic index were chosen for theoretical and practical reasons. For theoretical reasons, variables determining the demand for or supply of attributes were excluded. The hedonic index represents the reduced-form solution to a simultaneous system of demand and supply equations, so that including variables such as tenant's income or price of land in the index ought to identify those underlying equations.

Individual attributes were rescaled so their average and marginal prices would be equal.* For example, if additional rooms have declining marginal values in the marketplace, which would cause marginal and average prices to diverge, rooms should be rescaled. Here the natural logarithm of the number of rooms is used, a transformation that incorporates declining marginal value.

For practical reasons, condition ratings for the specific features of a dwelling (windows, walls, floors, etc.) were replaced with averages of the ratings for logically grouped features. Using such composite ratings forestalls the collinearity problems that would result from including the specific ratings in the regression. Moreover, the composite rating ought to have smaller observation errors than many of the individual components; therefore, using this rating should reduce the effects of such errors.

Rents are affected by factors other than the quantity of service provided. Landlords, for example, tend to raise rents more when tenants move than they do for current tenants, so that current tenants often enjoy price discounts. Also, dwellings on properties with resident landlords tend to rent for less than otherwise comparable dwellings. The regression includes variables to adjust the rent for such price discounts.

Only variables whose coefficients' t-value exceeded one were included in the regression, because satisfying that condition minimizes the standard error of the estimate and hence the index's prediction error.**

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*All attributes except dummy variables for the presence or absence of an attribute are scaled so that larger values are better. Thus, a priori all such attributes should have positive prices.

**See Yoel Haitovsky, "A Note on the Maximization of $\bar{R}^2$," *The American Statistician*, Vol. 23, 1969, pp. 20-21.

Reducing both errors increases the accuracy with which the index can measure the quantity of housing and location services, cross-sectional differences in services provided by different dwellings, and the change in services provided by a dwelling over time.

Table 2 lists the attributes chosen to compose the index as well as the variables included in the regression to adjust for differences in the price of residential service; it also gives their means and standard deviations. The attributes are separated into two major groups: those that measure the quantity of housing service and those that measure the quantity of location service. Each major group comprises three categories of attributes: for housing services, space, interior quality, and exterior quality; for location services, access to employment, neighborhood quality, and blockface quality. The housing categories differentiate housing "quantity" and "quality": Units that are similar in size may differ in other respects.

Table 3 shows the importance of the summary attributes in determining a dwelling's monthly gross rent. To judge the importance of the attributes, we used a five-step procedure that at each step deleted from the marketwide regression the one whose exclusion least increased the regression's standard error.* Location attributes were dropped first, since their exclusion only slightly increases the standard error from $20.00 per month to $20.53. Price adjustments were dropped next, which increased the standard error to $21.80 or by 9 percent relative to the marketwide regression's standard error. Of the remaining summary attributes, exterior quality is third most important, space second, and interior quality the most important. This pattern appears again in Sec. IV, where the index is used to show the change in the amount renters will spend on summary attributes as their income rises.

The next part of this section explains how independent variables were constructed and discusses their coefficients, which are presented in Table 4.**

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*Dropping a summary attribute means dropping all the attributes composing it.

**The coefficients in Table 4 were estimated with a generalized least squares procedure that accounts for differences in error term variance among dwelling types.

Table 2

MEANS AND STANDARD DEVIATIONS FOR VARIABLES USED TO FIT A HEDONIC INDEX FOR RENTAL DWELLINGS: BROWN COUNTY, WISCONSIN, 1973

Variable	Range of Values	Statistics	
		Mean	Standard Deviation
Dependent Variable			
Gross rent ($/month)	40–323	137.42	33.03
Housing Attributes			
Space			
Number of rooms (ln)	0–2.4	1.31	.30
Number of bathrooms	1–5	1.02	.13
Interior Quality			
Composite rating of interior quality	0–3	2.61	.51
Number of appliances supplied by the landlord	0–25	5.61	6.00
Storage space	Yes = 1, no = 0	.91	.29
Central or steam heat	Yes = 1, no = 0	.87	.34
Thermostat	Yes = 1, no = 0	.85	.36
Subdivided residential space	Yes = 1, no = 0	.16	.37
Exterior Quality			
Composite rating of exterior quality	0–3	2.41	.34
Composite rating of comparative building quality	0–2	1.31	.34
Lot size per dwelling (000 sq ft)	1–10.9	3.50	2.68
Wood or composition siding	Yes = 1, no = 0	.37	.48
Garage or carport	Yes = 1, no = 0	.52	.50
Single-family dwelling[a]	Yes = 1, no = 0	.11	.31
Duplex[a]	Yes = 1, no = 0	.08	.27
5–9 dwellings on property[a]	Yes = 1, no = 0	.42	.49
10+ dwellings on property[a]	Yes = 1, no = 0	.11	.32
Location Attributes			
Access to Employment			
Generalized access to employment	0–25.4	1.91	.53
Neighborhood Quality			
Composite rating of neighborhood quality	0–3	1.89	.38
Fraction of neighborhood that is open space	0–.86	.34	.25

Table 2 (continued)

Variable	Range of Values	Statistics	
		Mean	Standard Deviation
Location Attributes (continued)			
Blockface Quality			
Consumer shops	Yes = 1, no = 0	.34	.47
Institutions	Yes = 1, no = 0	.11	.31
Above average landscaping	Yes = 1, no = 0	.94	.23
Price Adjustments			
Length of stay (yrs)	0-18.5	2.94	4.81
Length of stay exceeding 3.5 years	0-15.0	1.05	4.16
Tenant's satisfaction with dwelling	0-3	2.39	.75
Resident landlord	Yes = 1, no = 0	.11	.32

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: Analysis used only data for those dwellings whose occupants stated they paid full market rent and only when complete information on variables listed was available.

[a]Excluded category is nonduplex dwellings on 2-4 dwelling properties.

Space

Two attributes measure the amount of space provided by a dwelling: the logarithm of the number of rooms (excluding bathrooms) and the number of bathrooms. Efficiency dwellings with complete kitchen facilities are assumed to have 1.5 rooms. The number of rooms is rescaled by using the natural logarithm to reflect that additional rooms have declining marginal value.* The estimated price for rooms is highly significant; t = 23.9, the largest t-value in the regression. Half-baths** are

*At the end of this section, residuals are analyzed to verify that presumption.

**A half-bath has either a flush toilet, a bathtub, or a shower, but does not have all the facilities of a complete bathroom.

Table 3

CUMULATIVE EFFECTS OF EXCLUDING SUMMARY ATTRIBUTES ON THE INDEX'S STANDARD ERROR

Excluded Summary Attributes	Standard Error	
	$/Month	Increase (%)
None	20.00	0.0
Location	20.53	2.7
Location, price adjustments	21.80	9.0
Location, price adjustments, exterior quality	24.39	22.0
Location, price adjustments, exterior quality, space	28.19	41.0
All[a]	33.03	65.2

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: Summary attributes were excluded in the order that least increased the standard error at each step.

[a]All consists of location, price adjustments, exterior quality, space, and interior quality, which exhausts the variables that compose the regression used to fit the marketwide index.

given a value of .5. (Earlier regressions consistently yielded estimated prices equal to one-half the price of full bathrooms.)

Interior Quality

Six attributes measure the interior quality of dwellings. The composite rating of interior quality combines tenants' appraisals of a dwelling's interior into a direct measure of interior quality. The remaining five attributes use evidence on the presence or absence of various dwelling characteristics to indirectly measure interior quality.

The composite rating of interior quality is a simple average of condition ratings provided by tenants for their dwellings' windows, walls and ceilings, floors and floor coverings, and their building. As shown in Table 5, each rating uses a 4-point scale. The ratings indicate that most tenants occupy dwellings whose interiors are good.

Table 4

REGRESSION STATISTICS FOR A HEDONIC INDEX FOR RENTAL DWELLINGS: BROWN COUNTY, WISCONSIN, 1973

Variable	Statistics	
	Estimated Price ($/mo.)	*t*-value
Housing Attributes		
Space		
Number of rooms (ln)	46.70	23.89
Number of bathrooms	18.86	4.74
Interior Quality		
Composite rating of interior quality	5.07	3.73
Number of appliances supplied by the landlord (sq)	1.11	9.22
Storage space[a]	3.95	2.22
Central or steam heat[a]	13.82	8.85
Thermostat[a]	9.90	6.28
Subdivided residential space[a]	-4.84	-3.06
Exterior Quality		
Composite rating of exterior quality	5.60	2.92
Composite rating of comparative building quality	5.80	3.26
Lot size per dwelling (000 sq ft)	1.27	4.24
Wood or composition siding[a]	-6.08	-4.65
Garage or carport[a]	3.16	2.77
Single-family dwelling[a]	3.81	1.75
Duplex[a]	31.12	13.90
5-9 dwellings on property	4.91	2.96
10+ dwellings on property	8.78	3.91
Location Attributes		
Access to Employment		
Generalized access to employment	7.86	4.61
Neighborhood Quality		
Composite rating of neighborhood quality	9.39	5.94
Fraction of neighborhood that is open space	9.92	2.64
Blockface Quality		
Consumer shops[a]	-3.69	-3.35
Institutions[a]	-5.54	-3.46
Above average landscaping[a]	5.03	2.12

Table 4 (continued)

Variable	Statistics	
	Estimated Price ($/mo.)	t-value
Price Adjustments		
Length of stay (yrs)	-4.45	-9.81
Length of stay exceeding 3.5 years	3.86	7.45
Tenant's satisfaction with dwelling	-4.69	-5.84
Resident landlord[a]	-2.31	-1.39
Other		
Constant term	-35.58	-4.34

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: Regression analysis uses only data for those dwellings whose occupants paid full market rent and only when complete information on variables listed was available. F = 111.98 with 27 and 1,708 degrees of freedom, R^2 = .64; standard error of the estimate = 20.00.

[a]Variable indicates whether attribute is present.

Building rating is included in the composite rating because it should incorporate tenants' assessment of the condition of the dwelling, although the condition of the dwelling does not directly measure interior quality. However, it does correlate well with the other measures (see Table 6).

Number of landlord-supplied appliances is the next attribute used to measure interior quality. That number replaces attributes identifying the type of appliance supplied because the number indicates well what is supplied (see Table 7). Nearly 85 percent of dwellings with two landlord-supplied appliances have a stove and a refrigerator. About 90 percent with three appliances have a stove, refrigerator, and dishwasher. The fourth appliance supplied by the landlord is nearly always an air conditioner.

The coefficient of reproducibility for Guttman scales measures how well the number of appliances predicts the type of appliances supplied. Mathematically, it equals one minus the number of errors (e.g., number

Table 5

DISTRIBUTIONS AND WEIGHTS FOR COMPONENTS OF INTERIOR QUALITY

Component	Distribution of Rating (%)				Weight
	Very Bad	Poor	Fair	Good	
Window rating	.9	6.3	27.8	66.0	.25
Wall and ceiling rating	1.0	5.4	27.4	66.2	.25
Floor and floor covering rating	1.2	6.6	33.2	59.0	.25
Building rating	1.0	6.2	30.6	62.2	.25

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: All variables are derived from household survey responses.

Table 6

CORRELATION MATRIX FOR COMPONENTS OF INTERIOR QUALITY

Row	Component	Column			
		1	2	3	4
1	Window rating	1.00			
2	Wall and ceiling rating	.42	1.00		
3	Floor and floor covering rating	.42	.52	1.00	
4	Building rating	.50	.56	.51	1.00

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: All variables are derived from household survey responses.

of dwellings having one appliance that is not a stove) divided by the total number of responses.* If that coefficient exceeds .90, then substituting the number of appliances for the type of appliances entails no loss of information. Here the coefficient equals .961.

*The total number of responses here equals the number of dwellings times the number of responses, or 1,736 × 5 = 8,680.

Table 7

CONDITIONAL DISTRIBUTION OF DWELLINGS WITH LANDLORD-SUPPLIED APPLIANCES

Number of Appliances Supplied by Landlord	Dwellings with Landlord-Supplied Appliances (%)				
	Stove	Refrigerator	Dishwasher	Air Conditioner	Disposal
1	75.2	5.4	16.1	3.3	0.0
2	98.1	85.4	13.9	1.9	0.7
3	99.5	97.0	91.9	10.6	1.0
4	100.0	100.0	99.6	97.3	3.3
5	100.0	100.0	100.0	100.0	100.0

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: Number of landlord-supplied appliances is calculated from tenants' responses.

The price for the squared number of landlord-supplied appliances is $1.11 per month, so that a dwelling with three such appliances would rent for $9.99 more per month than an otherwise comparable dwelling with no landlord-supplied appliances. One way to assess the reasonableness of that estimated price is to compute the present discounted value of a stove and refrigerator supplied by the landlord. Supplying those appliances would increase rent by $4.44 per month. Assuming they have a useful life of 20 years and that the real discount rate* is 2 percent per year, the present value of those appliances is $879.14, which was enough to pay for those appliances in 1974.

The next four attributes denote the presence of storage space, central forced air or steam heat, a thermostat that controls the amount of heat, and the location of the dwelling on property where additional dwellings were obtained by subdividing existing dwellings. Tenants supplied the information used to construct the first three attributes; landlords furnished information for the last attribute. Presence of storage space actually denotes presence of such space in the dwelling,

*A real rate takes into account the effects of price inflation.

garage, or any other area outside the dwelling. Presence of central forced air or steam heat indicates that those are the primary sources of heat as opposed to floor furnaces, wall heaters, built-in electric heat, portable room heaters, fireplaces, stoves, or no heat. Combining central forced air and steam heat into one attribute entails no loss of information or precision; previous regressions consistently yielded statistically indistinct prices, about $13.50 per month, for the two types of heat.

Presence of subdivided residential space is based on the landlord's response to "Were any units on your property obtained by subdividing existing residential space?" Although that attribute could refer to other dwellings on the property, it usually does not. More than 90 percent of the units for which subdivided residential space is present are located on properties with 2-4 dwellings. Those properties average about 2.25 dwellings per property; so for most dwellings in the data base used here, presence of subdivided residential space on the property ought to indicate that the dwelling itself was affected by subdividing.

Since subdivided dwellings probably have smaller rooms and less convenient interior layouts than others, they should rent for less than otherwise comparable dwellings, which is what the estimated price (-$4.84 per month) indicates.

Exterior Quality

The composite rating of exterior quality combines ten variables that rate the quality of a building's exterior. The trained field-workers who surveyed residential buildings supplied the data for all but one of those variables--the building rating supplied by the landlords. Table 8 gives the distribution of responses for all ten variables and the weights used to combine them; Table 9 shows how those variables correlate. The distributions imply that Brown County's buildings are well-maintained and that their quality varies little, which corresponds to other assessments of the county's housing stock. The weights chosen average the first six variables, which rate specific aspects of the exterior. This average yields another rating of overall condition, which is then averaged with the last four

Table 8

DISTRIBUTIONS AND WEIGHTS FOR COMPONENTS OF EXTERIOR QUALITY

Component	Distribution of Rating (%)				Weight
	Poor	Fair	Good	Excellent	
Roof rating	9.4	3.3	55.7	31.6	.03
Wall rating	4.6	7.4	52.7	35.3	.03
Window rating	.4	1.9	60.7	37.0	.03
Storm window rating	.2	3.1	56.1	40.6	.03
Sidewalk and driveway rating	.8	8.1	74.5	16.6	.03
Exterior repair rating	.8	10.4	61.8	27.0	.03
Overall cleanliness rating	.8	2.2	37.5	59.5	.20
Overall condition rating	.3	12.3	62.8	24.6	.20
Construction quality rating	.2	7.3	79.2	13.4	.20
Building rating	.1	1.6	29.4	76.4	.20

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: All variables except building ratings are derived from responses of trained fieldworkers who completed the residential building surveys. Building rating is derived from landlord responses.

variables.* Combining these ratings into a single rating is valid because the correlations between the ten ratings imply that each partly measures exterior quality.

The next attribute, the composite rating of comparative building quality, averages landlord's, tenant's, and trained fieldworker's appraisals of how their building's condition compares with others in the area. Table 10 gives the distribution and weights for those three appraisals; Table 11 shows how well they correlate. The distributions here again indicate that Brown County's buildings have relatively even quality.

*The weight assigned to each of the first six variables is (1/6) × (1/5) = .03.

Table 9

CORRELATION MATRIX FOR COMPONENTS OF EXTERIOR QUALITY

Row	Component	Column 1	2	3	4	5	6	7	8	9	10
1	Roof rating	1.00									
2	Wall rating	.47	1.00								
3	Window rating	.35	.45	1.00							
4	Storm window rating	.23	.37	.52	1.00						
5	Sidewalk and driveway rating	.22	.29	.26	.28	1.00					
6	Exterior repair rating	.61	.70	.53	.44	.32	1.00				
7	Overall cleanliness rating	.28	.35	.36	.42	.22	.38	1.00			
8	Overall condition rating	.57	.68	.52	.48	.32	.93	.51	1.00		
9	Construction quality rating	.08	.15	.14	.02	.09	.15	.08	.15	1.00	
10	Building rating	.18	.22	.24	.23	.17	.26	.22	.28	.06	1.00

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: All variables except building rating are derived from responses of trained field-workers who completed the residential building surveys. Building rating is derived from landlord responses.

Table 10

DISTRIBUTIONS AND WEIGHTS FOR COMPONENTS OF COMPARATIVE BUILDING QUALITY

Component	Comparative Quality (%)			Weight
	Worse	Similar	Better	
Landlord's rating	6.9	62.7	25.4	.33
Tenant's rating	15.1	67.3	17.6	.33
Fieldworker's rating	3.3	92.8	3.9	.33

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: Variables are derived from responses to landlord, tenant, or residential survey questions that ask for ratings of the quality of the building compared to that of others in the area.

Table 11

CORRELATION MATRIX FOR COMPONENTS OF COMPARATIVE BUILDING QUALITY

Row	Component	Column		
		1	2	3
1	Landlord's rating	1.00		
2	Tenant's rating	.31	1.00	
3	Fieldworker's rating	.22	.16	1.00

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: Variables are derived from responses to landlord, household, or residential building survey questions that ask for ratings of the quality of the building compared to that of others in the area.

Lot size per dwelling measures the amount of outdoor space available to tenants. It is truncated at 10,890 square feet (one-quarter acre), since previous regressions showed that more space does not contribute to the quantity of housing service.* Note that the price of such space, $1.27 per 1,000 square feet, does not equal the price of land. The former is constant in the cross section, whereas the latter is not. Here, location attributes control for variations in land prices.

Buildings with wood or composition siding supply less housing service than those whose exterior is aluminum, brick, stone, or cinder block, as evidenced by the estimated price: -$6.08 per month. Presence of wood or composition siding forms a single attribute because previous regressions showed that either reduces rent by about $6 per month.

Presence of a garage or carport indicates only whether such structures are on the property, not whether a dwelling's occupants have access to an enclosed or covered parking place. That distinction probably explains why garages and carports contribute so little to gross rent--only $3.16--which seems too small an amount, given the severity of winters in Brown County.

The next four attributes distinguish the density and type of property on which the dwelling is located. The excluded type here is a dwelling on a property with 2-4 units, none of which are duplexes. These attributes are included in the index to measure the effects of unobserved attributes such as style or attractiveness. The estimated prices indicate significant differences among dwelling types. Single-family homes rent for no more than the excluded class, whereas tenants on properties with 5-9 dwellings pay about $5.00 more per month. Tenants on properties with 10+ dwellings appear to pay more than tenants on properties with 5-9 units, but the difference is statistically insignificant. Only occupants of duplexes pay a large premium of $31 per

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*A linear function for lot size was fit, whose slope changed at one-quarter acre. Up to that point, the price of outdoor space was 75¢ per 1,000 square feet with a standard error of about 33¢. After that point, the price was zero. Such linear functions and their uses are discussed by Dale J. Poirier, *The Econometrics of Structural Change*, North-Holland Publishing Co., Amsterdam, 1976.

month.* Whether that premium is mostly due to higher hedonic prices or greater quantity is not clear. However, resolving that question is not critical because duplexes make up only 5 percent of the rental market. Moreover, the index adequately measures differences among duplexes regardless of which factor accounts for the size of the premium.

Location Attributes

The regression equation includes location attributes to avoid estimating biased prices for housing attributes and to break down gross rent into location and housing service. Here the effects of location on gross rent are measured by access to employment and neighborhood and by blockface attributes. These three groups of attributes correspond to increasingly narrower definitions of location. Generalized access uses data for all of Brown County. Neighborhood quality attributes use data that describe only the neighborhood in which the dwelling is located, whereas blockface quality attributes use data that describe only the specific blockface of the dwelling.

The attributes that make up those three groups account for the bulk of the variation in gross rents caused by locational differences, which, as we saw earlier, is small. Previous regressions included dummy variables that identified clusters of neighborhoods to test whether the regression should include other location attributes. Those variables were consistently insignificant.

Generalized Access to Employment

Generalized access to employment measures the closeness of dwellings to employment in Brown County. It is defined at the neighborhood level:

$$A_i = \hat{A}_i - \min_i \{\hat{A}_i\}$$

$$\hat{A}_i = \ln \left(E_i + \sum_{\substack{j=1 \\ j \neq i}}^{108} E_j / d_{ij}\right); \qquad i = 1, \ldots, 108, \tag{4}$$

*Unlike other properties with two dwellings, duplexes share a common wall.

where A_i = generalized access to employment for neighborhood i,
$\tilde{A}_i$ = a temporary variable,
ln = the natural logarithm,
$E_{i,j}$ = employment* in neighborhood i or j,
d_{ij} = the airline distance in miles between the centroids of neighborhoods i and j,
i = index of the 108 neighborhoods in Brown County.

For each neighborhood the sum in parentheses weights employment in other neighborhoods by its airline distance from the neighborhood and adds the resulting values to the neighborhood's employment. The neighborhood's residents thus have access to employment that varies directly with the number of jobs and inversely with how far away they are. Logarithmically transforming that sum makes successive increments to employment have declining effects on access. Finally, subtracting access's minimum value arbitrarily rescales access, so that its minimum value is zero.**

As predicted by the economic theory that describes housing prices in a spatial setting, access to employment has a positive price. Access has value because increasing it reduces the cost of commuting to and from work and because there is a fixed supply of land. Here, a dwelling with average access rents for about $15 more per month than a dwelling with minimum access.

Neighborhood Quality

The composite rating of neighborhood quality as well as the fraction of the neighborhood that is open space measure neighborhood quality. Both attributes are defined at the neighborhood level, so all dwellings in a neighborhood have the same values. The composite ratings average

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*Estimated from responses supplied by households.

**Access to employment is not the only attribute with an arbitrary zero point. Other attributes, especially those that rate quality, also have arbitrary zero points. The effects of that arbitrariness are discussed later.

trained fieldworkers' ratings of each blockface's buildings, yards, and cleanliness.* Table 12 distributes those ratings among four categories and gives the weights used to combine the ratings, which indicates that a simple average was used. The ratings are highly correlated (see Table 13), implying that the ratings correspond to a single attribute.

The positive price for neighborhood quality demonstrates that the market values that externality. Tenants pay about $9 per month for each one-unit increase in neighborhood quality.

The fraction of the neighborhood that is open space** measures residents' access to that space. Its positive price shows that most people value such access. Open space can add as much as $8.53 per month to gross rent or about 6 percent of average monthly gross rent.***

Blockface Attributes

The presence of consumer shops, institutions such as schools, and above average landscaping are attributes that measure blockface quality.† The estimated price of each attribute is about $5 per month absolute value, and the signs are reasonable. Dwellings on blockfaces with consumer shops or institutions command smaller gross rents, probably because the presence of such establishments leads to congestion, noise, and possibly vandalism. On the other hand, dwellings on blockfaces with above average landscaping rent for more than otherwise comparable dwellings, suggesting that this externality also has value in the marketplace.

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*Brown County is composed of about 8,300 such blockfaces, each of which was rated by trained fieldworkers. For a general assessment of the data they gathered and specific assessment of the ratings used here, see C. Lance Barnett, *Audit of the Baseline Neighborhood Survey in Site I*, The Rand Corporation, WN-9732-HUD, April 1977 (forthcoming as N-1115-HUD).

**Open space is the portion of each neighborhood's total acreage devoted to public parks, golf courses, woodland, and agriculture. It is derived from land use data collected by the Brown County Planning Commission.

***The maximum value for the fraction is .86 and the price per month is $9.92, so (.86)($9.92) = $8.53.

†All three attributes are based on observations by trained fieldworkers who completed the survey of residential buildings.

Table 12

DISTRIBUTIONS AND WEIGHTS FOR COMPONENTS OF NEIGHBORHOOD QUALITY

Component	Distribution of Rating (%)				Weight
	Poor	Fair	Good	Excellent	
Building rating	15.8	42.9	22.6	18.7	.33
Yard rating	15.3	48.9	29.2	6.6	.33
Cleanliness rating	24.8	55.3	19.5	.4	.33

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: Variables are derived from trained fieldworkers' ratings of individual blockfaces.

Table 13

CORRELATION MATRIX FOR COMPONENTS OF NEIGHBORHOOD QUALITY

Row	Component	Column		
		1	2	3
1	Building rating	1.00		
2	Yard rating	.88	1.00	
3	Cleanliness rating	.87	.82	1.00

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: Variables are derived from trained fieldworkers' ratings of individual blockfaces.

Price Adjustments

Although the theory presented above states that the market clearing price of housing and location services is a constant, the prices actually paid can vary. Most of that variation is essentially random, but some can be explained by the nature of relationships between tenants and landlords. The regression fit here includes variables that

characterize those relationships. The effect of those variables is to adjust the prices actually paid so that they are closer to the market clearing prices.

Length of Stay

Most hedonic indexes fit for rental housing find that the longer tenants stay in a dwelling, the more their rent drops relative to what new tenants would pay.* Exactly why tenants who stay receive discounts is unclear. One explanation is that those tenants may reduce maintenance costs for landlords who then return that saving as discounts. Another explanation is that landlords may value the steady income provided by long-staying tenants and may buy that stability with discounts.

Here the effect of tenants' length of stay on gross rent is modeled with a spline function that bends at 3.5 years. Each year of residence before 3.5 years reduces rent by about $4.50 per month. After 3.5 years, rents stop declining.** The maximum discount at 3.5 years equals about $16.00 per month or about 11 percent of average monthly gross rent.

Tenants' Satisfaction with Dwelling

Tenants' satisfaction with their housing was included in the index to measure the effects of attributes that were hard to quantify (e.g., style or superior interior layouts). If satisfaction measured such effects, it should have had a positive price. However, the coefficient for tenants' satisfaction is significantly negative, suggesting that it actually measures whether tenants have a "good deal." Assuming that housing and location attributes accurately measure quantities, tenants' satisfaction would rise as the price of housing or location services fell relative to the market clearing prices. For that reason, tenants' satisfaction belongs with other variables that adjust for price differences.

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*See, for example, Merrill, *Draft Report on Hedonic Indices.*

**Spline functions are piecewise linear. Along the jth piece the slope equals the sum of the slopes for the previous $j - 1$ pieces plus the slope for the jth piece. For lengths of stay exceeding 3.5 years, the slope is $-4.45 + 3.86 = -.59$, which is indistinguishable from zero.

Presence of a Resident Landlord

Landlords living on their property may choose tenants more carefully than other landlords, primarily because their tenants are also their neighbors. They might also retain desirable tenants by offering rent discounts. The estimated coefficient is consistent with such behavior. However, its value is small (-$2.12 per month) and is not significantly different from zero.

The Constant Term

The constant term should equal zero, so that setting all attributes equal to zero implies a monthly gross rent that equals zero; that is, dwellings that supply nothing command no rent. The constant term, however, is significantly negative, -$35.58 per month. The regression fits a negative constant term because the zero points chosen for the attributes, especially the composite ratings, are on average less than their true zero points.* The following equations justify that explanation. Consider the bivariate regression

$$R = -a + b(X + c), \qquad (5)$$

where R = monthly gross rent,

$-a$ = the negative constant term,

b = the estimated (positive) price of attribute X,

X = an attribute,

c = the difference between the chosen and true zero point for X.

Setting R and X equal to zero and rearranging terms yields

$$c = a/b,$$

*Excluding important attributes from the regression could also produce a similar result; however, as shown below, that is not the issue here. Also, our work on the hedonic index for St. Joseph County supports the explanation advanced here. That index has only two composite ratings, and the constant there is statistically indistinguishable from zero. See Charles W. Noland, *Hedonic Indexes for St. Joseph County, Indiana*, The Rand Corporation, N-1305-HUD, forthcoming.

so that c is greater than zero, which implies that the true zero exceeds the chosen zero.*

The differences between true and actual zero points do not impair the index's ability to measure differences in the services provided, since such measurement depends only on differences in the attributes' values, in which case the true zero points net out. The index can thus be used to estimate marginal propensities to consume individual attributes such as rooms and summary attributes such as space. Those differences, however, do mean that measurements on the attributes cannot be converted into percentages, since those differences imply that attributes are not measured on a ratio scale. In particular, expenditures on attributes cannot be used to estimate such elasticities as the income elasticity of the demand for space.

APPRAISING THE INDEX

The preceding portion of this section presented the index, documented the attributes measuring housing and location service, and when possible, assessed the signs and sizes of the estimated prices. In general, it found nothing amiss. The remainder of this section appraises the index's ability to accurately measure differences in the quantity of housing or location services supplied or consumed.

The standard error of the estimate measures how closely the regression equation fits the data and indicates the degree of confidence with which the regression can estimate rent or measure differences in the amount of services supplied or consumed. As shown in Table 14, the standard error here is smaller than those of other hedonic indexes.** The standard errors presented in that table have about the same or

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*It is possible to compute zero points for the attributes that yield zero for the constant term. However, the new zero points would not necessarily equal the true points.

**Unlike R^2s, which equal the fraction of the dependent variable's variation explained by the regression equation, standard errors can be meaningfully compared across data bases and in some instances across specifications.

Table 14

STANDARD ERRORS FOR HEDONIC INDEXES FIT TO EXPERIMENTAL HOUSING ALLOWANCE PROGRAM: DATA FOR RENTAL HOUSING

Institution and Housing Market	Standard Errors of the Estimate	
	$/Month	As Percent of Average Rent
Rand		
Brown County WI	20.00	15.3
Abt Associates		
Pittsburgh PA	19.99	18.8
Phoenix AZ	22.33	18.0
Urban Institute		
Pittsburgh PA	23.98	28.9
Phoenix AZ	29.90	29.5

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County; and from data in Sally Merrill's *Draft Report on Hedonic Indices as a Measure of Housing Quality*, Abt Associates, Cambridge, Mass., Report 76-9612, 23 December 1977, and from Jeanne E. Goedert, Larry J. Ozanne, Robert W. Tinney, and Joseph J. Valenza, *The Integrated Analysis of Housing Quality Improvements: Two Initial Approaches*, The Urban Institute, Washington, D.C., WP 216-15, 17 June 1975.

larger absolute values, but when expressed as a percentage of average rent, the error is noticeably smaller. Thus, the index fit here should be at least as accurate as those fit by others.

Having a nontrivial standard error for the regression equation raises the question: Are the errors systematic or random? Either incorrectly specifying attributes' functional forms or excluding important attributes from the regression would generate systematic errors. If such systematic errors occurred, the index would be biased. On the other hand, if the errors are random, the index ought to be unbiased. Determining which type of error prevails is most easily done by plotting

residuals against predicted values of the dependent variable and against independent variables. Because the logarithm of rooms is the index's most significant variable, a residual plot for that variable is reproduced here.

The figure plots average residuals of gross rent for each size of dwelling against the regression estimate, the latter displayed as a solid line. The distribution of residuals indicates that the room variable is correctly specified by the natural log form and that no important attributes correlated with rooms were excluded from the index.

Another test for the presence of specification error is to regress on the index's residual total household income, which would contain any excluded attributes. They should be normal goods, so their consumption should vary directly with income. A significant coefficient for income would then indicate that some important attributes had been excluded from the index, raising the possibility that the estimated prices are biased.*

Although income's coefficient differs significantly from zero (it is positive), what was excluded did not bias the estimated attribute prices. Income explains very little of the variation in the index's residual: The standard error of the estimate for this ancillary regression is $19.77 per month versus $20.00 per month variation for the index's residual, and its R^2 is less than .01. Moreover, when income is included in the hedonic index, none of the estimated attribute prices change very much.** In fact, none changed by more than one standard deviation.

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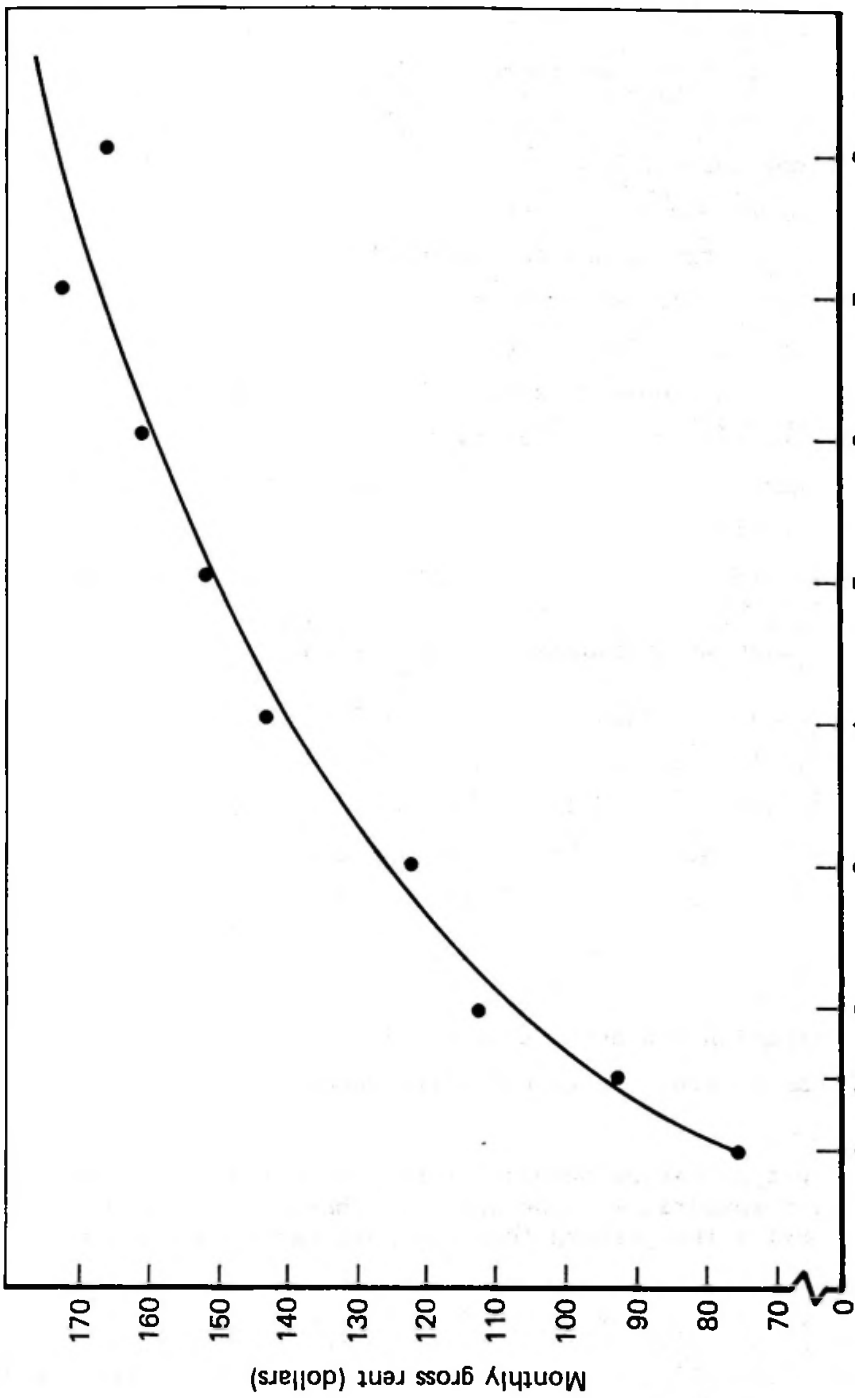
*The degree of bias depends directly on the correlations between included and excluded attributes as well as on the prices for the excluded attributes.

**Variation in the residuals, although not caused by a major misspecification, may be price variation occurring because individuals' knowledge of the housing market is imperfect and acquiring information is costly. Thus, specific transactions between a household and a landlord may take place at prices higher or lower than the expected market clearing prices. If the expected prices do not systematically vary within the market, then variation in the transaction prices does not adversely affect the index. It induces no bias, but does reduce the index's accuracy.



Effect of number of rooms on gross rent

The presence of significant dwelling-type premiums in the marketwide index could be brought about in part by specification errors--either misspecification of included attributes or by excluded attributes.* If those errors affect only a few attributes, their effect could be compensated for by transforming those attributes.** Here, however, the errors affected more than just a few attributes. Fitting five separate regressions, each of which includes all interactions between the variables that compose one summary attribute (i.e., space, interior quality, etc.) and dwelling types, and testing whether the interaction terms have nonzero coefficients indicates that the errors affect all attributes except those of residential space (see Table 15). Since space is one of the most important determinants of rent, finding that it is again unaffected by specification error is reassuring.

Introducing the interaction terms (overall more than 90 were used) only slightly affects the regression's predictive power. The highest R^2 obtained exceeds that for the marketwide regression by less than 1.5 percentage points; the smallest standard error is only $.27 less per month than that for the marketwide regression, which was obtained when the interactions between dwelling type and interior quality were included. That outcome is understandable. The attributes that the marketwide index excludes are probably the most subtle measures of quality, ones that ought to be most highly correlated with dwelling type and the included measures of interior quality.

CONCLUSIONS

The information presented thus far indicates that the index should accurately measure cross-sectional differences between dwellings. No

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*Dwelling type per se should not be considered an attribute, because it simply summarizes those features that cause some dwellings to yield more service than others (e.g., single-family homes and privacy).

**Included attributes can be transformed to account for excluded attributes. Consider rooms and average room size in square feet: If average room size varies across dwellings, then an interaction term between type of dwelling and average room size could be included to account for such variation.

Table 15

TESTS FOR PRICE DIFFERENCES BY ATTRIBUTE GROUP

Interaction Terms Tested	Number of Terms	*F*-value
Space attributes with dwelling-type indicators	8	1.16
Interior quality attributes with dwelling-type indicators	24	2.94[a]
Exterior quality attributes with dwelling-type indicators	20	3.16[a]
Location attributes with dwelling-type indicators	24	2.10[a]
Price adjustments with dwelling-type indicators	15	2.24[a]

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

NOTE: Attributes that compose each attribute group described above are defined in Table 1.

[a]Significant at 95 percent confidence level.

estimated coefficients have signs that cannot be reasonably explained. With only one exception those signs agree with what a priori reasoning would imply they should be. The prices also appear to have reasonable magnitudes. The index's standard error is no larger than that of other studies, and when expressed as a percentage of average rent, it is smaller. Tests for specification errors found no evidence for the presence of significant error, which suggests that the index is unbiased.

III. USING THE INDEX

A hedonic index for housing service can be used to transform measurements on attributes into measures of service that are comparable, only if the attribute prices do not differ between dwellings. That invariance is what allows attributes of dwellings and their locations to be treated as if they were a single good, that is, a composite commodity. This section first verifies that attribute prices are sufficiently constant across dwellings to treat housing as a composite commodity. Having established that, this section then uses the index to examine two aspects of consumer behavior: the relative effectiveness of alternative ways that renters search for dwellings, and the effect of income on renters' consumption of the attributes of dwellings.

HOUSING AS A COMPOSITE COMMODITY

Goods, such as the attributes of dwellings and their locations, can be treated as if they were a single commodity so long as their relative prices do not vary in the situation being studied.* One advantage of having goods thus related is that consumer behavior with respect to them can be more easily analyzed. This is so because the prices of those goods can be used to coalesce measurements on them into a scalar measure of the quantity of services supplied.

Here I will test whether the attribute prices vary between dwellings. Two factors could cause such variation. One is the existence of demand-based submarkets, which could support distinct vectors of attribute prices. The other is differences in the supply function of dwellings which, even in the longrun, could induce distinct vectors of attribute prices.

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*For the formal theory supporting that assertion, see J. R. Hicks, *Value and Capital*, Oxford Press, Oxford, England, 1939, pp. 33-34, 312-313. For a more general composite commodity theorem, see Nissan Liviatan, "A Generalization of the Composite-Good Theorem for Imperfect Markets," *Review of Economic Studies*, Vol. 33, 1966, pp. 45-56.

For any housing market to divide into submarkets supporting different attribute prices, several conditions must hold. First, the market must contain groups of consumers who prefer one type of dwelling (however defined) to another. Second, their demands (relative to supply) must differ across dwelling types. Third, the cross-elasticities of demand between dwelling types must be near zero. The first two conditions allow demand to concentrate in potential submarkets; the last condition keeps demand differences focused in those submarkets, so that different attribute prices can emerge.

The third condition, fundamental to the existence of submarkets supporting distinct attribute prices, was unlikely to have prevailed in Brown County in 1974. The only plausible circumstances that could bring about near zero cross-elasticities are extensive market segregation or, in the shortrun, a sudden demand surge. Brown County is characterized by an unusually homogeneous population: Ethnic identification is low, and less than 2 percent of its households are headed by a minority.* Thus, the usual bases for market segregation are absent. As for a sudden demand surge, the available evidence argues against it. Our studies of property values indicate that prior to 1974 they were rising at the same rate as consumer prices in general.** Our study of rent inflation after 1974 indicates that Brown County's rents rose at rates comparable to those of other cities in the North Central region and the nation during the three years after 1974.***

Even though attribute prices were not likely to have differed because of demand factors, supply functions may vary because of differing production technologies. The dimension along which they would most likely differ is dwelling type;† it is reasonable to suppose that

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*Kevin F. McCarthy, *Housing Choices and Residential Mobility in Site I at Baseline*, The Rand Corporation, WN-9029-HUD, August 1976 (forthcoming as N-1091-HUD).

**See the *Third Annual Report of the Housing Allowance Supply Experiment*, The Rand Corporation, R-2151-HUD, February 1977, pp. 68-70.

***See Stucker, *Rent Inflation in Brown County, Wisconsin: 1973-78*.

†Five dwelling types are distinguished here, four of which are included in the marketwide index: single-family homes, duplexes, dwellings on 5-9 dwelling properties, and dwellings on 10 or more dwelling properties. The excluded category is composed of dwellings on 2-4

single-family homes use a different technology than apartments in large structures. To test for differences in attribute prices, four regressions were fit, each of which included all interaction terms between one of the dwelling types identified in the marketwide regression and all other attributes (including price adjustments) in the regression. Table 16 presents *F*-values to test the null hypothesis that those interaction terms have coefficients that equal zero.* Only for single-family homes can the null hypothesis be accepted. For the other three dwelling types, there are significant price differences.

Those price differences, however, are not operationally important. Table 17 summarizes the differences between using the marketwide index and subindexes that incorporate price variations by dwelling type to measure changes in the quantity of services as attributes vary.** None of the differences is statistically distinct. The largest absolute difference is less than the marketwide index's standard error. The average absolute differences are small; for duplexes that difference is less than 8 percent of their average monthly gross rent of $179.

EFFECTS OF SEARCH STRATEGIES

McCarthy has used the index's residual to measure the effectiveness of various search strategies renters use to find homes that are bargains*** (i.e., dwellings renting at a discount). Such use of the residual is valid because the index used here sufficiently controls for quantity (leaving only price variation in the residual). Price

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dwelling properties that are not duplexes. For ease of explanation, the last three types will be referred to as 5-9, 10+, and 2-4, respectively.

*These tests are functionally equivalent to tests of whether the vector of coefficients for a given dwelling type differs from a single vector for the remaining types.

**The differences were obtained by using the marketwide index and an index fit to data for the indicated dwelling type to predict monthly gross rent for five vectors of independent variables: (a) the submarket's means less two standard deviations, (b) less one standard deviation, (c) untransformed, (d) plus one, and (e) plus two standard deviations.

***Kevin F. McCarthy, *Housing Search and Residential Mobility*, The Rand Corporation, R-2451-HUD, September 1979.

Table 16

TESTS FOR PRICE DIFFERENCES
BY DWELLING TYPE

Interaction Terms Tested	Number of Terms	*F*-value
Single-family homes with all other attributes[a]	22	1.28
Duplexes with all other attributes[a]	23	2.36[b]
5-9 dwellings on property with all other attributes[a]	23	2.73[b]
10+ dwellings on property with all other attributes[a]	23	2.12[b]

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

[a]Excludes indicator variables for the other dwelling types.

[b]Significant at 95 percent confidence level.

Table 17

DIFFERENCES BETWEEN MONTHLY GROSS RENTS PREDICTED
USING MARKETWIDE INDEX AND SUBINDEXES

Dwelling Type	Differences Between Predictions	
	Average of Absolutes	Maximum
Duplexes	13.08	21.80
5-9 dwellings on property	2.88	4.80
10+ dwellings on property	3.45	6.01

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys for Brown County.

discounts and premiums are measured by

$$P' = \frac{R - \hat{R}}{\hat{R}} = \frac{PQ - \overline{P}Q}{\overline{P}Q} = \frac{P - \overline{P}}{\overline{P}}, \qquad (6)$$

where P' = the relative price of a dwelling,

R = gross rent,

$\hat{R}$ = predicted gross rent,

P = price paid in a dwelling,

Q = quantity of services supplied,

$\overline{P}$ = hedonic price for residential services.

The substitution of $\overline{P}Q$ for $\hat{R}$ is justified because dwellings can be treated as a composite commodity.

When P' is regressed on variables indicating how households searched for their dwellings as well as on the characteristics of those households, the only strategy found that consistently ferrets out bargains is finding the dwelling through tips from friends. That same regression also shows that households eligible for the housing allowance program occupy bargain dwellings, presumably because they face competing demands for their meager budgets and so emphasize price in their housing choices.

MARGINAL EXPENDITURES FOR SUMMARY ATTRIBUTES

Table 18 shows marginal expenditures on four summary attributes (space, interior quality, exterior quality, and location) and total residential services as a function of income.* Marginal rather than absolute expenditures are used because the index is capable only of measuring differences. The marginal expenditures equal the difference between the expenditures of low-income households (i.e., those whose annual income is less than $5,000) and what households in each income bracket actually

*Tables 18 and 19 cannot predict the effects of increasing renters' income, because as income rises, some renters would choose to become owners (whose consumption patterns are known to differ from those of renters, even controlling for income).

Table 18

MARGINAL EXPENDITURES ON SUMMARY ATTRIBUTES AS INCOME INCREASES: HOUSEHOLDS WITH INCOMES OVER $5,000

Income Category	Marginal Expenditure ($/mo.) Relative to Low-Income Families[a]				
	Space[b]	Interior Quality[b]	Exterior Quality[b]	Location[b]	Residential Services[c]
$5,001-7,500	-.81	3.44	2.71	.45	5.79
$7,501-10,000	2.24	3.24	3.86	.29	9.33
$10,001-12,500	4.65	4.19	6.18	1.31	16.33
$12,501-15,000	4.28	7.43	10.88	1.93	24.52
$15,001-17,500	4.21	7.55	8.77	.29	20.82
$17,501-20,000	9.84	8.08	15.40	1.97	35.29
$20,001+	7.01	9.45	17.71	2.34	36.51

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys in Brown County.

NOTE: Table entries are computed by subtracting average predicted expenditure for families whose annual income is less than $5,000 from remaining average predicted expenditure.

[a] Families whose annual income is less than $5,000.

[b] See Table 1 for attributes in each hedonic good.

[c] Predicted gross rent plus price adjustments.

spend. The highest income renters, for example, spend $7.01 more per month for space than the lowest income households.

Expenditures on summary attributes were computed by multiplying the value of each component by its price and summing the products.* Expenditures on space, for example, equal $46.70 times the natural logarithm of the number of rooms, plus $18.86 times the number of bathrooms.

Several conclusions can be drawn from the patterns in Table 18. First, renters' marginal propensity to consume residential service** is

*Table 4 gives the estimated prices for the individual attributes and identifies the attributes that compose each summary attribute. Since prices are constant, marginal expenditures equal marginal consumption.

**Residential service equals monthly gross rent plus the price discounts that accrue with length of stay and those due to tenants' satisfaction and presence of a resident landlord.

very small. Families whose annual income falls between $17,501 and $20,000 spend only $29.50 more per month than families whose annual income falls between $5,001 and $7,500. Differencing the midpoints of those intervals and dividing by 12 to obtain monthly income yields a marginal propensity to consume residential services of $.03 per month; this means that an extra dollar of monthly income causes housing consumption to increase by $.03. That number is consistent with current income elasticities we estimate using data for Brown County.*

Second, most increased consumption is brought about by better exterior and interior quality, a fact consistent with the finding on the relative importance of the attributes. The highest income households spend $36.51 more per month than the lowest income households. Nearly 75 percent of that difference ($27.16 out of $36.51) is accounted for by increased expenditures on the quality attributes; almost 50 percent is due to increased expenditures for exterior quality alone. Thus, higher income households appear to prefer "better" housing to "more" housing.

Finally, expenditures for location have a very irregular relationship to income. Table 19, whose format and entries were obtained in the same manner as Table 18, shows that the irregularity is caused by shifting composition in the location attributes. As income rises, renters purchase less access to employment. On the other hand, they buy better neighborhoods. In Brown County, those expenditure changes tend to offset one another, yielding the irregular pattern observed in Table 18.

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*See John E. Mulford, *The Income Elasticity of Housing Demand*, The Rand Corporation, R-2449-HUD, July 1979. He estimates that renter's current income elasticity of expenditures is about .15. Assuming an average expenditure share of .25, the implied marginal propensity to consume is .0375.

Table 19

MARGINAL EXPENDITURES ON LOCATION ATTRIBUTES AS INCOME INCREASES RELATIVE TO LOW-INCOME FAMILIES

Income Category ($/yr)	Marginal Expenditures Relative to Low-Income Families[a] ($/mo.)			
	Access to Employment	Neighborhood[b] Quality	Blockface[b] Quality	Location[c]
$5,000-7,500	-.83	1.33	-.05	.45
$7,501-10,000	-1.66	1.95	0.00	.29
$10,001-12,500	-1.37	2.18	.50	1.31
$12,501-15,000	-1.81	3.69	.05	1.93
$15,001-17,500	-3.53	3.75	.07	.29
$17,501-20,000	-3.00	4.32	.65	1.97
$20,001+	-2.20	4.04	.50	2.34

SOURCE: Tabulated by author from 1,736 records of baseline household, residential building, neighborhood, and landlord surveys in Brown County.

NOTE: Table entries are computed by subtracting average predicted expenditure for families whose annual income is less than $5,000 from remaining average predicted expenditures.

[a] Families whose annual income is less than $5,000.

[b] See Table 1 for attributes in each hedonic good.

[c] Expenditure on location equals the sum of expenditures on access to employment, neighborhood quality, and blockface quality.

IV. CONCLUSIONS

The purpose of this report has been to present and appraise the usefulness of a hedonic index fit to marketwide data describing Brown County's rental housing stock in 1974. All evidence for that appraisal is now available. Section II showed the relative importance of the five groups of variables that compose the regression with which the index was fit: Location attributes are unimportant, as are price adjustments; attributes of dwellings are the most important. Section II also discussed the 27 attributes and price adjustments used to fit the index. With one exception (tenants' satisfaction with their dwellings) their signs and magnitudes were generally reasonable. When external evidence was available, it confirmed that the magnitudes of the coefficients were roughly correct. Tests for specification error showed that although the index does exclude some attributes valued by the market, their exclusion does not adversely affect the accuracy with which the index can measure contemporaneous differences among dwellings.

After verifying that dwellings can be treated as a composite good, Sec. III showed two ways the index can be used to analyze household behavior. It first showed how the index was used to determine whether search strategies adopted by renters significantly affected the price they paid. The main finding there was surprising but plausible: The best way to find housing bargains is through tips from friends. The index was also used to study how renters change their expenditures on four summary attributes as their income rises. Consumption of space varies much less with income than does consumption of interior and exterior quality; so higher income renters buy "better" rather than "more" housing. Changes in the last two summary attributes account for about 75 percent of the increased consumption of residential services (housing plus location services). Although the amount renters spend on location does not vary with income, what they buy does. Higher income renters live farther from the center of town, giving up access in order to occupy better neighborhoods.

The index might also be used to measure changes in housing services brought about by the housing allowance program. It is unlikely, however, that the program will affect many of the attributes that compose the index. All but three dwelling attributes (the composite ratings) refer to structural characteristics of the dwelling that would change only by substantial rehabilitation or remodeling. The allowance program rarely induces such remodeling.* Certainly it is improbable that the allowance program will affect the location attributes of dwellings. Therefore I predict that the index will not distinguish allowance-induced changes from zero. Nonetheless, the index is a valuable tool for analyzing the characteristics of Brown County's rental housing market and the behavior of its participants.

One obvious use of the index would be to estimate expenditure functions for the summary attributes. Such functions would incorporate the effects of differences in household size, life-cycle stage, assets, and household income. Once such functions were fit, they could be used with data on allowance recipients to determine how receiving allowance income affected recipients' choice of summary attributes. Another use of the index would be to compute differences in the prices of neighborhoods (i.e., how much more it costs to live in neighborhood A compared with neighborhood B). If those differences were substantial, they would provide an explanation for the program's lack of interneighborhood mobility.**

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*See James L. McDowell, *Housing Allowances and Housing Improvement*, The Rand Corporation, N-1198-HUD, September 1979.

**The *Fourth Annual Report of the Housing Assistance Supply Experiment*, The Rand Corporation, R-2302-HUD, May 1978, presents early findings on the program's effects on recipients' mobility.

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CONSUMPTION INCREASES CAUSED BY HOUSING ASSISTANCE PROGRAMS

C. PETER RYDELL
JOHN E. MULFORD

R-2809-HUD
APRIL 1982

HOUSING ASSISTANCE SUPPLY EXPERIMENT

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The Office of Policy Development and Research
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PREFACE

This report draws on research conducted by The Rand Corporation as part of the Housing Assistance Supply Experiment, which was sponsored and funded by the Office of Policy Development and Research, U.S. Department of Housing and Urban Development (HUD). The report is a product both of research on the market effects of housing allowances under HUD Contract H-1789 and of basic research on housing market behavior under HUD Grant H-5099RG.

Four information sources are crucial to the report's results:

- G. Thomas Kingsley and Priscilla M. Schlegel, *Housing Allowances and Administrative Efficiency*, The Rand Corporation, forthcoming.
- Stephen K. Mayo, Shirley Mansfield, David Warner, and Richard Zwetchkenbaum, *Housing Allowances and Other Rental Housing Assistance Programs--A Comparison Based on the Housing Assistance Demand Experiment; Part 1; Participation, Housing Consumption, Location, and Satisfaction; Part 2: Costs and Efficiency*, Abt Associates, Inc. (Part 1: AAI 79-111, Part 2: AAI 79-132), June 1980.
- John E. Mulford, James L. McDowell, Lawrence Helbers, Michael Murray, and Orhan Yildiz, *Housing Consumption in a Housing Allowance Program*, The Rand Corporation, R-2779-HUD, forthcoming.
- C. Peter Rydell, *Price Elasticities of Housing Supply*, The Rand Corporation, R-2846-HUD, forthcoming.

Readers interested in the housing allowance program as compared with public housing programs or unrestricted cash grants may also be interested in a parallel report, which compares the allowance program with the Section 8 Existing Housing Assistance Program:

- C. Peter Rydell, John E. Mulford, and Lawrence Helbers, *Price Increases Caused by Housing Assistance Programs*, The Rand Corporation, R-2677-HUD, October 1980.

SUMMARY

This report compares and contrasts three methods of providing housing assistance to low-income renters: the public housing program, which actually constructs housing for eligible tenants; the housing allowance program, which supplements the income of eligible tenants on condition that they live in housing that meets minimum standards; and unrestricted cash grants, which unconditionally supplement the income of eligible tenants. All three provide not only housing benefits (increased housing consumption for program participants and, to a limited extent, for nonparticipants by means of market effects), but also nonhousing benefits (increased nonhousing consumption brought about by subsidy formulas that more than pay for increased housing consumption).

Each program entails costs that exceed its benefits. Total program costs equal the subsidies that pay for housing and nonhousing increases plus nonsubsidy expenses. Nonsubsidy expenses include the costs of conducting eligibility tests in all three programs and of enforcing the housing standards in the housing allowance and public housing programs; they also include above-market development costs in the public housing program.

Dividing housing and nonhousing consumption increases by total program cost yields the two ratios by which this report evaluates the alternate programs: (a) dollars of increased housing consumption per program dollar, and (b) dollars of increased nonhousing consumption per program dollar. Adding the measures gives total consumption increases per program dollar; the sum is always less than 1.0 because of nonsubsidy program costs.

The evaluation finds that if the alternative programs serve the same population, impose the same housing standards, and provide the same total subsidy to participants, the allowance program will perform unambiguously better than public housing and conditionally better than cash grants:

Type of Consumption	Consumption Increase per Program Dollar		
	Housing Allowances	Public Housing	Unrestricted Cash Grants
Housing	.15	.08	.07
Nonhousing	.68	.32	.81
Total	.83	.40	.88

Housing allowances are shown to deliver almost twice as much increase in housing consumption (per program dollar) as public housing, and more than twice the increase in nonhousing consumption. The poorer performance of the public housing program is due to the above-market development costs incurred in constructing public housing, and also to cutbacks in privately supplied housing that offset almost nine-tenths of the publicly supplied housing.

Compared with unrestricted cash grants, housing allowances are found to produce more than two times the housing consumption increase per program dollar but only about four-fifths the nonhousing increase. Total increases per program dollar are higher for unrestricted cash grants because the allowance program incurs the extra expense of enforcing the housing standards--which lead, however, to greater housing benefits. The choice between housing allowances and unrestricted cash grants depends on the relative importance given housing and nonhousing consumption increases. The allowance program is preferable to unrestricted cash grants if double the housing assistance is more important than a one-sixth cut in nonhousing assistance.

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I. INTRODUCTION

There are two fundamentally different strategies for providing housing assistance to low-income households: (a) the supply strategy, which constructs housing that meets minimum standards and rents it to low-income households below cost; and (b) the demand strategy, which augments the income of low-income households, provided they live in housing that meets the minimum standards. Both strategies subsidize low-income households. They differ in that the first increases the supply of standard housing directly, while the second increases it indirectly through the private market's response to demand increases.

Before 1970, U.S. housing policy relied almost exclusively on the supply strategy. However, during the last decade the supply and demand strategies have assumed roughly equal importance.[1] In the future, if the new administration has its way, the demand strategy will become increasingly dominant.[2]

What is causing this revolution in U.S. housing policy? First, the supply strategy costs too much: government-built housing costs considerably more than privately built housing. Second, the demand strategy works: the private market does in fact supply additional standard housing, provided the government subsidizes demand and enforces the minimum standards.

Seven studies during the past dozen years have reported estimates of how much more government-built housing costs than privately built housing.[3] Smolensky (1968) found the ratio of public cost to private

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[1] Only 5 percent of the subsidized rental units in 1970, but 52 percent of the additional subsidized rental units from 1970 to 1977 were privately owned existing units. See *HUD Statistical Yearbook, 1971*, (1972, Table 149); and *1977*, (1978, Tables H85 and H125).

[2] Office of Management and Budget director David A. Stockman told the House banking committee on March 6, 1981, that he "would rather provide direct assistance to the families or individuals that need housing assistance than through the construction programs that we have today." See the *Housing and Development Reporter* (1981, p.849).

[3] In all these studies, "cost" comprises the annualized development cost, plus operating costs, plus governmental subsidies such as property tax reductions.

some former participants live in dwellings that are in better condition than they would have been without the demand program. (The upgrading caused by the program does not instantly decay when participants leave the program; see Mulford et al., forthcoming.)

So far we have followed the traditional method of housing program analysis in which the participant is the unit of account and which treats housing consumption increases per participant and program costs per participant. We depart from tradition, however, to combine the two measures into a single one: dollars of increased housing consumption per dollar of total program cost. That measure ignores the question whether program benefits are concentrated on a few households or spread out over many, focusing instead on a program's ability to convert assistance dollars to housing benefits.

Then, because no housing program provides only housing benefits, we also analyze a parallel ratio: dollars of nonhousing consumption increase per dollar of total program cost. Increases in nonhousing consumption arise whenever the income subsidy provided by an assistance program is larger than the housing consumption increase it causes.

The increases in nonhousing consumption caused by housing assistance programs are, in general, larger than the housing consumption increases. That is a surprising outcome for housing programs, but easily explained. Federal housing programs tend to require low-income families to pay only a fourth of their income for housing; that is what the average U.S. household pays for housing. However, in actuality, low-income households pay on the average over half their income for housing (see Mulford, 1979). Consequently, when low-income households join a housing assistance program, a substantial amount of the subsidy they receive goes to nonhousing consumption.

The large antipoverty component of housing assistance programs raises the question whether the programs contribute more to housing consumption than unrestricted cash grants would. After all, if low-income households receive an income supplement, at least some of it would be spent on increased housing consumption; and since an unrestricted cash grant program would not incur the costs of providing housing (as in the supply strategy) or of enforcing minimum housing

standards (as in the demand strategy), the dollars of increased housing consumption per program dollar could conceivably be even greater in an unrestricted cash grant program than in either the supply- or demand-strategy housing assistance programs.

Consequently, even though our report concerns housing assistance programs, it also analyzes an unrestricted cash grant program. We want to know not only which housing assistance strategy is best (supply or demand), but also whether either is better than unrestricted cash grants.

We cannot always unambiguously rank the alternate programs. Only if a program is better than another program on both measures (dollars of increased housing consumption per program dollar, and dollars of increased nonhousing consumption per program dollar) can it be deemed better without doubt. The sum of the two measures--total consumption increase per program--cannot be used to rank alternate programs because any housing program distorts consumption choices. Both the supply and demand housing assistance strategies deliberately force program participants to consume more housing than they would if provided unrestricted cash grants with an equivalent subsidy. Given that program design, housing policymakers obviously weight increased housing consumption more heavily than they do increased nonhousing consumption (see the discussion of housing as a merit good in De Salvo, 1976). On the other hand, since housing program participants overconsume housing (in terms of their own preferences), they give less weight to increased housing consumption than to increased nonhousing consumption (see the discussion of "consumption inefficiency" in Murray, 1980). Consequently, since neither the providers nor the recipients of housing assistance weight our two outcome measures equally, the sum of the two measures does not correctly measure program benefits.

Moreover, the two measures are not the only ones by which housing assistance programs are judged. For example, reduction in occupied substandard housing is a major goal of both supply- and demand-strategy housing assistance programs. Numerous other objectives are noted in the housing literature. Nevertheless, there is wide agreement that increases in housing and nonhousing consumption are important evaluation criteria.

To be concrete, we must analyze particular programs in particular places at particular times. For the supply strategy, we examine public housing programs in Pittsburgh, Pennsylvania, and Phoenix, Arizona, in 1975. For the demand strategy, we examine the housing allowance program (HASE) in Green Bay, Wisconsin, and South Bend, Indiana, from 1973 to 1977.

The choice of programs is dictated by the fact that public housing and housing allowances are the purest examples of the supply and demand strategies ever operated in the United States. Locations and dates are dictated by data availability. The Mayo et al. (1980) study of Pittsburgh and Phoenix provides the best data on benefits and costs in public housing programs; and HASE provides the only information about benefits and costs in a full-scale housing allowance program.[6]

The plan here is first to analyze changes in housing and nonhousing consumption by participants in alternate assistance programs (Sec. II), then to consider changes in nonparticipant consumption caused by the programs (Sec. III). In both analyses, the focus systematically rests on the two fundamental performance measures: housing consumption increases per program dollar and nonhousing consumption increases per program dollar.

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[6]Benefit and cost data from the limited-scale, random assignment housing allowance program conducted by the Housing Allowance Demand Experiment in Pittsburgh and Phoenix, analyzed in Appendix A, are found consistent with the HASE data.

II. CONSUMPTION CHANGES OF PARTICIPANTS

This section compares the housing and nonhousing consumption increases (per program dollar) enjoyed by participants in three housing assistance programs: (a) the public housing program, which uses the supply strategy; (b) the housing allowance program, which uses the demand strategy; and (c) an unrestricted cash grant program, which can be thought of as the demand strategy without the requirement that housing meet minimum standards.

The analysis first compares the performance of actual public housing and housing allowance programs. Second, it estimates what the public housing program's performance would be if it served the same population, imposed the same housing standards, and granted the same participant subsidies as the allowance program. Third, it estimates the performance of an unrestricted cash grant program that serves the same population and grants the same participant subsidies as the allowance program.

In all three programs, the total consumption increase of participants is the sum of a housing and a nonhousing consumption increase (see Fig. 2.1). The housing consumption increase consists of what the housing participants consume above what they would have consumed without the program. It equals the difference between the market rent of the average program unit and that of the average nonprogram unit. The nonhousing consumption increase is the amount of participant income freed for nonhousing consumption. It equals the difference between the market rent of the average nonprogram unit and the average contribution to rent made by program participants.

The subsidy to program participants equals the difference between the market rent of the average program unit and the average tenant contribution toward that rent. Given the above definitions of housing and nonhousing consumption increases, we see that the subsidy equals the total consumption increase participants experience.

Total program cost is the sum of the subsidy provided to participants and the nonsubsidy program costs. Nonsubsidy program costs in the housing allowance program include the expense of administering the

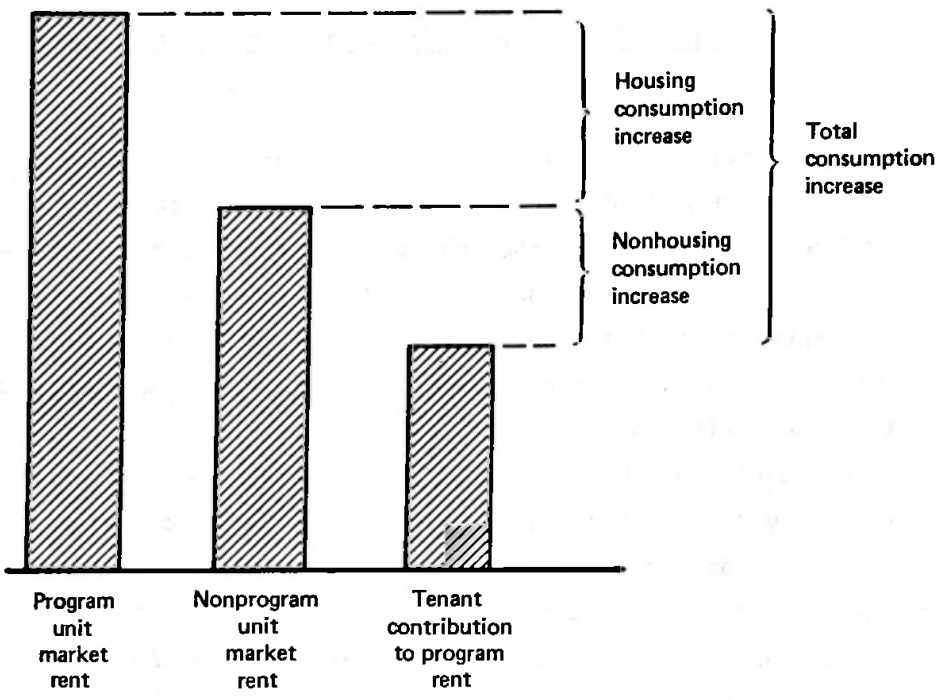

Fig. 2.1 — Components of participant consumption increases

means tests that establish participant eligibility and that of carrying out the housing inspections that enforce the program's housing standards. Nonsubsidy costs in the public housing program also include expenses for means tests and standards enforcement; but they also include the differential between the public and the private costs of constructing and operating housing. In an unrestricted cash grant program, the means test is the only nonsubsidy cost.

CONSUMPTION INCREASES PER PROGRAM DOLLAR

To estimate housing and nonhousing consumption increases per program dollar, we first assemble information on four program design characteristics. The first two consist of rents: the average rent of program units (i.e., average housing consumption of program participants) and the average rent of nonprogram units (i.e., the average amount of housing that participants would consume if they were not in a housing

assistance program). The third and fourth characteristics constitute program costs: participant subsidies and nonsubsidy costs.

Mayo et al. (1980) provide information about those characteristics for the public housing programs in Pittsburgh and Phoenix during 1975. Mulford et al. (forthcoming) and Kingsley and Schlegel (forthcoming) provide it for the housing allowance program conducted in Green Bay and South Bend during the period 1973-1977. The top panels in Tables 2.1 and 2.2 report the estimates from all three sources.

Next, we use the estimates for the four design characteristics to calculate the average housing and nonhousing consumption increases. A participant's housing consumption increase is the difference between his or her program and nonprogram unit market rents. A participant's nonhousing consumption increase is the difference between his or her subsidy and the nonhousing consumption increase. The middle panels of Table 2.1 and 2.2 report the results.

The bottom panel of the tables reports the consumption increases as proportions of total program cost (subsidy cost plus nonsubsidy cost). Dollars of increased housing consumption per program dollar are found to be 0.14 in the public housing program and 0.13 in the housing allowance program. Dollars of increased nonhousing consumption per program dollar come to 0.27 in the public housing program and 0.71 in the allowance program. The two programs thus perform about the same as regards housing consumption, but the allowance program performs two-and-a-half times better as far as nonhousing consumption is concerned.

PERFORMANCE OF COMPARABLE PROGRAMS

The public housing program is considerably less efficient than the housing allowance program. Nonsubsidy costs average $142 a month in the public housing program but only $14 a month in the allowance program. However, in spite of its greater nonsubsidy cost, as we have just seen, public housing induces approximately the same housing consumption increase, per program dollar, as does the allowance program. The explanation does not lie in the housing standards requirement, since unit market rent is slightly lower in the public housing program than in the

Table 2.1

CHARACTERISTICS OF PUBLIC HOUSING PROGRAM

Characteristic	Pittsburgh	Phoenix	Average
Design Characteristics (Monthly Dollars per Participant)			
Program unit market rent[a]	132.0	158.0	145.0
Nonprogram unit market rent[b]	107.0	117.0	112.0
Participant subsidy[c]	79.0	113.0	96.0
Nonsubsidy cost[d]	158.4	124.8	141.6
Distribution of Program Cost (Monthly Dollars per Participant)			
Housing consumption increase[e]	25.0	41.0	33.0
Nonhousing consumption increase[f]	54.0	72.0	63.0
Nonsubsidy cost	158.4	124.8	141.6
Total	237.4	237.8	237.6
Distribution of Program Cost (Proportion of Total)			
Housing consumption increase	.105	.172	.139
Nonhousing consumption increase	.228	.303	.265
Nonsubsidy cost	.667	.525	.596
Total	1.000	1.000	1.000

SOURCE: Stephen K. Mayo, Shirley Mansfield, David Warner, and Richard Zwetchkenbaum, *Housing Allowances and Other Rental Housing Assistance Programs--A Comparison Based on the Housing Allowance Demand Experiment;* Part 1: *Participation, Housing Consumption, Location, and Satisfaction;* Part 2: *Costs and Efficiency*, Abt Associates, Inc. (Part 1: AAI #79-111, Part 2: AAI #79-132), June 1980.

[a]The source, Part 1, p. 74, reports that the two-standard-deviation range about the mean monthly estimated market rent of public housing units is 100-164 in Pittsburgh and 126-190 in Phoenix. The mid-points of those ranges are the mean rents.

[b]The source, Part 1, p. 94, reports that public housing participants increase their housing consumption by $25 per month in Pittsburgh and by $41 per month in Phoenix. Nonprogram unit market rent equals program unit market rent less the increased housing consumption.

[c]Source, Part 1, p. 94.

[d]The source, Part 2, p. 136, reports that the ratio of resource cost to market rent is 2.20 in Pittsburgh and 1.79 in Phoenix. Multiplying program unit market rents by those ratios yields resource costs per unit; then subtracting the market rent yields nonsubsidy program cost (i.e., the part of program costs that does not go to the participant as benefits).

[e]Program unit market rent less nonprogram unit market rent.

[f]Participant subsidy less housing consumption increase.

Table 2.2

CHARACTERISTICS OF HOUSING ALLOWANCE PROGRAM

Characteristic	Green Bay	South Bend	Average
Design Characteristics (Monthly Dollars per Participant)			
Program unit market rent[a]	163.75	152.29	158.02
Nonprogram unit market rent[b]	151.95	140.72	146.34
Participant subsidy[c]	71.13	75.97	73.55
Nonsubsidy cost[d]	13.55	13.55	13.55
Distribution of Program Cost (Monthly Dollars per Participant)			
Housing consumption increase[e]	11.80	11.57	11.68
Nonhousing consumption increase[f]	59.33	64.40	61.87
Nonsubsidy cost	13.55	13.55	13.55
Total	84.68	89.52	87.10
Distribution of Program Cost (Proportion of Total)			
Housing consumption increase	.139	.129	.134
Nonhousing consumption increase	.701	.720	.710
Nonsubsidy cost	.160	.151	.156
Total	1.000	1.000	1.000

SOURCE: John E. Mulford, James L. McDowell, Lawrence Helbers, Michael Murray, and Orhan Yildiz, *Housing Consumption in a Housing Allowance Program*, The Rand Corporation. R-2779-HUD, forthcoming; and G. Thomas Kingsley and Priscilla M. Schlegel, *Housing Allowances and Administrative Efficiency*, The Rand Corporation, forthcoming.

[a]Mulford et al. (forthcoming, Table A.6). Gross rent for allowance recipients at end of program year 3 (184.36 in Green Bay and 178.08 in South Bend) deflated to mid-1975 dollars using the national consumer price index (i.e., multiplying by .8882 in Green Bay and by .8552 in South Bend).

[b]Mulford et al. (forthcoming, Table A.6). Gross rent allowance recipients would have spent without the allowance program (171.08 in Green Bay and 164.55 for South Bend) deflated to mid-1975 dollars in the same way as program rents.

[c]Mulford et al. (forthcoming, Table 3.2). Annual rate of housing allowance payment at end of program year 3 (961 in Green Bay and 1,066 in South Bend) divided by 12 to yield monthly payment and deflated to mid-1975 dollars in the same way as program rents.

[d]Kingsley and Schlegel (forthcoming, Table 6.2). Annual administrative costs for renter recipients in mid-1976 (172 in Green Bay, assumed to be the same in South Bend because the administrative costs for all recipients are the same in both locations) divided by 12 to yield monthly costs and deflated to mid-1975 dollars using the national consumer price index (i.e., multiplying by .9455).

[e]Program unit market rent less nonprogram unit market rent.

[f]Participant subsidy less housing consumption increase.

allowance program ($145 as against $158 per month). But nonprogram unit market rent in the public housing program is considerably lower than in the allowance program ($112 as opposed to $146 per month). We conclude that the public housing program serves households with lower incomes than the allowance program attracts, and hence raises housing consumption more than the housing allowance program does under approximately the same housing consumption requirements.

The population served by the public housing program is not an intrinsic characteristic of that program. In the past, in fact, the program served higher-income households than it now does. Its limited number of units (compared with the number of eligible households) has only recently been allocated to the poorest of low-income households. If the public housing program ever attempted to serve all eligible households (as the allowance program does), the average preprogram income of its participants, and hence the average nonprogram unit market rent, would be the same as in the allowance program.

To reveal the difference in program performance attributable to assistance strategy (as opposed to population served and subsidy given), we compare the programs for the same population, the same housing standards, and the same participant subsidies. In other words, the nonprogram unit market rent, the program unit market rent, and the participant subsidy must be the same to compare the performance of the supply and demand housing assistance strategies.

None of the program characteristics is intrinsic to the strategy; rather, each depends on choices that can be made identically, no matter which assistance strategy is used. Nonprogram unit market rent can be made identical by hypothesizing the same population. Program unit market rent can be made the same by establishing identical housing standards. The participant subsidy can be made the same by adjusting the tenant contribution to rent in the public housing program so that the average public housing subsidy equals the average housing allowance payment.

Any set of program characteristics could be used to make the comparison. Here we use those of the allowance program because it is open to all households eligible for housing assistance. Table 2.3 reports

Table 2.3

HOUSING ALLOWANCES COMPARED WITH PUBLIC HOUSING

Characteristic	Housing Allowances[a]	Public Housing
Design Characteristics (Monthly Dollars per Participant)		
Program unit market rent	158.02	158.02[b]
Nonprogram unit market rent	146.34	146.34[b]
Participant subsidy	73.55	73.55[b]
Nonsubsidy cost	13.55	141.60[c]
Distribution of Program Cost (Monthly Dollars per Participant)		
Housing consumption increase[d]	11.68	11.68
Nonhousing consumption increase[e]	61.87	61.87
Nonsubsidy cost	13.55	141.60
Total	87.10	215.15
Distribution of Program Cost (Proportion of Total)		
Housing consumption increase	.134	.054
Nonhousing consumption increase	.710	.288
Nonsubsidy cost	.151	.658
Total	1.000	1.000

SOURCE: Tables 2.1 and 2.2.

[a] From Table 2.2.

[b] Same as in housing allowance program for comparability.

[c] From Table 2.1.

[d] Program unit market rent less nonprogram unit market rent.

[e] Participant subsidy less housing consumption increase.

the result of making program unit market rent, nonprogram unit market rent, and participant subsidy the same in the public housing program as in the housing allowance program.[1] The dollars of increased parti-

[1] We assume that the public housing program's nonsubsidy cost per participant remains unchanged when the service characteristics are adjusted. If that assumption errs at all, it is in the direction of underestimating the cost, since the adjustment in service characteristics raises the program's housing standards (i.e., raises the program unit market rent).

cipant housing consumption per program dollar become 0.05 (down from 0.14 in the actual program), and the dollars of increased participant nonhousing consumption per program dollar become 0.29 (up from 0.27 in the actual program.

EFFECT OF UNRESTRICTED CASH GRANTS

Even though the housing allowance program provides more housing benefits per program dollar than the public housing program yields, its housing benefits are not large; only 13 cents of an allowance program dollar go to increased housing consumption for participants. In contrast, 71 cents out of an allowance program dollar go to increased nonhousing consumption for participants (see Table 2.3). The nonhousing benefits are thus 5.5 times larger than the housing benefits.

Such large nonhousing benefits raise the question whether the housing allowance program accomplishes anything more than an unrestricted cash grant program would. In short, is the allowance program really a housing program, or just welfare under a new name?

Table 2.4 demonstrates that housing allowances indeed constitute a housing program. An unrestricted cash grant program that served tenants with the same nonprogram market rents and provided the same total subsidy would increase participant housing consumption only about half as much as the housing allowance program does (7.3 cents compared with 13.4 cents out of a program dollar).

The reason allowances provide more housing benefits per program dollar than unrestricted cash grants is that by imposing minimum housing standards, we increase the housing consumption effect by a greater proportion than we increase total program cost. Mulford et al. (forthcoming) show with HASE data that requiring participants to occupy standard housing changes the effect on their housing consumption from $6.04 to $11.68 a month--almost a 100 percent increase in housing benefits. Kingsley and Schlegel (forthcoming) use HASE data to show that implementing the standard housing requirement changes total program costs from $82.77 to $87.10 a month--an increase of only 5 percent.

Table 2.4

HOUSING ALLOWANCES COMPARED WITH UNRESTRICTED CASH GRANTS

Characteristic	Housing Allowances[a]	Unrestricted Cash Grants
Design Characteristics (Monthly Dollars per Participant)		
Program unit market rent	158.02	152.38[b]
Nonprogram unit market rent	146.34	146.34[c]
Participant subsidy	73.55	73.55[c]
Nonsubsidy cost	13.55	9.22[d]
Distribution of Program Cost (Monthly Dollars per Participant)		
Housing consumption increase	11.68	6.04[e]
Nonhousing consumption increase	61.87	67.51[f]
Nonsubsidy cost	13.55	9.22
Total	87.10	82.77
Distribution of Program Cost (Proportion of Total)		
Housing consumption increase	.134	.073
Nonhousing consumption increase	.710	.816
Nonsubsidy cost	.156	.111
Total	1.000	1.000

SOURCE: John E. Mulford, James L. McDowell, Lawrence Helbers, Michael Murray, and Orhan Yildiz, *Housing Consumption in a Housing Allowance Program*, The Rand Corporation, R-2779-HUD, forthcoming; and G. Thomas Kingsley and Priscilla M. Schlegel, *Housing Allowances and Administrative Efficiency*, The Rand Corporation, forthcoming.

[a]From Table 2.3.

[b]Mulford et al. (forthcoming, Table 3.3) shows that 51.7 percent of the increased housing consumption in the housing allowance program is caused by increased recipient income (the remaining 48.3 percent is from required housing standards). An unrestricted cash grant program would therefore cause recipients to consume only (.517)(11.69) = 6.04 dollars per month more housing, making the average program unit market rent 146.34 + 6.04 = 152.38.

[c]Same as for housing allowances (for comparability).

[d]Kingsley and Schlegel (forthcoming, Table 6.2) show that 68.0 percent of the administration costs in the housing allowance programs is caused by income transfers (the remaining 32.0 percent is caused by enforcing housing standards). An unrestricted cash grant program would therefore have administrative costs of (.680)(13.55) = 9.22 dollars per month per recipient.

[e]Program unit market rent less nonprogram unit market rent.

[f]Participant subsidy less housing consumption increase.

The large effect of housing requirements found in HASE contrasts with the small effect noted in the Housing Allowance Demand Experiment (HADE). Friedman and Weinberg (1980, pp. 105 and 119) report no significant difference between the housing consumption increases caused by the allowance program and by an unrestricted cash grant program. However, HADE's samples for the unrestricted cash grant program were very small--only 59 households in Pittsburgh and 37 in Phoenix--which led to large statistical uncertainty. While the HADE estimate of the effect of housing standards on housing consumption is not significantly different from zero, neither is it statistically different from the HASE estimate.

In contrast, the HASE estimate of the effect of housing standards on housing consumption is based on samples of 1,848 households in Green Bay and 1,945 households in South Bend. True, HASE did not run an unrestricted cash grant program as HADE did. Rather, the HASE estimate of an unrestricted cash grant program's performance comes from analyses of the effect of housing standards on the allowance program. Because of its considerably larger samples, however, the HASE indirect analysis of the effect of housing standards yielded more information than the HADE direct analysis.

Of course, that housing allowances are better than unrestricted cash grants at increasing participant housing consumption does not necessarily define housing allowances as a better assistance program. Because the unrestricted cash grant program yields fewer housing benefits and does not pay for enforcing housing standards, it causes larger increases in nonhousing consumption for participants than does the housing allowance program ($0.82 as against $0.71 increased nonhousing consumption per program dollar). Whether the allowance program is better than the unrestricted cash grant program depends on the relative weight given the two types of consumption increase.

III. CONSUMPTION CHANGES OF NONPARTICIPANTS

Having determined the effect of housing assistance programs on participant consumption, we now analyze their effect on nonparticipant consumption. First we review the known qualitative effects. Then we obtain quantitative estimates by applying the market-effects theory developed in Appendix B to the three programs.

The qualitative effect of the public housing program on nonparticipants is unambiguous: it increases both their housing and their nonhousing consumption. The dwellings vacated by households who move into public housing become excess supply in the private market; the price of housing services falls; and nonparticipants spend their housing savings to increase their housing and nonhousing consumption.

The qualitative effect of the housing allowance program on nonparticipants is unambiguous in the case of nonhousing consumption (it goes down). On the other hand, housing consumption can be either decreased or increased. The most common effect is the price effect, in which the increased demand for housing services caused by allowances drives up the price of those services, thereby reducing both housing and nonhousing consumption.

However, the price effect is not the only way the allowance program can influence nonparticipant consumption. One effect occurs when, in anticipation of future allowance support, nonparticipants who eventually join the program consume more housing services than they would have without the program (which we call the "anticipation effect"). Another occurs when former participants who only recently left the program consume more housing services than otherwise because the dwelling repairs they made to satisfy the program standards have not yet deteriorated (which we call the "inertia effect").

Both the anticipation and the inertia effects increase the housing consumption of nonparticipants. To pay for those increases, nonhousing consumption must decrease by an equal amount. Hence the two effects counteract the price effect on the housing consumption of nonparticipants, making the net effect ambiguous; and the anticipation and inertia

effects reenforce the price effect on the nonhousing consumption of nonparticipants, making the combined effect a clear decrease.

The qualitative effect of the unrestricted cash grant program on nonparticipant consumption is the same as that of the housing allowance program. The analysis differs only in that there are no housing standards in the unrestricted cash grant program, so there is no inertia effect. However, both the price effect and the anticipation effect occur, which is enough to produce the same qualitative effect as in the housing allowance program.

On balance, then, adding nonparticipant consumption changes to those of participants will improve the performance of the public housing program relative to the housing allowance and unrestricted cash grant programs. The question is, By how much? We find that the nonparticipant consumption changes are not very large compared with the participant consumption changes (see Table 3.1). Consequently, the results reported in Sec. II are not perceptibly altered by the analysis here.

The public housing and the housing allowance programs cause nonparticipants to increase their housing consumption, while the unrestricted cash grant program has essentially no effect on nonparticipant housing consumption. Only the public housing program causes nonparticipants to increase their nonhousing consumption. Total consumption by nonparticipants increases under the public housing program and decreases under the housing allowance and unrestricted cash grant programs.

Table 3.1

CONSUMPTION CHANGES OF NONPARTICIPANTS

Type of Consumption	Consumption Change per Assistance Program Dollar		
	Public Housing	Housing Allowances	Unrestricted Cash Grants
Housing	.029	.012	-.002
Nonhousing	.029	-.025	-.005
Total	.058	-.013	-.007

SOURCE: Appendix C, Tables C.1 and C.2.

IV. CONCLUSIONS

Combining the consumption increases of participants (Sec. II) with those of nonparticipants (Sec. III) yields the total housing and nonhousing consumption increases caused by each housing assistance program. Table 4.1 shows that the consumption increases range from a high of $0.146 per program dollar in the allowance program to a low of $0.071 per program dollar in the unrestricted cash grant program. Nonhousing consumption increases range from a high of $0.811 per dollar in the unrestricted cash grant program to a low of $0.317 per program dollar in the public housing program.

The relation of the performances of the three assistance programs is illustrated in Fig. 4.1. Housing allowances deliver almost twice the housing consumption increases and more than twice the nonhousing consumption increases (per program dollar) of those public housing delivers. Compared with unrestricted cash grants, allowances produce more than two times the housing consumption increases but only about five-sixths the nonhousing consumption increases (per program dollar). Housing allowances are clearly better than public housing on both measures. However, whether they are better than unrestricted cash grants depends on the weights given housing and nonhousing assistance. The housing allowance program is better than unrestricted cash grants only if double the housing assistance is more important than a one-sixth cut in nonhousing assistance.

The poor performance of the public housing program relative to either housing allowances or unrestricted cash grants is due to its nonsubsidy program costs. Studies over the past decade have found that providing housing services publicly costs considerably more than providing them privately--according to Mayo et al. (1980), (the study used in this analysis), almost twice as much.

The relatively poor performance of unrestricted cash grants as regards housing consumption increases and their superior performance regarding nonhousing consumption increases have the same cause: the subsidy is not earmarked. Not requiring minimum housing standards

Table 4.1

CONSUMPTION CHANGES CAUSED BY ALTERNATE HOUSING ASSISTANCE PROGRAMS

Type of Consumption	Consumption Change per Assistance Program Dollar		
	Public Housing	Housing Allowances	Unrestricted Cash Grants
Participants			
Housing	.054	.134	.073
Nonhousing	.288	.710	.816
Total	.342	.844	.889
Nonparticipants			
Housing	.029	.012	-.002
Nonhousing	.029	-.025	-.005
Total	.058	-.013	-.007
Total			
Housing	.083	.146	.071
Nonhousing	.317	.685	.811
Total	.400	.831	.882

SOURCE: Tables 2.3, 2.4, and 3.3.

NOTE: Programs compared for the same population, the same total subsidy to participants, and the same housing standards (public housing and housing allowances).

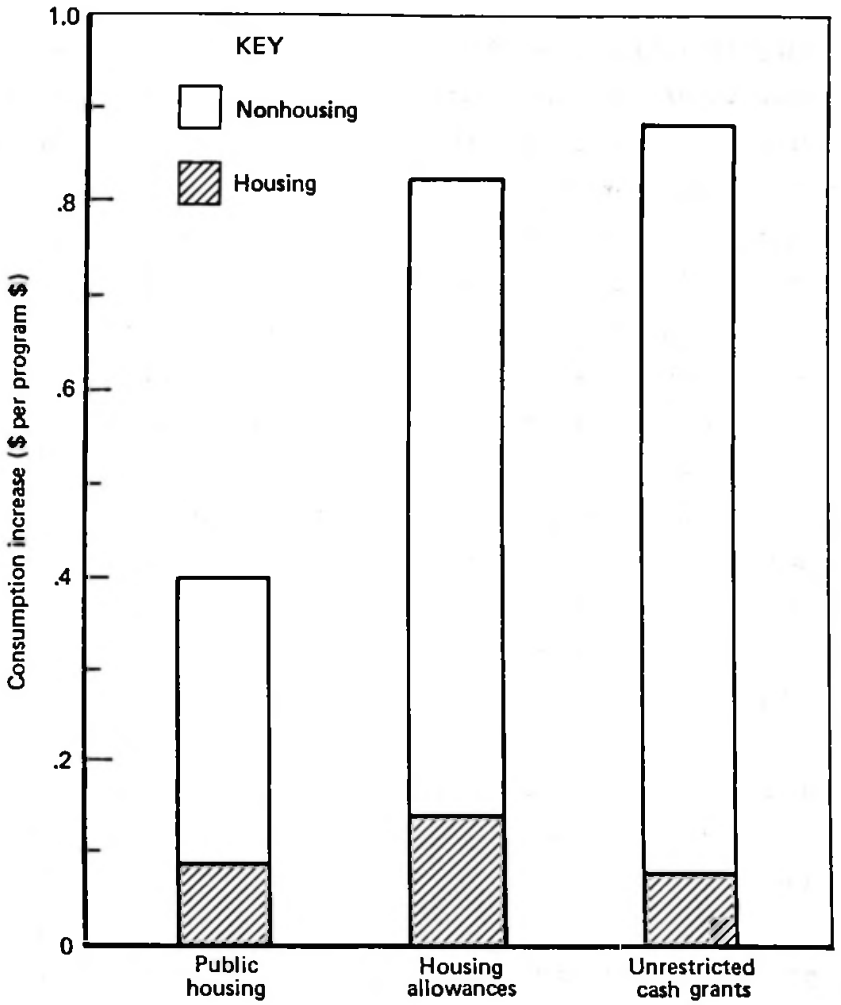

Fig. 4.1 — Housing and nonhousing consumption increases caused by alternate housing assistance programs

reduces program costs but also reduces the amount of assistance relative to the costs and amount of assistance in the housing allowance program. Both reductions cause nonhousing consumption to be higher in an unrestricted cash grant program than in the allowance program.

Focusing exclusively on the housing assistance provided by the three programs under consideration, we find that the housing allowance program does better than either the public housing program or the unrestricted cash grant program, even though we consider nonparticipant as well as participant benefits (see Fig. 4.2). The housing consumption changes of nonparticipants are largest for public housing, smaller but still positive for housing allowances, and virtually zero for unrestricted cash grants. However, the differential nonparticipant housing benefits are nowhere large enough to alter the program ranking established by the participant benefits.

Nonparticipant housing benefits are not large in the public housing program because, according to our estimates, the private market offsets 89 percent of public housing by reducing privately supplied housing.[1] Our estimate, based on the price elasticity of housing supply reported in Rydell (forthcoming), is higher than the 86 percent estimated by Swan (1976) and the 80 percent estimated by Murray (1980) because in addition to the decreased new construction in the private market considered by those two studies, we also implicitly include increased housing removal in the private market.

Nonparticipant housing benefits are not negative in the housing allowance program. That is because the anticipation and inertia effects cause increases in nonparticipant housing consumption that more than offset the decreases caused by the allowance program's effect on market prices. Mulford et al. (forthcoming) show that the allowance program causes nonparticipants to consume more housing than they would

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[1]The 89 percent offset estimate is calculated as follows: if there were no offset, the public housing program would cause 0.734 dollars of increased housing consumption per program dollar, the sum of preprogram unit market rent and the recipient housing consumption increase (see Table 2.3); but the program actually causes only 0.083 dollars of increased housing consumption per program dollar (see Table 4.1), making the offset ratio (0.734 - 0.083) / 0.734 = 0.89. See Appendix B for additional discussion of the offset percentage.

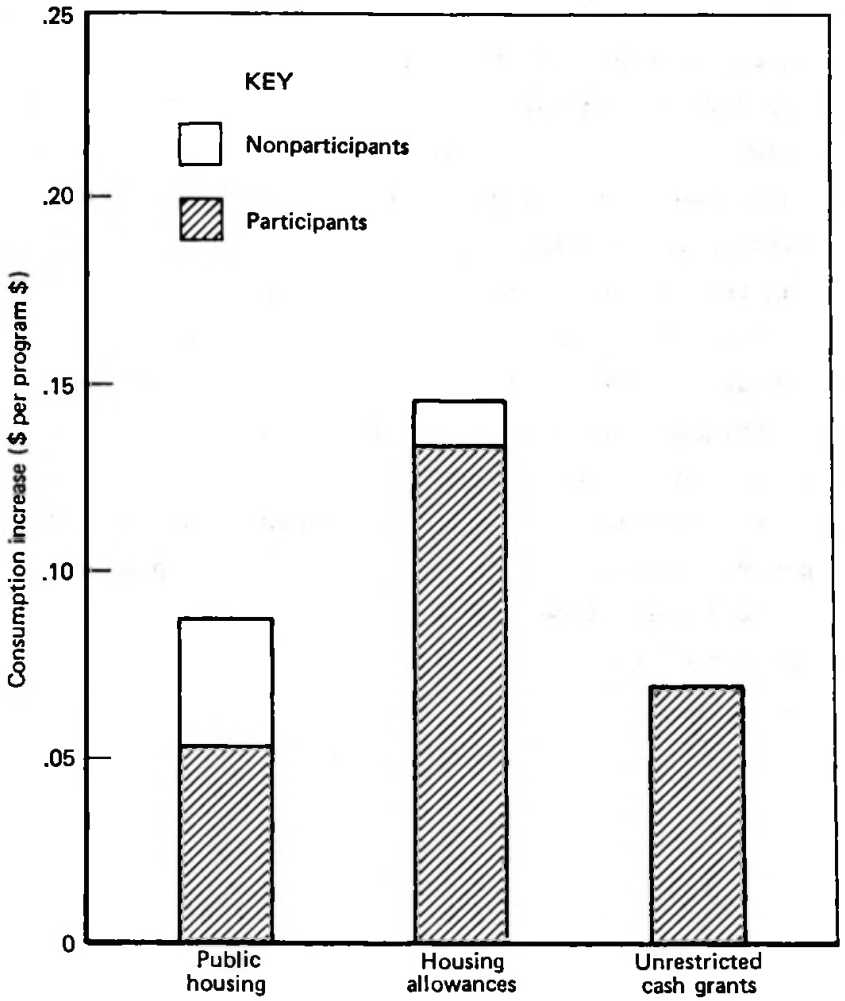

Fig. 4.2 — Participant and nonparticipant housing consumption increases caused by alternate housing assistance programs

without the program: those who expect to join the program anticipate the program subsidy, and those who have recently left the program benefit from the "inertia" of the program standards.

In short, the demand-subsidy strategy is better than the supply-subsidy strategy at providing housing assistance, provided the demand subsidy is conditional on participants meeting housing standards. (Housing consumption increases caused by the housing allowance program are twice those caused by the public housing program, per program dollar.) Without the housing standards, the demand-subsidy strategy is worse than the supply-subsidy strategy at providing housing assistance. (Housing consumption increases caused by an unrestricted cash grant program are slightly less than those caused by the public housing program, per program dollar.) Moreover, the demand-subsidy strategy is also better than the supply-subsidy strategy at providing nonhousing assistance. (Nonhousing consumption increases caused by the housing allowance program and by an unrestricted cash grant program are, respectively, 2.2 and 2.6 times those caused by the public housing program, per program dollar.)

Appendix A

COMPARISON OF HOUSING ALLOWANCE PROGRAMS IN HASE AND HADE

This report uses Housing Assistance Supply Experiment (HASE) data to evaluate the performance of the housing allowance program. Those data were chosen because HASE evaluated a full-entitlement housing allowance program committed for ten years to the metropolitan areas involved (Green Bay and South Bend).

A second source of data on the housing allowance program was provided by the Housing Allowance Demand Experiment (HADE). Those data result from a partial-entitlement housing allowance program run with a three-year commitment to the metropolitan areas involved (Pittsburgh and Phoenix). This appendix reviews the HADE data on the performance of the housing allowance program, finding them consistent with the HASE data.

Tables A.1 and A.2 report HADE data on the housing allowance program using the same format in which Table 2.2 reported HASE data. The two tables are necessary because two different HADE reports give somewhat different accounts of the allowance program's performance. Resolving the two accounts is beyond the scope of this report, but averaging them to arrive at a single HADE description, we find it is very close to that provided by HASE (see Table A.3).

Table A.1

HADE HOUSING ALLOWANCE PROGRAM CHARACTERISTICS ACCORDING TO MAYO ET AL.

Characteristic	Pittsburgh	Phoenix	Average
Design Characteristics (Monthly Dollars per Participant)			
Program unit market rent[a]	128.0	164.0	146.0
Nonprogram unit market rent[b]	112.0	137.0	124.5
Participant subsidy[c]	77.0	107.0	92.0
Nonsubsidy cost[d]	19.2	14.8	17.0
Distribution of Program Cost (Monthly Dollars per Participant)			
Housing consumption increase[e]	16.0	27.0	21.5
Nonhousing consumption increase[f]	61.0	80.0	70.5
Nonsubsidy cost	19.2	14.8	17.0
Total	96.2	121.8	109.0
Distribution of Program Cost (Proportion of Total)			
Housing consumption increase	.166	.222	.197
Nonhousing consumption	.634	.657	.647
Nonsubsidy cost	.200	.127	.156
Total	1.000	1.000	1.000

SOURCE: Stephen F. Mayo, Shirley Mansfield, David Warner, and Richard Zwetchkenbaum, *Housing Allowances and Other Related Housing Assistance Programs--A Comparison Based on the Housing Assistance Demand Experiment;* Part 1: *Participation, Housing Consumption, Location, and Satisfaction;* Part 2: *Costs and Efficiency,* Abt Associates, Inc., (Part 1: AAI #79-111, Part 2: AAI #79-132), June 1980.

[a]The source, Part 1, p. 76, reports that the mean estimated market rent of allowance program units differs from those of public housing (see Table 2.1) by -4 dollars per month in Pittsburgh and by +6 dollars per month in Phoenix.

[b]The source, Part 1, p. 94, reports that housing allowance participants increase their housing consumption by 16 dollars per month in Pittsburgh and by 27 dollars per month in Phoenix. Nonprogram unit market rent equals program unit market rent less the increased housing consumption.

[c]Source, Part 1, p. 94.

[d]The source, Part 2, p. 136, reports that the ratio of resource cost to market rent is 1.15 in Pittsburgh and 1.09 in Phoenix. Multiplying program unit market rents by those ratios yields the resource costs per unit, and then subtracting the market rent yields the nonsubsidy program costs (i.e., the part of program costs that do not go the participants as benefits).

[e]Program unit market rent less nonprogram unit market rent.

[f]Participant subsidy less housing consumption increase.

Table A.2

HADE HOUSING ALLOWANCE PROGRAM CHARACTERISTICS
ACCORDING TO FRIEDMAN AND WEINBERG

Characteristic	Pittsburgh	Phoenix	Average
Design Characteristics (Monthly Dollars per Participant)			
Program unit market rent[a]	135.6	159.2	147.4
Nonprogram unit market rent[b]	130.0	137.0	133.5
Participant subsidy[c]	65.0	81.0	73.0
Nonsubsidy cost[d]	19.2	14.8	17.0
Distribution of Program Cost (Monthly Dollars per Participant)			
Housing consumption increase[e]	5.6	22.2	11.1
Nonhousing consumption increase[f]	59.4	58.8	59.1
Nonsubsidy cost	19.2	14.8	17.0
Total	84.2	95.8	87.2
Distribution of Program Cost (Proportion of Total)			
Housing consumption increase	.067	.232	.127
Nonhousing consumption increase	.705	.614	.678
Nonsubsidy cost	.228	.154	.195
Total	1.000	1.000	1.000

SOURCE: Joseph Friedman and Daniel H. Weinberg, *Housing Consumption Under a Constrained Income Transfer: Evidence From a Housing Gap Housing Allowance*, Abt Associates, Inc., AAI #79-41, June 1980, Table 5-21, p. 141; and Table A.1.

[a] Nonprogram unit market rent plus increased housing consumption caused by the program.

[b] Amount of housing services participants would have consumed without the program.

[c] Average allowance payment.

[d] From Table A.1 (only the Mayo study reported nonsubsidy costs).

[e] Program unit market rent less nonprogram unit market rent.

[f] Participant subsidy less housing consumption increase.

Table A.3

ALTERNATIVE ESTIMATES OF HOUSING ALLOWANCE PROGRAM CHARACTERISTICS

Characteristic	HADE Program			HASE Program
	Mayo et al.	Friedman-Weinberg	Average	
Design Characteristics (Monthly Dollars per Participant)				
Program unit market rent	146.0	147.4	146.7	158.02
Nonprogram unit market rent	124.5	133.5	129.0	146.34
Participant subsidy	92.0	73.0	82.5	73.55
Nonsubsidy cost	17.0	17.0	17.0	13.55
Distribution of Program Cost (Monthly Dollars per Participant)				
Housing consumption increase	21.5	11.1	17.7	11.68
Nonhousing consumption increase	70.5	59.1	64.8	61.87
Nonsubsidy cost	17.0	17.0	17.0	13.55
Total	109.0	87.2	99.5	87.10
Distribution of Program Cost (Proportion of Total)				
Housing consumption increase	.197	.127	.178	.134
Nonhousing consumption increase	.647	.678	.651	.710
Nonsubsidy cost	.156	.195	.171	.156
Total	1.000	1.000	1.000	1.000

SOURCE: Tables 2.1, A.1, and A.2.

Appendix B

ESTIMATION OF CONSUMPTION CHANGES OF NONPARTICIPANTS

The public housing program enables renter households who do not participate in the program to increase their housing consumption. The reason is that participants in the program leave the private market, which causes a reduction in the price of rental housing there, which therefore enables nonparticipants to enjoy consumption increases. Because the price elasticity of demand for rental housing services is 0.5, the total increase in consumption by nonparticipants is divided equally between housing and nonhousing consumption increases.

The housing allowance and unrestricted cash grant programs, on the other hand, both force nonparticipants to decrease their consumption. The explanation is that increased demand for housing by program participants causes an increase in the price of rental housing services, which then forces nonparticipants to accept consumption decreases. Because of anticipation and inertia effects on the housing consumption of nonparticipants, the total decrease in their consumption is not divided equally between housing and nonhousing. Rather, nonparticipants decrease their housing consumption less than their nonhousing consumption. (In fact, the anticipation and inertia effects in the housing allowance program are large enough to outweigh the price effect; the housing consumption of nonparticipants actually increases slightly under that program.)

Our numerical estimates of consumption changes of nonparticipants have already been given (see Table 3.1). This appendix presents the market theory behind those estimates. Specifically, it derives formulas for the changes in the housing and nonhousing consumption of nonparticipants and assembles the necessary parameter estimates. We derive the formulas by first estimating the total changes in housing and nonhousing consumption caused by housing assistance programs, then subtracting the consumption changes of participants.

Our analysis of market effects focuses on the "long run," where the supply of housing services has completely adjusted to the demand shifts

caused by housing assistance programs. That focus yields the policy-relevant information of how the programs perform over a long period. Deviations from the long-run performance in the initial years of a program are of interest when planning a new program, but they have little relevance when choosing among programs.

Although the analyses are very similar, there are sufficient differences between the supply-subsidy program (public housing) and the demand-subsidy programs (housing allowances and unrestricted cash grants) to warrant separate derivations. To highlight the similarities, the two derivations are given in parallel, and the conclusions are presented in identically formatted tables to facilitate comparison.

PUBLIC HOUSING

The public housing program constructs housing, drawing its consumers from the private market. The total change in housing consumption caused by public housing equals the consumption of public housing less the change in private market consumption due to the demand reduction there, which can be expressed as

$$H(x) = mx - [P_o Q_o - P_o Q(x)], \qquad \text{(B.1)}$$

where $H(x)$ = change in rental housing consumption (dollars per month at preprogram prices) as a function of program size,

x = size of the public housing program (measured in total program dollars per month),

m = market rent of public housing (dollars per program dollar),

$Q(x)$ = consumption of rental housing services in the private market, as a function of program size, $Q_o = Q(0)$, and

P_o = preprogram price of housing services.

Note that we evaluate the private market housing consumption, $Q(x)$, using the preprogram price of housing services, P_o. That makes $H(x)$ indicate change in housing services purchased rather than change in rent paid for those services.

The total change in nonhousing consumption caused by the public housing program equals the increase in household income due to program subsidies less the increase in rent paid for housing consumption, or

$$N(x) = [mx - cx] - [mx + P(x)Q(x) - P_oQ_o], \qquad \text{(B.2)}$$

where $N(x)$ = change in nonhousing consumption (dollars per month) as a function of program size,

c = tenant contribution to rent (dollars per program dollar),

$P(x)$ = price of rental housing services in the private market as a function of program size, $P_o = P(0)$.

The subsidy that increases household income equals the market rent of public housing, mx, less the tenant contribution to rent, cx. The increase in rent paid for housing consumption equals the market rent of the public housing[1] plus the increased expenditure on rental housing in the private market. Note that we evaluate the private market housing consumption, $Q(x)$, using the price of housing services under the program, $P(x)$, to make $P(x)Q(x) - P_oQ_o$ indicate change in rent paid rather than change in services purchased.

The private market reaction to the public housing program is determined by the intersection of the demand and supply curves for rental housing services. The first curve relates the demand for rental housing services to the price of those services and to the size of the reduction in private market demand caused by the public housing program:

$$Q(x) = [Q_o - \frac{vx}{P_o}][\frac{P(x)}{P_o}]^{-S}, \qquad \text{(B.3)}$$

---

[1] Public housing tenants do not pay full market rent, but neither do they ever explicitly receive the subsidy the program gives them. To simplify the algebra, our analysis assumes that they receive the subsidy and pay full rent. The assumption is for convenience only; it does not alter the conclusions.

where $Q(x)$ = demand for rental housing services as a function of program size, $Q_o = Q(0)$,

v = reduction in rental housing demand in the private market caused by the public housing program (dollars of market rent for the housing that program participants would have been occupying if they had not joined the program, per program dollar), and

S = price elasticity of rental housing demand (percentage decrease in demand per one percent increase in the price of rental housing services).

The supply curve relates the supply of housing services (which, in long-run equilibrium, is the same as realized demand)[2] to the price of those services:

$$Q(x) = Q_o\left[\frac{P(x)}{P_o}\right]^Y, \tag{B.4}$$

where Y = price elasticity of rental housing supply (percentage increase in supply per one percent increase in the price of rental housing services).

Solving Eqs. (B.3) and (B.4) for the equilibrium price and supply of housing services in the private market as a function of the size of the public housing program yields

$$P(x) = P_o\left[1 - \frac{vx}{P_oQ_o}\right]^{\frac{1}{Y+S}}, \tag{B.5}$$

---

[2]Note that this analysis does not explicitly mention occupancy rates. The rates are important only in analyzing short-run market behavior. However, given that they never equal 1.0, supply exceeds demand even in long-run equilibrium, when occupancy rates are a constant (in a given housing market). To avoid carrying an extra constant throughout the analysis, we implicitly measure housing supply by total housing supply times the long-run equilibrium occupancy rate.

and

$$Q(x) = Q_o\left[1 - \frac{vx}{P_oQ_o}\right]^{\frac{1}{Y+S}} . \qquad (B.6)$$

Substituting those market results into Eqs. (B.1) and (B.2) then produces

$$H(x) = mx - \left[P_oQ_o - P_oQ_o\left(1 - \frac{vx}{P_oQ_o}\right)^{\frac{1}{Y+S}}\right], \qquad (B.7)$$

and

$$N(x) = [mx - cx] - \left[mx + P_oQ_o\left(1 - \frac{vx}{P_oQ_o}\right)^{\frac{Y+1}{Y+S}} - P_oQ_o\right] . \qquad (B.8)$$

Because public housing programs serve only a small fraction of the rental population, vx/P_oQ_o is much smaller than 1.0, so we can use the approximation

$$\left[1 - \frac{vx}{P_oQ_o}\right]^{\alpha} \simeq 1 - \alpha\left[\frac{vx}{P_oQ_o}\right] \qquad (B.9)$$

and considerably simplify Eqs. (B.7) and (B.8). Using that approximation and dividing the result by program size, x, gives the final formulas for the total changes in housing and nonhousing consumption caused by the public housing program per program dollar:

$$\frac{H(x)}{x} = m - \left[\frac{Y}{Y+S}\right] v , \qquad (B.10)$$

and

$$\frac{N(x)}{x} = v - c + \left[\frac{1-S}{Y+S}\right] v . \qquad (B.11)$$

Readers who prefer calculus to algebra can obtain Eqs. (B.10) and (B.11) from Eqs. (B.7) and (B.8) by differentiating with respect to program size, x, and evaluating the result at $x = 0$ to find the effect of a marginal program dollar when program size is small relative to market size.

The bottom line of Table B.1 reports our conclusions about the effect of the public housing program on total housing and nonhousing consumption. The top line of the table recognizes that the increase in housing consumption of participants equals the market rent of public housing units, m, less the market rent of the units the participants would have lived in if they had not joined the program, v; and that the increase in nonhousing consumption of participants equals the nonprogram unit rent, v, less the tenant contribution to rent, c. (Figure 2.1 in Sec. II illustrates those relationships.)

The middle line of the table obtains the consumption increases of nonparticipants by subtracting the participant increases from the total increases. When evaluated using the parameter estimates presented at the end of this appendix, the formulas for nonparticipants yield the public housing effects reported in Table 3.1 (Sec. III).

Note that the formulas in Table B.1 highlight the role of supply elasticity in determining the effect of the public housing program on

Table B.1

FORMULAS FOR CONSUMPTION CHANGES CAUSED BY PUBLIC HOUSING PROGRAM

Consumer	Consumption Changes per Assistance Program Dollar	
	Housing	Nonhousing
Participants	$m - v$	$v - c$
Nonparticipants	$v - \left[\frac{Y}{Y + S}\right] v$	$\left[\frac{1 - S}{Y + S}\right] v$
Total	$m - \left[\frac{Y}{Y + S}\right] v$	$v - c + \left[\frac{1 - S}{Y + S}\right] v$

NOTE: Table B.3 presents summary definitions (and estimates) of the parameters in these formulas.

housing consumption. If supply were completely inelastic ($Y \neq 0$), then $Y/(Y + S) = 0.0$, and the increase in housing consumption of nonparticipants would equal the market rent of the housing participants would have occupied if there had been no program, v; and the total increase in housing consumption would equal the market rent of public housing, m. In other words, if supply is completely inflexible, there is no private market offset to the publicly supplied housing.

On the other hand, if supply is completely elastic ($y = \infty$), then $Y/(Y + S) = 1.0$, and there is no increase in the housing consumption of nonparticipants. In that case, the private-market offset equals the entire amount of housing participants would have lived in if there had been no program.

The supply elasticity estimate used in this analysis (judged by the authors to be the best now available) is $Y = 11.3$. Together with the demand elasticity estimate, $S = 0.5$, that supply elasticity makes $Y/(Y + S) = 0.958$, which is much closer to the 1.0 value of the completely elastic supply case than to the 0.0 value of the completely inelastic supply case. Consequently, our analysis indicates that the private-market offset to publicly supplied housing is very large. Specifically, we estimate that 89 percent of the publicly supplied housing is offset by decreases in privately supplied housing.[3]

HOUSING ALLOWANCES AND UNRESTRICTED CASH GRANTS

The housing allowance and unrestricted cash grant programs give participating households additional income and rely on the private market to expand supply to satisfy the new demand. They work entirely through the private market. Accordingly, the increased housing consumption caused by the program simply equals the changed consumption in market:

$$H(x) = P_O Q(x) - P_O Q_O \ , \qquad \text{(B.12)}$$

[3]The offset fraction is calculated by $[Y/(Y + S]v/m = 0.89$, using the parameter estimates $Y = 11.3$, $S = 0.5$, $m = 0.734$, and $v = 0.680$ from the last part of this appendix.

where $H(x)$ = change in rental housing consumption (dollars per month at preprogram prices) as a function of program size,

x = size of the demand-subsidy program (measured in total program dollars per month),

$Q(x)$ = consumption of rental housing services, as a function of program size, $Q_o = Q(0)$, and

P_o = preprogram price of housing services.

Note that we evaluate housing consumption, $Q(x)$, using the preprogram price of housing services, P_o. That makes $H(x)$ indicate change in housing services purchased rather than change in rent paid for those services.

The total change in nonhousing consumption caused by a demand-subsidy program equals the increase in household income due to program subsidies less the increase in rent paid for housing consumption:

$$N(x) = [hx + nx] - [P(x)Q(x) - P_oQ_o] , \qquad (B.13)$$

where $N(x)$ = change in nonhousing consumption (dollars per month) as a function of program size,

h = increase in housing consumption for program participants (dollars per program dollar),

n = increase in nonhousing consumption for program participants (dollars per program dollar), and

$P(x)$ = price of rental housing services as a function of program size, $P_o = P(0)$.

The subsidy that increases household income equals the sum of the increases in the housing and nonhousing consumption of participants, $hx + nx$. The increase in rent paid equals the rent paid under the program, $P(x)Q(x)$, less the rent that would have been paid if there had been no program, P_oQ_o.

The market's reaction to a demand-subsidy program is determined by the intersection of the demand and supply curves for rental housing services. The demand curve relates the demand for rental housing

services to the price of those services and to the size of the demand increase caused by the program:

$$Q(x) = \left[Q_o + \frac{hx + ghx}{P_o}\right]\left[\frac{P(x)}{P_o}\right]^{-S}, \qquad \text{(B.14)}$$

where $Q(x)$ = demand for rental housing services as a function of program size, $Q_o = Q(0)$,

g = increased housing consumption for nonparticipants due to anticipation and inertia effects (dollars per dollar of increased housing consumption for participants), and

S = price elasticity of rental housing demand.

The shift in the demand curve caused by a demand-subsidy program is estimated in Eq. (B.14) by the sum of participant increases in housing consumption, hx, and the nonparticipant increases in housing consumption due to anticipation and inertia effects, ghx. Those expenditures are divided by the price of housing services, P_o, to convert them into measures of housing quantity.

The supply curve relates the supply of housing services to the price of those services:

$$Q(x) = Q_o\left[\frac{P(x)}{P_o}\right]^{Y}, \qquad \text{(B.15)}$$

where Y = price elasticity of rental housing supply.

Solving Eqs. (B.14) and (B.15) for the equilibrium price and supply of housing services as a function of program size yields

$$P(x) = P_o\left[1 + \frac{hx + ghx}{P_o Q_o}\right]^{\frac{1}{Y+S}}, \qquad \text{(B.16)}$$

and

$$Q(x) = Q_o\left[1 + \frac{hx + ghx}{P_oQ_o}\right]^{\frac{Y}{Y+S}} \qquad \text{(B.17)}$$

Substituting those market equilibrium results into Eqs. (B.12) and (B.13) produces

$$H(x) = P_oQ_o\left[1 + \frac{hx + ghx}{P_oQ_o}\right]^{\frac{Y}{Y+S}} - P_oQ_o, \qquad \text{(B.18)}$$

and

$$N(x) = [hx + nx] - \left[P_oQ_o\left(1 + \frac{hx + ghx}{P_oQ_o}\right)^{\frac{Y+1}{Y+S}} + P_oQ_o\right]. \qquad \text{(B.19)}$$

Because even full-entitlement demand-subsidy programs serve only a small fraction of the renter population, $[hx + ghx] / P_oQ_o$ is much smaller than 1.0, so we can use the approximation

$$\left[1 + \frac{hx + ghx}{P_oQ_o}\right]^{\alpha} \cong 1 + \alpha\left[\frac{hx + ghx}{P_oQ_o}\right] \qquad \text{(B.20)}$$

to simplify Eqs. (B.18) and (B.19). Using that approximation, and dividing by program size, x, gives the final formulas for the total changes in housing and nonhousing consumption caused by demand-subsidy programs per program dollar:

$$H(x) = h - \left[\frac{S}{Y + S}\right]h + \left[\frac{Y}{Y + S}\right]gh \ , \qquad \text{(B.21)}$$

and

$$N(x) = n - \left[\frac{1 - S}{Y + S}\right]h - \left[\frac{Y + 1}{Y + S}\right]gh \ . \qquad \text{(B.22)}$$

The bottom line of Table B.2 reports our conclusions about the effect of demand-subsidy programs on total housing and nonhousing consumption. The top line of the table recognizes the consumption

Table B.2

FORMULAS FOR CONSUMPTION CHANGES CAUSED BY HOUSING ALLOWANCE AND UNRESTRICTED CASH PROGRAMS

Consumer	Consumption Changes per Assistance Program Dollar	
	Housing	Nonhousing
Participants	h	n
Nonparticipants	$-\left[\frac{S}{Y+S}\right]h + \left[\frac{Y}{Y+S}\right]gh$	$-\left[\frac{1-S}{Y+S}\right]h - \left[\frac{Y+1}{Y+S}\right]gh$
Total	$h - \left[\frac{S}{Y+S}\right]h + \left[\frac{Y}{Y+S}\right]gh$	$n - \left[\frac{1-S}{Y+S}\right]h - \left[\frac{Y+1}{Y+S}\right]gh$

NOTE: Table B.3 presents summary definitions of the parameters in these formulas.

increases of participants. The middle line obtains the consumption changes of nonparticipants by subtracting the participant increases from the total increases. When evaluated by the parameter estimates given at the end of this appendix, the nonparticipant formulas yield the demand-subsidy program effects reported in Table 3.1.

Note that the nonparticipant consumption changes would be unambiguously negative if there were no anticipation or inertia effects (i.e., if $g = 0$). The existence of those effects makes it possible for demand-subsidy programs to increase the housing consumption of nonparticipants. Note also the dependence of the nonparticipant consumption changes on the price elasticity of supply. If supply is completely inelastic ($Y = 0$), then the housing consumption of nonparticipants decreases by an amount equal to the housing consumption increase of participants. In other words, if supply is completely inflexible, program participants gain housing only at the expense of nonparticipants. On the other hand, if supply is completely elastic ($Y = \infty$), then the housing consumption of nonparticipants increases by the full amount of the anticipation and inertia effects, because under completely elastic supply there is no increase in the price of rental housing services to cause demand reductions.

PARAMETER ESTIMATES

Table B.3 presents estimates of the program parameters needed to solve the formulas in Tables B.1 and B.2. The first five parameters give program effects in dollars per total program cost, as estimated from the data in Tables 2.3 and 2.4. For example, the market rent of the average public-housing unit is $158.02 per month, and the total cost of the public housing program per unit is $215.15 per month (see Table 2.3); the ratio of the former to the latter is 0.734 (the estimate of parameter m for public housing in Table B.3).

The sixth parameter in Table B.3 gives the effects of anticipation and inertia in the housing assistance programs on the housing consumption of nonparticipants (in dollars per dollar of increased housing consumption by participants).

The final two parameters needed for the formulas in Tables B.1 and B.2 are the price elasticity of demand, S, and the price elasticity of housing supply, Y. Our estimates are $S = 0.5$ and $Y = 11.3$, derived in a forthcoming report (C. Peter Rydell, *Price Elasticities of Housing Supply*, The Rand Corporation, R-2846-HUD). Appendix C of the present report analyzes the sensitivity of our conclusions to the estimates of those parameters.

Table B.3

PROGRAM PARAMETERS IN FORMULAS FOR CONSUMPTION CHANGES

Symbol	Description	Estimate		
		Public Housing	Housing Allowances	Unrestricted Cash Grants
m	Program unit market rent (per program dollar)	0.734	1.814	1.841
v	Nonprogram unit market rent (per program dollar)	0.680	1.680	1.768
c	Participant contribution to rent (per program dollar)	0.392	0.970	1.952
h	Increased housing consumption by participants (per program dollar)	0.054	0.134	0.073
n	Increased nonhousing consumption by participants (per program dollar)	0.288	0.710	0.816
g	Increased housing consumption by nonparticipants due to anticipation and inertia effects (per dollar of increased housing consumption by participants)	0	0.141	0.021

SOURCE: Parameters m, v, c, h, and n estimated from data in Tables 2.3 and 2.4 of the present report. Parameter g estimated from Table 4.1 in Mulford et al., *Housing Consumption in a Housing Allowance Program*, The Rand Corporation, R-2779-HUD, forthcoming.

NOTE: The first five parameters are related by $h = m - v$ and $n = v - c$; see Fig. 2.1.

Appendix C

SENSITIVITY OF CONCLUSIONS TO PRICE ELASTICITIES OF SUPPLY AND DEMAND

This report's conclusions about program-induced changes in housing and nonhousing consumption depend on estimates of the price elasticity of rental housing demand, S, and the price elasticity of housing supply, Y (see the formulas in Tables B.1 and B.2). The estimates of those elasticities, $S = 0.5$ and $Y = 11.3$ come from a forthcoming report and will not be derived here, although we analyze the sensitivity of this report's conclusions to those estimates.

The estimated price elasticity of demand is the result of a literature review showing $S = 0.5$ as the central tendency of many separate estimates. Almost all the studies report estimates lying between 0.2 and 0.8.

The estimated price elasticity of supply, $Y = 11.3$, is the result of an analysis of cross-sectional Annual Housing Survey (AHS) data from 59 metropolitan areas. The 95 percent confidence interval estimate of the supply elasticity is 7.0 to 23.0.

Table C.1 shows the result of varying the demand elasticity from 0.2 to 0.8 and the supply elasticity from 7.0 to 23.0. Each panel of the table was constructed using the formulas for total consumption changes given in Tables B.1 and B.2.

Comparing the bottom panels with the top panel, we find that varying the estimates of the demand and supply elasticities over the indicated ranges does not change this report's qualitative conclusions. In all five panels of the table, the housing allowance program yields more housing benefits (per assistance program dollar) than either the public housing or the unrestricted cash grant program. Also, in all five panels the unrestricted cash grant program does best on nonhousing benefits (per program dollar) and the housing allowance program does second best.

If we restrict attention to the housing benefits, the analysis becomes simple enough for an exhaustive sensitivity analysis in a single diagram. Using the formulas for total housing consumption changes in

Table C.1

CONSUMPTION CHANGES UNDER ALTERNATIVE SUPPLY AND DEMAND ELASTICITIES

Type of Consumption	Consumption Changes per Assistance Program Dollar		
	Public Housing	Housing Allowances	Unrestricted Cash Grants
Actual Supply and Demand Elasticities[a]			
Housing	.083	.146	.071
Nonhousing	.317	.685	.811
Total	.400	.831	.882
Low Supply Elasticity, Low Demand Elasticity[b]			
Housing	.073	.149	.072
Nonhousing	.354	.674	.806
Total	.427	.823	.878
Low Supply Elasticity, High Demand Elasticity[c]			
Housing	.124	.137	.067
Nonhousing	.305	.687	.813
Total	.429	.824	.880
High Supply Elasticity, Low Demand Elasticity[d]			
Housing	.060	.152	.074
Nonhousing	.311	.686	.812
Total	.371	.838	.886
High Supply Elasticity, High Demand Elasticity[e]			
Housing	.077	.148	.072
Nonhousing	.294	.690	.814
Total	.371	.838	.886

SOURCE: Tables 2.3, 2.4, B.1, and B.2.

NOTE: S = price elasticity of rental housing demand, Y = price elasticity of rental housing supply.

[a] $Y = 11.3$, $S = 0.5$

[b] $Y = 7.0$, $S = 0.2$

[c] $Y = 7.0$, $S = 0.8$

[d] $Y = 23.0$, $S = 0.2$

[e] $Y = 23.0$, $S = 0.8$

Tables B.1 and B.2 (and using the parameter estimates in Table B.3), we find that the total housing consumption increases caused by the alternate assistance programs are functions of the ratio of the supply elasticity to the demand elasticity, Y/S. Figure C.1 shows how total housing consumption in the three housing assistance programs varies with that ratio.

The dots in the figure indicate program performance under our point estimate of the demand and supply elasticities ($S = 0.5$, $Y = 11.3$, so that $Y/S = 22.6$). There, the housing allowance program does the best job of producing housing benefits (per program dollar) and the public housing program does second best.

If the ratio of supply elasticity to demand electricity were greater than 35.7, then the unrestricted cash grant program would yield more housing benefits than the public housing program. That result could be true because the highest ratio in our sensitivity analysis is $Y/S = 76.7$ (the consequence of $S = 0.3$ and $Y = 23.0$).

If the ratio of supply elasticity to demand elasticity were lower than 7.4, then the public housing program would yield more housing benefits (per program dollar) than the housing allowance program. That result is not likely because the lowest ratio in our sensitivity analysis is $Y/S = 10.0$ (the consequence of $S = 0.7$ and $Y = 7.0$).

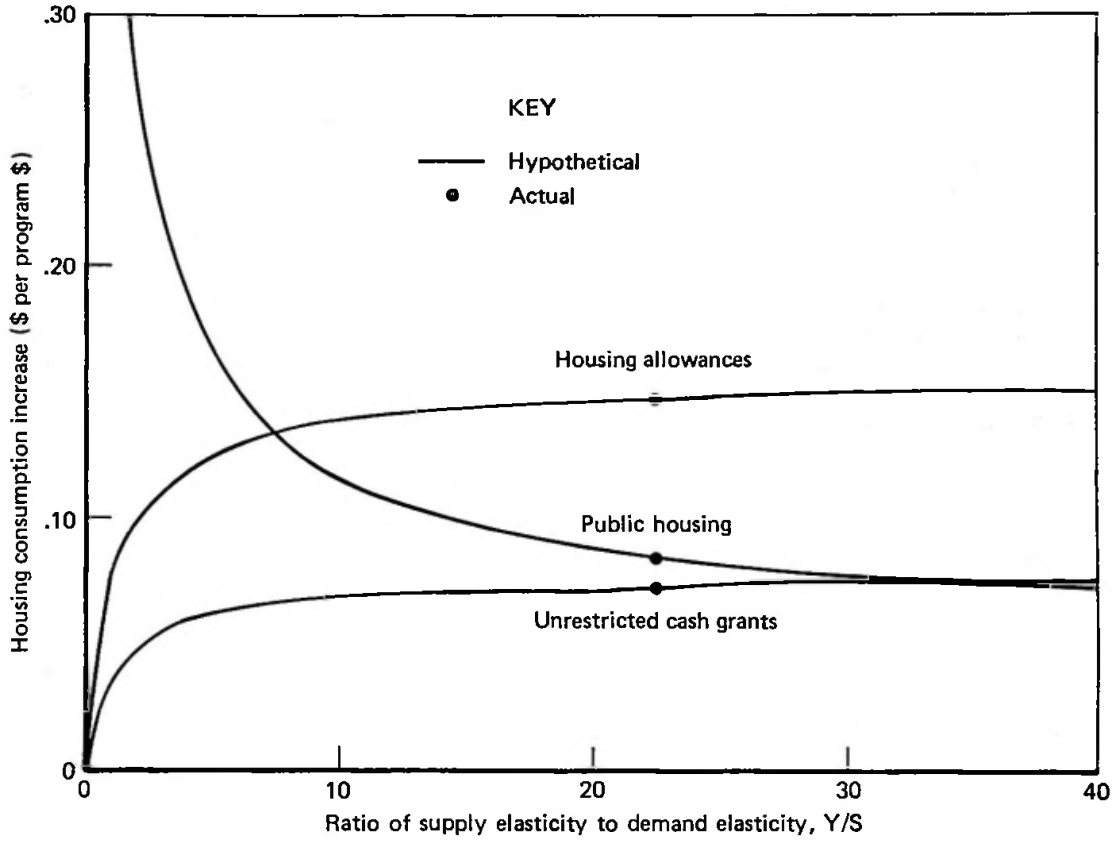

Fig. C.1 — Housing consumption increases caused by alternate housing assistance programs under varying ratios of supply elasticity to demand elasticity

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