Housing Allowance Demand Experiment

The Demand for Rental Housing: Evidence from a Percent of Rent Housing Allowance

Joseph Friedman
Daniel H. Weinberg

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Abt Associates Inc., Cambridge, Massachusetts

ABT ASSOCIATES INC
55 WHEELER STREET, CAMBRIDGE MASSACHUSETTS 02138
TELEPHONE • AREA 617-492-7100

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THE DEMAND FOR RENTAL HOUSING:
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PERCENT OF RENT HOUSING ALLOWANCE

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Principal Authors: Joseph Friedman
Daniel H. Weinberg

Contract Manager	Quality Control Reviewer	Management Reviewer

ABSTRACT

This report analyzes the housing consumption of households participating in the Housing Allowance Demand Experiment that received Percent of Rent housing allowances. Analyses of both housing expenditures and housing services (a measure of real housing) are carried out using a variety of approaches. Also examined are household response over time and the possibility of bias due to sample selection.

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Joseph Friedman
Daniel H. Weinberg

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SUMMARY

This report is one of a series of technical reports on the final results of housing programs tested in the Housing Allowance Demand Experiment. The Demand Experiment, authorized by Congress in the Housing Act of 1970, was designed to test the concept of direct cash assistance to low-income households enabling them to rent suitable housing. The experiment focused on the ways low-income renter households use housing allowances. It tested a variety of allowance plans involving approximately 1,200 low-income Experimental households and 500 Control low-income households at two sites: Allegheny County, Pennsylvania (Pittsburgh) and Maricopa County, Arizona (Phoenix), during 1973-1977. Each household enrolled in the experiment was offered monthly allowance payments for three years. Analysis is based on data from the first two years of payments.

The subject of this report is Percent of Rent housing allowances, one of the major types of housing allowance payment formulas tested in the Demand Experiment. The Percent of Rent plans offered eligible households rebates equal to some fraction of their gross monthly rent. Within the Demand Experiment, households were divided into five groups, receiving rebates of 20, 30, 40, 50, or 60 percent of their monthly rent. Thus, for example, a household receiving a 50 percent rebate would be given $50 if its rent were $100 and $100 if its rent were $200. Such a household could move into a unit twice as expensive without changing its original out-of-pocket housing expenditures. Alternatively, it could retain its original housing at half the original cost.

A Percent of Rent rebate reduces the effective price of housing for recipients, thereby creating a distinct incentive for recipients to improve their housing by, in effect, making housing a "bargain" relative to other goods and services. A household receiving a 50 percent rebate, for example, has its rent cut in half whether it stays where it is or moves to other housing. Price cuts, in the case of most goods, normally lead to increased purchases. When the price cut is in the form of a rent rebate, demand and expenditures for housing are expected to increase--and housing conditions to improve commensurately.

There are obvious potential advantages to this kind of housing allowance payment. It automatically ties allowance payments to a household's own contri-

bution toward meeting its housing needs and does so in an administratively simple way. It allows each household a wide range of choice by not requiring households to choose housing of a particular type or in a particular location. It automatically adjusts payments to take account of local housing costs. On the other hand, households may or may not use their rebate to improve their housing. Even if they do spend the rebate on housing, they may or may not obtain decent housing that meets public policy objectives unless specific housing standards are imposed and enforced. The rebate may lead households to shop less carefully for housing, resulting in their payment of more than they otherwise would for the housing they obtain. The effectiveness, efficiency, and equity of such rebate programs depend on exactly how households respond to the rebates.

The percentage rebates offered in the experiment depended only on the experimental plan to which they household was assigned. Since higher income households tend to have higher rental expenditures than do lower income households, this means that they also tended to receive larger allowance payments. An actual program would probably vary the percentage rebate with income or rent so that higher income households would not tend to receive higher payments. The effects of such program variations can be estimated from the responses to the experimental plans.

Income transfers through general assistance, social security, or other transfer programs, would provide an alternative to assistance specifically tied to housing. Such general transfers offer households a wider range of choice in spending the additional transfer income. Further, they may be administratively easier to operate and to coordinate with other assistance programs. Their relative effectiveness, efficiency, and equity in terms of housing again depends on the way in which households change their housing in response to changes in household income. Thus the same questions arise in evaluating the housing impact of both rent rebate and income transfer programs.

Estimates of housing responses to income transfers are obtained from two sources. First, since income transfers essentially increase recipient incomes, their impact on housing can be estimated by analyzing the way in which low-income households' housing normally varies with household income. Second, the Demand Experiment included a small sample of households that received an unconstrained income transfer. These households, called Unconstrained households, provide direct observation of the effect of income transfers on the housing of recipients.

The analysis described in this report first estimates an expenditure function that shows how households change their housing expenditures in response to the housing price reductions created by the Percent of Rent rebates and how changes in nonexperimental variables, particularly income, affect housing expenditures. It then examines the extent to which changes in housing expenditures due to rent rebates or other factors are likely to be translated into improved housing. It thus provides the basic tools for designing and evaluating alternate rent rebate and income transfer programs.

The following major conclusions emerged from the analysis:

1. Relative to Control households, experimental households receiving Percent of Rent rebates increased their housing expenditures by a small but statistically significant percentage.

   The overall increase in expenditures for Percent of Rent households at both sites was 26 percent, compared to 18 percent for Control households. The experience of Control households provides a benchmark estimate of normal behavior--how Percent of Rent households would have changed their housing expenditures in the absence of the rent rebate. Thus, it appears that the net effect of the price reduction was to induce only an 8 percentage point increase in housing expenditures above normal levels. This finding is confirmed by an estimated expenditure function (which takes into account nonexperimental differences between Percent of Rent and Control households).

2. As might be expected, households respond to Percent of Rent rebates only when they move. Thus the full effect of a rent rebate will develop gradually as recipients move.

   Households that moved during the experiment had much larger normal rent increases than those that did not. Control households that moved increased their housing expenditures by 29 percent in Pittsburgh and 30 percent in Phoenix as compared with increases for nonmover Control households of 13 percent and 7 percent respectively. Percent of Rent households that moved increased their housing expenditures 16 percentage points more than Control movers in Pittsburgh and 8 percentage points more in Phoenix. Percent of Rent households that did not move increased their expenditures by only 2 percentage points more than Control nonmovers in Pittsburgh and by the same percent as Control nonmovers in Phoenix.

3. The estimated relation between the housing expenditures of low-income households and changes in housing prices and income is the same at both sites. These estimates indicate only small changes in housing expenditures in response to changes in price or income. A 10 percent reduction in the price of housing resulted in only a 2.2 percent increase in housing expenditures; a 10 percent increase in household's average income resulted in only a 3.6 percent increase in housing expenditures.

   Estimates for the two sites gave almost identical results in terms of the change in housing expenditures with respect to changes in the price of housing or household income. The estimated response to price changes are lower than estimates from most previous studies, which are based on much less reliable price data than that provided by the Demand Experiment. The estimated responses to income changes are based on cross-sectional estimates using three-year average annual household income and are also somewhat lower than most previous studies. These estimates were confirmed by analysis of the small sample of Unconstrained households which received an income transfer payment.

4. The estimated response of housing expenditures to changes in housing prices are lower than most estimates based on nonexperimental data. The estimated response to changes in income is also in the lower range of estimates based on nonexperimental data, though not markedly so.

   Estimates of the increase in gross housing expenditures to a 10 percent rent rebate based on nonexperimental data have ranged from 1 percent to 19 percent, with most studies giving values of around 7 percent. In contrast, the estimates in this report indicate an increase in gross housing expenditures of 2.2 percent. Nonexperimental estimates are hampered by problems in estimating differences in housing prices which may seriously bias those results, however. On the other hand, the experimental data are subject to several reservations; they are limited to low-income households, which may have lower responses than higher income households; the duration of the experiment may have limited households' understanding or willingness to change their housing; and it is possible to propose models under which longer run responses would be larger than those observed at the end of two years, even for households that move. No evidence was found to support any of these alternatives, though the tests available are not always conclusive.

Estimates of responses to a 10 percent increase in household income based on nonexperimental household data have generally ranged from a 1 percent to 6 percent increase in housing expenditures. The estimate from the Demand Experiment is 3.6 percent, which is close to, but somewhat lower than the mid-point of the nonexperimental estimates. This is not unexpected, since the Demand Experiment estimate is itself based on analysis of nonexperimental variations in income, though it is also consistent with responses to the experimentally induced changes in income provided by the Unconstrained plan, as well as estimated housing expenditure responses in the Seattle-Denver Income Maintenance Experiments.

5. Most of the allowance payment under a rent rebate program will not be used for increased housing expenditures. Even less of an income transfer payment will be used to increase housing expenditures. Given the very high rent burdens of recipients, some allocation of payments to nonhousing expenditures may be desirable even from a housing perspective.

While the proportion of a rent rebate allowance payment used for increased housing expenditures tends to increase with the rebate level, the estimated responses to changes in housing prices indicate that even a rebate of 90 percent of rent would result in increased housing expenditures amounting to less than half the total payment. A 40 percent rebate program would lead to increased housing expenditures of about 27 percent of the allowance payments. The estimated effect of increased income transfers on housing expenditures is even smaller. The income transfer payment necessary to achieve the same change in housing expenditures as a rent rebate of 40 percent would be from two to four times as large as the rent rebate payment.

At enrollment, half of the Percent of Rent households at each site had rent burdens in excess of 32 percent of income and almost a third had rent burdens greater than 40 percent of income. After two years, the median rent burden for Percent of Rent households net of the allowance payment was 21 percent of income in Pittsburgh and 24 percent of income in Phoenix. The estimated expenditure functions suggest that reduction in rent burden under a rent rebate will be somewhat larger at higher rebate levels and for households with higher pre-rebate rent burdens. Households with a 40 percent of income rent burden would on average be expected to reduce their rent burdens to 27 percent of income under a 40 percent rebate and to 20 percent of income under a 60 percent rebate.

6. Minority households (black in Pittsburgh but predominantly Spanish American in Phoenix) made smaller changes in housing expenditures in response to changes in the price of housing or income than did nonminority households. There is no consistent evidence of important differences in response among other demographic groups.

   The percentage change in housing expenditures resulting from a given percentage change in household income is estimated to be about half as large for minority households as for nonminority households. The percentage change in response to rent rebates is estimated to be about three-fourths that of nonminority households. Although small samples of movers preclude exact estimation for subpopulations of minority households, it appears that Spanish American households in Phoenix may show even smaller responses than black households in Phoenix or Pittsburgh. The lower response of minority households is associated with a lower initial rent in Phoenix, though not in Pittsburgh.

   A variety of other demographic factors were tested, including age, sex, and education of head of household, household size, and household composition. Of these only household composition proved significant when the sites were analyzed separately, and even this variable was not significant for estimates based on the combined sites.

7. The changes in real housing made in response to the rent rebates were smaller than the expenditure changes. It appears that from one-fifth to

one-half or more of the expenditure changes induced by the rent rebates represented increasing spending without concommitant increases in housing services obtained.

Hedonic indices, based on statistical relationships between the housing characteristics of a unit and its rent, were used to compare the average market rent of units with the rents paid by Percent of Rent households. Results differed among demographic groups and between sites. Allowing for the fact that hedonic indices do not fully reflect all real changes in housing, it still appears that about one-fifth of the increased housing expenditure by nonminority Percent of Rent households in Pittsburgh went for increased spending above the amounts usually needed to purchase the level of housing services that they actually obtained. The comparable figure in Phoenix is one-half. Small sample sizes make investigation of minority response more tentative. It appears, however, that minorities in Phoenix, and especially Spanish American households, may have had little or no real change in their housing and little or no change in their housing expenditures. Once again, the smaller response for minority households is associated with a much lower initial quality in Phoenix.

SOURCES OF STATEMENTS

1. Tabulation of expenditure changes are given in Table 2-1. Price elasticities estimated based on all Percent of Rent households are given in Table 4-1.

2. Tabulation of expenditure changes are given in Table 2-5.

3. Comparison of estimates for the two sites is based on households that moved as shown in Tables 4-2 and 4-3. The results of previous studies and the price data used in them are discussed in Section 3.3. Estimates for Unconstrained households are shown in Table 4-6.

4. A summary of recent evidence on household response to changes in price and income is presented in Section 3.3. The possibility that higher income households have higher responses is examined in the discussion of Tables 4-4 and 4-5. The limited duration of the experiment is discussed in Section 6.1.

5. Allocation of the Percent of Rent rebates and income transfers to increased housing expenditures is discussed in Section 2.2. Rent burden figures at enrollment and two years are given in Appendix Table X-4.

6. Estimated expenditure functions for different demographic groups are discussed in Section 4.3. The comparison of minority and nonminority households is based on Table 4-10.

7. The comparison of expenditure changes and real changes in housing is discussed throughout Chapter 5. See especially Table 5-7 and the discussion in the text.

CHAPTER 1

INTRODUCTION

This is one of a series of final technical reports on the Housing Allowance Demand Experiment. The Demand Experiment was designed to provide information on how low-income households use housing allowance payments. The experiment offered monthly allowance payments to approximately 1,200 low-income households selected at random in each of two sites: Pittsburgh (Allegheny County), Pennsylvania and Phoenix (Maricopa County), Arizona. Several different allowance plans were tested involving different payment formulas and housing requirements. In addition, a control group of approximately 500 low-income households was enrolled at each site. Households remained in the experiment and received payments for three years after they enrolled. The calendar period covered by the experiment was roughly from late 1973 to early 1977. Evaluation is based on household responses in the first two years after enrollment.

There were four basic treatment plans under which households were enrolled: Housing Gap, Unconstrained, Percent of Rent, and Control.[1] Households in Housing Gap plans were offered payments designed to bridge the gap between the cost of modest, existing standard housing and a reasonable fraction of household income. The Housing Gap allowance payment was linked to participants' housing by housing requirements--households received an allowance only if they occupied a unit meeting the program's housing standards.[2] The Unconstrained plan offered households a payment based on the same formula as in the Housing Gap plan but without a housing requirement. This plan resembled general income support programs, except that the payment amount was determined by need for housing rather than for all household expenses.

Percent of Rent plans offered households a rent rebate in the form of a cash payment equal to a fixed fraction of their monthly rent. Households in Percent of Rent plans had no housing requirements to meet. Their payment was tied directly to the amount spent for housing. Finally, the group of

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[1] See Appendix I for a detailed discussion of the design.

[2] The housing response of these households is discussed in Friedman and Weinberg (1979).

Control households did not receive any housing allowance payment beyond a $10 monthly cooperation payment for providing the same information as Experimental households. They provided a comparison group against which to estimate the effect of different allowance plans.

This report focuses mainly on the housing consumption of households in the Percent of Rent housing allowance plans. The Percent of Rent plans reduce the price of housing to participants because the government shares in the cost of whatever housing the participant selects. A household with a 50 percent rebate, for example, only has to spend $75 of its own money to rent a $150 unit; its price of housing has been halved. Thus analyzing responses to the Percent of Rent rebates is in effect analyzing the way in which households respond to changes in the price of housing.

Previous analyses of household responses to variations in the price of housing have been based on comparisons of housing expenditures across cities or years with different estimated overall housing costs. The Percent of Rent plans tested in the Demand Experiment provide the first direct observations of household responses to a well-defined change in the price of housing relative to other goods and services. Similarly, the Unconstrained plan and the naturally occurring variation in household income and rent can be used to analyze households' housing response to changes in income.

The Percent of Rent plans in particular are not intended as prototype programs.[1] Rather, they, together with Unconstrained and Control households, are intended to allow estimation of a general relation between housing consumption and the price of housing, household income, and other demographic characteristics. This general relation--called a demand function--can then be used to estimate the effects on housing of a variety of housing assistance and income maintenance programs.[2]

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[1] In order to facilitate analysis, the rent rebates tested in the Demand Experiment offered a constant percentage rebate to eligible households, regardless of the household's actual rent or income. A realistic program probably would offer smaller rebates to higher income households and restrict the range of housing expenditures to which the rebate applied.

[2] In addition, economic theory links the demand function to a wide variety of household behavior. Although these theoretical links apply only to individual households, the average behavior represented by an estimated demand function can provide important insights into the overall behavior of eligible households.

Housing demand functions are estimated in this report both in terms of housing expenditures and in terms of an estimated hedonic index of housing services. The analysis of expenditures as a function of the price of housing and household income provides estimates of the extent to which payments under a Percent of Rent housing allowance or an income maintenance program will be translated into increased spending for housing. This is of interest in itself and because differences in housing expenditures are expected to reflect real differences in recipient housing as well.

However, changes in housing expenditures may not always lead to real changes in housing. Most obviously, general inflation implies higher dollar expenditures without any change in the housing services provided by a dwelling unit. The changes in expenditure estimated here account for inflation, so that this poses no problem. Even apart from inflation, changes in expenditure may still not be reflected in real changes in participant housing. If allowance recipients are unable to act effectively in the private market or if they shop less carefully, then they might end up spending more for the same housing than they otherwise would. Hedonic indices address this problem by providing estimates of the normal market value of a unit in terms of its physical characteristics. Comparison of the hedonic value of a unit with the actual rent charged can be used to sort out the extent to which households are paying above- or below-average rents and thus provides estimates of the real change in participant housing.[1]

The mechanism that households use in changing their housing consumption is also of interest. As would be expected, renter households usually make large changes in their housing only when they move. Accordingly, the full impact of changes in the price of housing may only be realized gradually, as households move. Alternatively, households may, even when they move, only adjust their housing in stages. The analysis below investigates the dynamics of housing demand and examines the possibility of gradual adjustment to changed circumstances. Dynamic models also suggest that the limited duration of the experiment (three years) may play a role in affecting the adjustment process, and this possibility is examined as well.

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[1] Changes in other measures, such as physical housing standards, are presented as well.

Chapters 2 through 4 of this report focus on expenditure changes in response to rent rebates. Chapter 2 presents a basic tabular analysis of changes in expenditures and rent burden (the proportion of income devoted to rent), illustrating the important role residential mobility plays in those changes. It then provides a brief summary of the results of estimating demand functions and applies the demand function parameters to the estimation of impact of existing and potential government programs.

Chapter 3 develops the theoretical issues involved in estimating housing demand functions, presents the two functional forms employed in this report, and discusses the results of other recent attempts to estimate housing demand functions. Chapter 4 then presents the estimated demand functions in terms of housing expenditures based on data from the Demand Experiment and taking into account both the price discount offered to Percent of Rent households and the income transfer offered to Unconstrained households. The estimates are contrasted with those from previous studies of housing demand. Movers are selected for primary analysis and the influence of various demographic characteristics (in particular minority status and household composition) on housing expenditures is examined for this group.

Chapter 5 shifts the focus from housing expenditures to housing services and examines household response to the housing allowance payment in terms of both changes in the specific physical characteristics of the dwelling unit and in the estimated average market value of the unit (the hedonic index of housing services). The chapter compares household response as measured alternatively by expenditures and housing services. This comparison enables determination of the extent to which households overpay for their unit relative to the market average price.

Finally, Chapter 6 discusses several technical problems involved in using experimental data to specify and estimate response functions. The first problem examined is the role of housing market dynamics and its interaction with the limited duration of the experiment in affecting household adjustment to the rent rebate. Second is the problem of selection bias on the elasticity estimates (due to differential acceptance, attrition, or mobility). The final problem examined is the extent to which households did not understand the program and hence did not respond to the Percent of Rent rebates.

REFERENCES

Friedman, Joseph and Daniel H. Weinberg, Housing Consumption Under a Constrained Income Transfer: Evidence from a Housing Gap Housing Allowance, Cambridge, Mass., Abt Associates Inc., April 1979 (revised June 1980).

CHAPTER 2

SUMMARY OF EXPENDITURES CHANGES

This chapter provides a brief summary of the effects of Percent of Rent allowances on housing expenditures. The chapter starts with a tabular overview of changes in housing expenditures and rent burden for Percent of Rent households. These are compared with changes for Control households. Similar comparisons are presented for Unconstrained households, which received a direct income-conditioned payment, unconnected with their housing expenditures.

Tabular analysis, however, does not control sufficiently for other influences on household behavior. Section 2.2 therefore presents the estimated demand function for housing as developed in Chapters 3 and 4. This function, based on the responses of Percent of Rent and Control households, relates housing expenditures to household income and the price of housing. It can be used to estimate housing expenditure responses to a wide variety of rent rebate and income-transfer programs, as indicated in Section 2.3.[1]

2.1 TABULAR OVERVIEW OF EXPENDITURE CHANGES

Rent rebates provide an incentive to increase rental expenditures by reducing the effective price of housing to recipients. A household with a 50 percent rebate, for example, would have to spend only $75 out-of-pocket to get housing that rents in the market for $150. From the point of view of the tenant, this rebate is equivalent to a halving of the price of housing. In general, for a household with a percentage rebate of "a", the price per unit of housing drops from p_H to $(1-a)p_H$. Thus, recipient households are expected to increase housing expenditures relative to Control households during the experiment. As shown in Table 2-1, the average increase in rental expenditures for recipients was higher than that for Control households at both sites. Percent of Rent households increased their housing expenditures by an average of 26 percent in each site, while Control households had a smaller increase--18 percent.[2]

[1] Appendix VII presents a further application of the demand function results to a microeconomic theory of residential mobility.

[2] More detailed tabulations of rent changes are presented for each percentage rebate plan in Appendix Table X-1. The increase in rent is generally larger for households with larger percentage rebates. The percentage changes reported in the text are the mean of the ratio of the change in rent to the rent at enrollment. The appendix tables also report the ratio of the mean change in rent to the mean rent at enrollment.

Table 2-1

MEAN MONTHLY HOUSING EXPENDITURES AT ENROLLMENT AND AT TWO YEARS AFTER ENROLLMENT

TREATMENT GROUP	MEAN HOUSING EXPENDITURES: At Enrollment	MEAN HOUSING EXPENDITURES: At Two Years	MEAN CHANGE IN HOUSING EXPENDITURES: Amount	MEAN CHANGE IN HOUSING EXPENDITURES: Percentage[a]	SAMPLE SIZE
		PITTSBURGH			
Percent of Rent households	$114	$139	$25	26%	(385)
Control households	115	133	18	18	(289)
		PHOENIX			
Percent of Rent households	132	162	30	26	(280)
Control households	128	145	17	18	(252)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

a. Percentage change is defined as the mean of the ratio of the change in rent to the rent at enrollment.

These figures suggest that the rent rebate did indeed induce Percent of Rent households to increase their housing expenditures and that households were sensitive to the price of housing. A straightforward, but crude way of measuring the expenditure response induced by the allowances is the amount by which recipient households' rent increases exceed that of Control households. Table 2-1 indicates that the experimentally induced change in housing expenditure, net of the "normal" increases represented by Control households, averaged 8 percentage points in each site. The average price reduction attributable to the rent rebate was approximately 40 percent. Consequently, a rough estimate of the price elasticity of housing expenditures (the percentage change in expenditures for a 1 percent change in price) is the ratio of these two numbers or -0.20 (that is, for every 10 percent decrease in price, housing expenditures increased by about 2 percent).

Table 2-2 presents similar figures for Unconstrained households. For the two sites combined, the mean percentage change in housing expenditures for Unconstrained households was almost the same as for Percent of Rent households--27 percent (22 percent in Pittsburgh and 35 percent in Phoenix). Thus, the net increase in expenditures above normal was about 9 percentage points. The payment averaged about 30 percent of income, implying an income elastic-

Table 2-2

MEAN MONTHLY HOUSING EXPENDITURES AT ENROLLMENT
AND AT TWO YEARS AFTER ENROLLMENT FOR UNCONSTRAINED HOUSEHOLDS

SITE	MEAN HOUSING EXPENDITURES		MEAN CHANGE IN HOUSING EXPENDITURES		SAMPLE SIZE
	At Enrollment	At Two Years	Amount	Percentage[a]	
Pittsburgh	$107	$128	$21	22%	(59)
Phoenix	135	165	30	35	(37)

SAMPLE: Unconstrained households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

a. Percentage change is defined as the mean of the ratio of the change in rent to the rent at enrollment.

ity (the percentage change in expenditures due to a 1 percent change in income) of approximately 0.30.

The overall allocation of the Percent of Rent allowance payments between increased housing expenditures and increased spending for other goods and services can be estimated roughly by dividing the average net increase for Percent of Rent households (the difference between expenditure changes for Percent of Rent and Control households, as shown in Table 2-1) by the average allowance payment. Overall, only a small fraction of the total allowance payments went to increased rent (see Table 2-3).[1]

These figures may be compared with changes for Unconstrained households. Economic theory asserts that the "price incentive" for increased spending on housing that is created by the rent rebates will be larger than the "income incentive" created by an equal cash grant unrelated to housing expenditures. The former is, in effect, a "matching grant" which rewards a household increasingly for its own expenditures, whereas the latter is, in effect, a "lump sum" transfer without particular incentives for increased housing expenditures. Thus, households are expected to spend more on housing of each dollar of a rent rebate than they would each dollar of a direct, unrestricted cash grant. This is confirmed by Table 2-3. Though the percentage increases in expenditures for Unconstrained households in the sites combined was almost the same as for Percent of Rent households, the average allowance payment for Unconstrained households was much larger, so that the increase as a percentage of the payment was smaller. This suggests that, as expected, rent rebates are more effective than unconstrained income transfers in channeling money into housing.

The part of the payment not spent on increased housing expenditure was available for nonhousing goods and services. One measure of this diversion is the change in "rent burden," the proportion of income spent on housing. Low-income households that spend more than 25 percent of their income on housing are often considered to be deprived.[2] These households are thought to have too little residual income available to spend on nonhousing goods and services in order to achieve a modest standard of living. Absent the receipt of a housing allowance, rent burden is simply the ratio R/Y, where

[1] The figures in the table are adjusted for normal changes in rent as measured by the mean change for Control households.

[2] Lane (1977) has discussed the origin and essential arbitrariness of this 25 percent "rule of thumb" for deprivation.

Table 2-3

PROPORTION OF ALLOWANCE PAYMENT ALLOCATED TO INCREASED RENTAL EXPENDITURES

TREATMENT GROUP	MEAN CHANGE IN RENT ABOVE NORMAL[a]	MEAN PAYMENT	PROPORTION USED FOR INCREASED EXPENDITURES[b]	SAMPLE SIZE
		PITTSBURGH		
Percent of Rent households	$7	$49	14%	(385)
Unconstrained households	3	55	5	(59)
		PHOENIX		
Percent of Rent households	13	59	22	(289)
Unconstrained households	13	108	12	(37)

SAMPLE: Percent of Rent and Unconstrained households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

a. This is computed as the mean change for Experimental households minus the mean change for Control households.

b. This is computed as the mean change above normal divided by the mean payment. It is intended to represent a program average rather than a household average.

R is monthly housing expenditures and Y is monthly income.[1] With the rent rebate, the out-of-pocket rent payments of recipients are reduced by the amount of the rebate. The rent burden is then defined as (1-a)R/Y, where "a" is the percentage rebate.

Most households in the Demand Experiment had rent burdens well above what has often been considered the normative target (25 percent). At enrollment, the median rent burden for Percent of Rent households was 32 percent.[2] Recipients of the rent rebates reduced their rent burden significantly over the two years of the experiment. As shown in Table 2-4, the median rent burden for Percent of Rent households fell from 0.32 at enrollment for both sites to 0.21 in Pittsburgh and 0.24 in Phoenix at two years.[3] Reduction of high rent burdens to free household resources for other expenditures may be an important policy goal in itself. However, reduction of rent burden is not peculiar to Percent of Rent. The net-of-payment rent burden for Unconstrained households at the end of two years was 0.20 in Pittsburgh and 0.13 in Phoenix.[4]

Increased expenditures on housing often accompany moving to a new unit with higher rent. In both Pittsburgh and Phoenix, households that moved experienced an increase in rental expenditures at least twice as high as that of nonmover households (see Table 2-5).[5] A striking feature is the larger increase in rent apparent for movers with larger percentage rebates as shown in Figure 2-1.[6] On the other hand, Percent of Rent and Control households

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[1] Rent burden statistics are highly sensitive to definitions of the income variable used in the denominator. Statistics reported in the text are median figures based on net disposable income. (For a further discussion of this issue, see Appendix III and Budding, 1978.)

[2] If rent burden is further broken down by income, higher-income households have lower rent burden than do low-income households since housing expenditure does not increase in proportion with income.

[3] Appendix Tables X-2 and X-3 present median and mean rent burden, respectively, by percentage rebate level.

[4] See Appendix Table X-4 for additional detail on the distribution of rent burden.

[5] Breakdowns of these figures by rebate level are provided in Appendix Tables X-5 and X-6.

[6] Most of the visual impression of larger experimental effects for higher rebates is the result of very high responses of movers under the 60 percent plan. In fact, households assigned to this plan were generally (continued)

Table 2-4

CHANGES IN RENT BURDEN
FROM ENROLLMENT TO TWO YEARS

TREATMENT GROUP	MEDIAN RENT BURDEN At Enrollment	MEDIAN RENT BURDEN At Two Years	MEDIAN CHANGE IN RENT BURDEN	SAMPLE SIZE
PITTBURGH				
Percent of Rent households	0.32	0.21	-0.11	(388)
Control households	0.29	0.26	-0.04	(290)
Unconstrained households	0.35	0.20	-0.17	(59)
PHOENIX				
Percent of Rent households	0.32	0.24	-0.09	(282)
Control households	0.32	0.30	-0.02	(256)
Unconstrained households	0.33	0.13	-0.23	(38)

SAMPLE: Percent of Rent, Unconstrained, and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

NOTE: Rent burden is defined as the ratio of net rent to disposable income (see Appendix III for definitions of these variables).

Table 2-5

MEAN MONTHLY HOUSING EXPENDITURES AT ENROLLMENT AND AT TWO YEARS AFTER ENROLLMENT

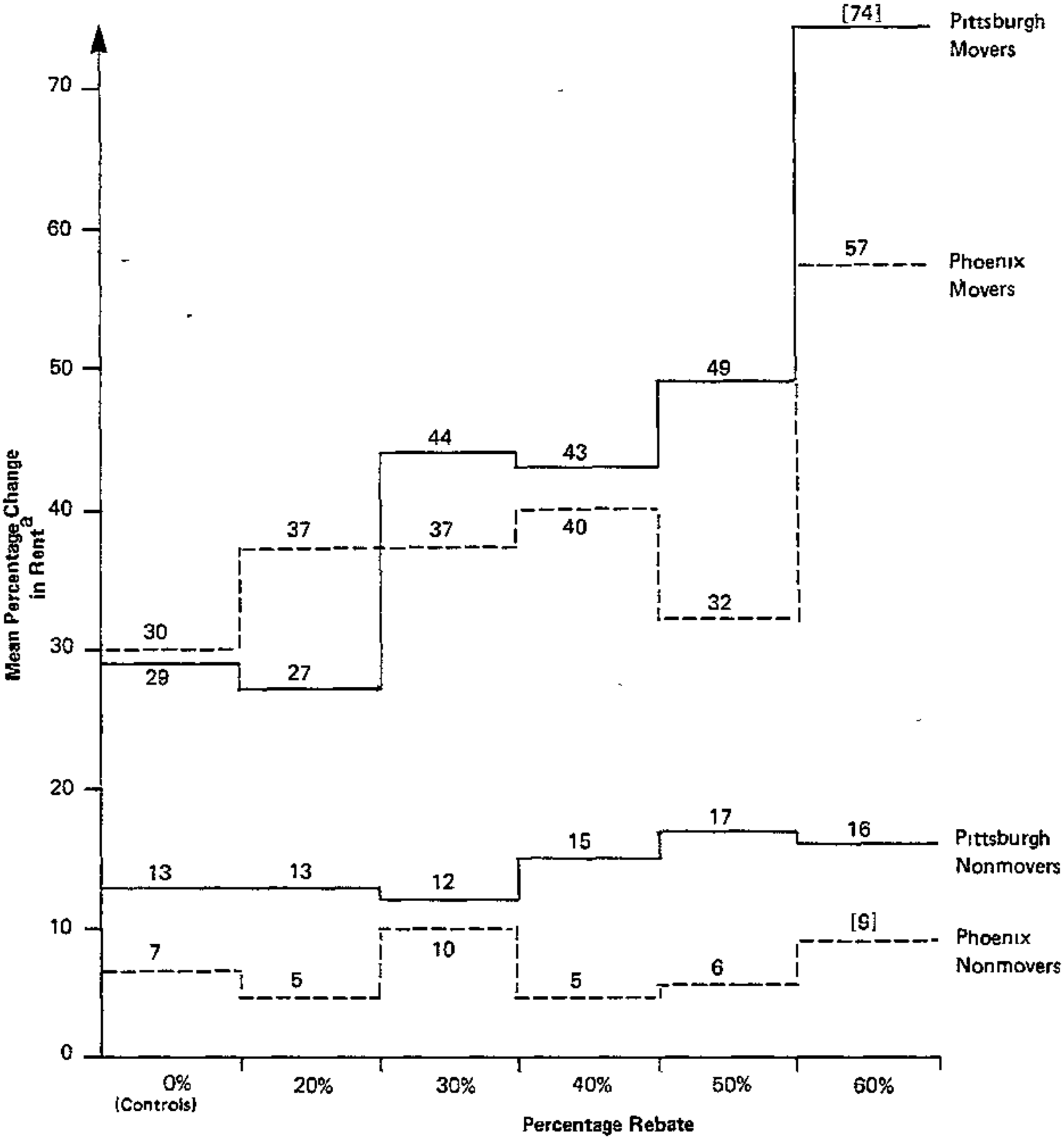
HOUSEHOLD GROUP	MEAN HOUSING EXPENDITURES		CHANGE IN HOUSING EXPENDITURES		SAMPLE SIZE
	At Enrollment	At Two Years	Amount	Percentage[a]	
		PITTSBURGH			
Movers					
Percent of Rent	$114	$156	$41	45%	(142)
Control	120	147	26	29	(94)
Unconstrained	109	145	36	39	(22)
Nonmovers					
Percent of Rent	114	130	16	15	(243)
Control	112	127	14	13	(195)
Unconstrained	106	119	13	12	(37)
		PHOENIX			
Movers					
Percent of Rent	135	179	44	38	(169)
Control	132	160	28	30	(123)
Unconstrained	128	175	48	55	(21)
Nonmovers					
Percent of Rent	127	134	8	7	(111)
Control	125	132	7	7	(129)
Unconstrained	145	151	7	8	(16)

SAMPLE: Percent of Rent, Unconstrained, and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

a. Percentage change is defined as the mean of the ratio of the change in rent to the rent at enrollment.

Figure 2–1
MEAN PERCENTAGE CHANGE IN HOUSING EXPENDITURES BETWEEN ENROLLMENT AND TWO YEARS AFTER ENROLLMENT



SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

NOTE. Brackets indicate entries based on 15 or fewer observations.

[a]Percentage change in rent is defined as the mean of the ratio of the change in rent to the rent at enrollment.

that did not move experienced about the same change in rental expenditures. This suggests that any experimental effect will manifest itself through mobility.

Elasticities for movers can be computed from the data in Table 2-5. Percent of Rent movers had a net effect averaged between the sites of about 12 percentage points with an average rebate of about 40 percent, giving a price elasticity of about -0.30. Unconstrained households had an average net increase of about 17 percentage points with payments equal on average to about 30 percent of their income, implying an income elasticity of about 0.57. Both estimates for movers are larger than for the overall sample.

Movers also allocated a much larger proportion of the rebate to increased rental expenditure than did nonmovers, due to their larger increase in rent (see Table 2-6).[1] Further, the percentage of the allowance payment allocated to increased housing expenditures by Unconstrained movers was 12 percentage points less than that for Percent of Rent movers in Pittsburgh and 5 points less in Phoenix, confirming the relative effectiveness of rent rebates to income transfers.

In sum, Percent of Rent households did respond to the rent rebate offered to them by increasing their housing expenditures more than they otherwise would have. As might be expected, responses were closely tied to moving. Percent of Rent and Unconstrained households that did not move changed their expenditures by approximately the same amount as Control households. Even among movers, however, much of the allowance payment went to expenditure on nonhousing goods. Percent of Rent payments were, however, more efficient in channeling money into housing than were the unconstrained income transfers.

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lower-income households than households enrolled in the other Percent of Rent or Control plans. Comparison of the mean percentage change for these households with similar Control households, however, shows that there is still a marked difference between Percent of Rent and Control movers in Pittsburgh, but the difference is much smaller in Phoenix (and more like other rebate levels). Households assigned to the 20 percent plan were higher-income households. These households show, in Pittsburgh, a very low or nil net response. Comparison with Control households of the same income does not change this finding. (See Appendix Tables X-7 through X-9.)

[1] The net changes by mobility status were computed using Control movers or nonmovers as appropriate. The figures in Table 2-6 show that the mean proportion for both Percent of Rent movers and nonmovers exceeded the mean proportion for similar Unconstrained households. See Appendix Table X-10 for the proportions for households receiving each percentage rebate.

Table 2-6

PROPORTION OF ALLOWANCE PAYMENT ALLOCATED TO INCREASED RENTAL EXPENDITURES, BY MOBILITY STATUS

TREATMENT GROUP	MEAN CHANGE IN RENT ABOVE NORMAL[a]	MEAN PAYMENT	PROPORTION USED FOR INCREASED EXPENDITURES[b]	SAMPLE SIZE
		PITTSBURGH		
Percent of Rent households				
Movers	$15	$56	27%	(143)
Nonmovers	2	46	4	(248)
Unconstrained households				
Movers	10	64	15	(22)
Nonmovers	-1	49	-2	(37)
		PHOENIX		
Percent of Rent households				
Movers	16	68	24	(171)
Nonmovers	1	46	2	(114)
Unconstrained households				
Movers	20	104	19	(21)
Nonmovers	0	114	0	(16)

SAMPLE: Percent of Rent and Unconstrained households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

a. This is computed as the mean change for Experimental households minus the mean change for the appropriate Control households.

b. This is computed as the mean change above normal divided by the mean payment. It is intended to represent a program average rather than a household average.

The next section presents the main results of the analysis of the Percent of Rent housing allowance.

2.2 DEMAND FUNCTION ESTIMATES

As discussed in Section 2.1, the rebates offered to Percent of Rent households can be considered as reductions in the effective price of housing. Examining response to the experimentally arranged rebate is thus equivalent to examining housing response to price changes. The possibility of obtaining evidence on the effect of housing price changes on the housing consumption of individual households was indeed one of the major reasons for including Percent of Rent plans in the Demand Experiment.[1] The evidence presented in Section 2.1 was inadequate for this determination as tabulations do not control for additional factors that may have affected housing expenditures.

The problem of relating consumption response to prices and income is not new. Economists have developed a rigorous framework for analyzing such responses--consumer demand theory. The behavioral relationship between housing consumption on the one hand and prices and income on the other is termed the demand function for housing. The demand function is one way to obtain a smoothed response surface. Along with experimental variations in price and income, nonexperimental variations in household income among the Experimental and Control households enable estimation of such a housing demand function.[2] Analysis of these data in terms of demand functions is useful in two ways. First, the theory of demand both provides some empirical hypotheses about the expected sign of estimated coefficients and allows ready application of the estimated demand functions to the estimation of responses to a variety of possible programs. Second, previous estimates of demand functions both help to indicate the probable magnitude of effects and provide a better understanding about possible estimation difficulties and the confidence with which the results may be used.

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[1] Section 3.3 discusses some of the previous research on the effects of price (and income) changes on housing consumption.

[2] Experimental variation in income was provided by the Unconstrained allowance plan. Households in this plan received an income-based payment, available simply as addition to income with no constraints placed on its expenditure. The sample size for this plan is small, however, so that estimates in this report are based primarily on nonexperimental differences in income.

The demand function itself can be used to provide information to model a wide range of possible alternative housing policies. Any demand function permits estimation of changes in housing consumption resulting from given changes in housing prices or in income. For example, knowing how housing demand responds to price changes would be valuable for evaluating alternative rent-conditioned housing allowance payment formulas. Similarly, knowledge of how housing demand responds to income changes would be valuable in evaluating the housing response to any income-conditioned transfer program.

While economic theory provides guidance on the variables expected to influence housing demand, as well as on their expected direction of influence, only general constraints are placed on the functional form of the relationship. Choosing a functional form is simply one way of smoothing the response function presented in Figure 2-1. Two forms are examined in Chapters 3 and 4 of this report--a linear form (a linear expenditure function) and a logarithmic form (called log-linear). Neither is superior in all respects, each has attractive features, and both yield similar results. For convenience, the log-linear form estimated for households that moved during the experiment is focused on for the rest of this chapter. Paralleling the tabulations of the previous section, this form can be used to demonstrate the effect of the percentage rebate on rental expenditures, on the proportion of the payment devoted to increased rent, and on the change in rent burden.

One way of characterizing demand functions is by the elasticities of demand --the percentage change in expenditures resulting from a given percentage change in prices or in income. For the log-linear form, these elasticities are constant:

(1) $$\ln(R) = \alpha + \beta_1 \ln(Y) + \beta_2 \ln(1-a)$$

where

R = the gross rental expenditures

Y = average monthly income

a = the percentage rebate offered

α = the estimated constant term, and

β_1 and β_2 = the income and price elasticities of demand, respectively.

The average elasticities for the low-income renters in the Demand Experiment population, estimated for households that moved during the experiment, are approximately -0.22 for price and 0.36 for income--falling between the crude estimates presented in Section 2.1 for the samples of all households and movers.[1] Thus, for households that move, a 10 percent decrease in price will lead to, on average, a 2.2 percent increase in housing expenditure while a 10 percent increase in income would lead to, on average, a 3.6 percent increase in expenditures. The average rebate of 40 percent would therefore lead to an increase of 9 percent above normal, controlling for income changes.

Interestingly, the average estimated price and income elasticities for all households in the two sites are almost identical to those estimated for households that moved. (They are somewhat lower in Pittsburgh and higher in Phoenix with almost no difference in the two-site average.) This is true despite the fact that Percent of Rent recipients that did not move showed little or no increase in expenditures beyond that found for nonmoving Control households. It appears that the Percent of Rent rebates induced some households to move to more expensive units sooner than they otherwise would have. This effect would be expected to diminish over time as normal mobility rates catch up to the experimentally generated increase in mobility. At the same time, as more households move, more would be expected to increase their expenditures in response to the rebate. Thus, although individual households adjust to the rebates gradually, as they move, the total aggregate effect of the rebate on the demand for housing may not increase substantially over time, at least not after two years.

The log-linear form can be used to show the effect of the rebate on the proportion of the payment devoted to rent as a function of the percentage

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[1] These estimates are from a log-linear demand function for movers, pooling the two sites with a site-specific intercept, using average income. Chapter 4 discusses the implications of demographic and income differences for the elasticities. The elasticities appear to vary with these socioeconomic characteristics. Furthermore, they are estimated with stochastic error. See Chapter 4 for confidence intervals and Chapter 6 for a discussion of possible sources of bias.

rebate:[1]

$$\text{(2)} \qquad \frac{\Delta R}{S} = \frac{(1-a)^{\beta_2}-1}{a(1-a)^{\beta_2}} .$$

Equation (2) indicates that, given the estimated price elasticity of -0.22 and the average rebate of 40 percent, 27 percent of the allowance payment will be devoted to increased rent (cf. Table 2-6). The proportion of the payment devoted to increased rent in Equation (2) increases with the rebate, though gradually. Using the same price elasticity of -0.22, 24 percent of the payment will be allocated to increased expenditures under a 20 percent rebate and 30 percent under a 60 percent rebate.

The same form can be used to demonstrate the effect of the Percent of Rent plans on rent burden. The change in rent burden can be expressed as[2]

$$\text{(3)} \qquad \Delta(R/Y) = e^{\alpha}Y^{(\beta_1-1)} \; [(1-a)^{\beta_2+1}-1].$$

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[1]From Equation (1), initial expenditure is

$$\text{(i)} \qquad R_0 = e^{\alpha}Y^{\beta_1}.$$

The rebate changes desired rent to

$$\text{(ii)} \qquad R_1 = e^{\alpha}Y^{\beta_1}(1-a)^{\beta_2}.$$

Since the payment S is a fraction of R_1 ($S = aR_1$), the change in rent, ΔR, as a fraction of S if the household were to adjust its expenditure to the level implied by the demand function is thus

$$\text{(iii)} \qquad \frac{R_1-R_0}{S} = \frac{(1-a)^{\beta_2}R_0-R_0}{a(1-a)^{\beta_2}R_0} ,$$

which is Equation (2).

[2]From Equation (1):

$$\text{(i)} \qquad R_0 = e^{\alpha}Y^{\beta_1} \text{ and}$$

$$\text{(ii)} \qquad R_1 = e^{\alpha}Y^{\beta_1}(1-a)^{\beta_2},$$

as in footnote 2 on the previous page. From (i) and (ii),

$$\text{(iii)} \qquad \frac{(1-a)R_1}{Y} - \frac{R_0}{Y} = \frac{1}{Y}\Big[(1-a)\; e^{\alpha}Y^{\beta_1}(1-a)^{\beta_2} - e^{\alpha}Y^{\beta_1}\Big],$$

which reduces to Equation (3).

For the mean income of approximately $420 per month and for the average rebate of 40 percent, this implies a change in mean rent burden of 11 percentage points, from 35 percent to 24 percent. As the percentage rebate increases, the implied decrease in rent burden will be larger as well.

Finally, the relative impact on rental expenditures of unrestricted income transfers and rent rebates of equivalent magnitude may be compared using the estimated numbers. A straightforward comparison is possible because unrestricted income transfers operate through <u>income</u> elasticities of demand, and rent rebates operate through <u>price</u> elasticities of demand.

A price subsidy should always produce a greater increase in housing expenditures than an equivalent income subsidy. With an equivalent income subsidy, the household can purchase the same amounts of housing and other goods as it purchases under the price subsidy. However, under the income subsidy it still faces the original, higher price for housing and so may be expected to buy less housing than under the price subsidy, which offers the incentive of lower housing prices.[1]

The extent of the difference in housing expenditures under the two types of subsidy depends on the income and price elasticities and the initial rent-income ratio. The relative efficiency of price subsidies (E, the ratio of the subsidy needed under a price subsidy, S_p, to that needed under an income subsidy, S_Y) in translating an allowance payment into a given additional expenditure on housing is:[2]

$$E = \frac{S_p}{S_Y} = a\left(\frac{R_0}{Y}\right)\left[(1-a)^{-\beta_2(1-\frac{1}{\beta_1})} - (1-a)^{-\beta_2}\right]^{-1}. \tag{4}$$

The efficiency is generally larger (for a given initial rent-income ratio), as the price elasticity is larger in absolute value, and is larger as the income elasticity is smaller.

Table 2-7 presents the efficiency of a price subsidy relative to an income subsidy for various rent-income ratios and price discounts based on a log-

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[1] The household will be able to purchase more nonhousing goods for each unit of housing given up under the higher housing prices prevailing under the income subsidy than under the rent subsidy, implying that the quantity of housing consumed will be less.

[2] See Appendix IV for derivation of this formula.

linear demand function with a price elasticity of -0.22 and an income elasticity of 0.36, assuming households are initially consuming an amount of housing determined by the demand function using initial prices. For an initial (median) rent-income ratio of 0.30, the payment needed under a price discount plan would range from less than one-half (with a 20 percent rebate) to less than one-third (with a 60 percent rebate) that needed under an unrestricted income transfer to induce the same housing change. For example, for a household with income of $500, spending 30 percent of its income on rent ($148), a price subsidy of 40 percent would lead to an increase in rent to $166 and result in a subsidy payment of $66. To induce the same change in equilibrium rent, an income subsidy would have to be $183.[1]

Table 2-7

EFFICIENCY OF PRICE AND INCOME SUBSIDY[a]

PRICE DISCOUNT (Percentage Rebate)	INITIAL RENT-INCOME RATIO 0.20	0.30	0.40
20 percent	0.29	0.43	0.57
40 percent	0.24	0.37	0.49
60 percent	0.20	0.29	0.39

NOTES: Assumptions: log-linear demand function
price elasticity = -0.22
income elasticity = 0.36

a. Efficiency is defined as the ratio of size of price subsidy needed to size of income subsidy needed for a given change in rental expenditure. See Appendix IV for derivation of the efficiency formula.

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[1]This efficiency in converting subsidy payments into housing changes is obtained at the cost of a reduced value of the payment to the recipient. Just as rent rebates are always theoretically more efficient than direct income transfers in achieving a given change in rent, an income transfer is theoretically more efficient than rent rebates at making people "better off" (in their own terms). Part of the rent rebate is spent inducing households to buy extra housing.

It is worth noting that there is evidence (reported in Chapter 5) that a price discount (such as that provided by a Percent of Rent subsidy) may lead to shopping inefficiency on the part of the household. In other words, since households are not paying the market price for additional amounts of housing services obtained, they may well be willing to accept less than the market average of housing services per dollar of increased gross expenditure. This reduces, but does not entirely eliminate the relatively greater efficacy of price discounts over income supplements in promoting changes in recipient housing.

2.3 APPLICATIONS

The lack of any housing requirement or income condition in the simple rent rebate plans tested in the Demand Experiment make them unlikely candidates for an ongoing program. Though very simple to administer and analyze, they suffer from inequity because higher-income households would typically have higher rents and therefore larger payments. This drawback could be overcome by a more complex design, such as allowing the percentage rebate to depend on income. Estimates about household response to the simple form of rent rebates tested in the Demand Experiment can provide a basis for estimating response to alternative forms of rent rebates. They can also be used to evaluate housing response to proposed (or existing) income maintenance schemes, as well as existing assistance programs with rent subsidy features. The rest of this section illustrates the way in which the estimated demand function can be applied to these problems.

Income-conditioned Percent of Rent Plans

A housing assistance plan based on percentage rent rebates would probably have a percentage rebate which is related to income in order to reduce inequity. An "income-conditioned percent of rent" plan is one such prototype. In such a plan, inequity is reduced by decreasing the percentage of rent subsidized with income. The subsidy formula would be

(5) $$S = a(Y) \cdot R$$

where

S = the subsidy payment

$a(Y)$ = the percentage of rent subsidized, a function of income Y, and

R = rent.

Various forms of the function $a(Y)$ can be considered, ranging from an administratively simple schedule, such as that used in the federal personal income tax system:

(6) $$a(Y) = \begin{cases} a_1 & \text{for } Y \leq Y_1 \\ a_2 & \text{for } Y_1 < Y \leq Y_2 \\ \vdots & \\ a_n & \text{for } Y_{n-1} < Y \leq Y_n \\ 0 & \text{for } Y_n < Y \end{cases}$$

to an analytically simple formula, such as Carlton and Ferreira (1977), termed variable percent of rent,

(7) $$S = \begin{cases} [1 - \frac{Y}{Y^*}]\ R & \text{for } Y \leq Y^* \\ 0 & \text{for } Y > Y^*. \end{cases}$$

Analysis of the potential housing expenditure impact of an income-conditioned percent of rent plan will depend on numerous factors including the formula's income levels, household income, and rent. For illustration, the effects of several alternative plans are discussed below for hypothetical four-person households.[1] The focus of the discussion is on the effect of each program on households' rent burdens and expenditures.[2]

<u>Variable percent of rent</u>. For illustration, the parameter Y^* in Equation (7) --the income level at which the subsidy falls to zero--is set to \$600 per month, approximately the income eligibility limit for families of size 3 or 4

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[1] The effects of possible differential participation rates in these plans is ignored.

[2] In addition to expenditure changes, when payments depend on income, households may be induced to change their incomes, if possible. This implication is ignored here.

enrolled in Percent of Rent plans.[1] Table 2-8 shows the effects on housing for households of this size for various income levels.[2]

<u>British rent allowance.</u> Alternatively, income may be used to adjust the payment level rather than the rebate as in the case of a formula actually in use in Great Britain[3]:

$$S = \begin{cases} .6R + .25\ (Y^{*}-Y) & \text{for } Y \leq Y^{*} \\ .6R + .17\ (Y^{*}-Y) & \text{for } Y > Y^{*} \end{cases} \tag{8}$$

$$\text{subject to } S \leq S_{max},^{4}$$

where Y^{*} is called the "needs" allowance.[5] The British allowance formula provides both a price and an income subsidy (see Ricketts, 1976). Price declines by 60 percent. Using an estimate of -0.22 for price elasticity, this decline leads to a 22.3 percent increase in expenditures.[6] The addition to income depends on income level. For example, for a household with income of $200 a month and a needs allowance of $250, the percentage increase in housing expenditures due to the income effect is 2.2 percent.[7] In contrast, for a household with income of $300 a month and the same needs

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[1] The actual enrollment income limits were $6,750 per year in Pittsburgh and $8,650 per year in Phoenix for a household of size 3 or 4.

[2] Wide variation in outcomes are possible because initial household situations differ. The mean initial rent and rent burden are used to provide a benchmark. Use of the estimated demand equations to provide initial rent does not change the results.

[3] See Ricketts (1976) or Trutko, Hetzel, and Yates (1978).

[4] The maximum payment, S_{max}, is £8 per week in London and £6.50 per week elsewhere (Ricketts, 1976, p. 237). These can be adjusted for inflation. This maximum effectively limits the range of rents subsidized.

[5] The needs allowance schedule is:

single person	£17.75 per week
married couple	£24.25 per week
each dependent child	£3.55 per week

(see Ricketts, 1976, p. 244).

[6] The Percentage change in rent = $[(1-a)^{\beta_2}-1] = [(0.4)^{-0.22}-1] = 0.223$.

[7] The subsidy leads to an increase in income of 0.25 x ($250=200) = $12.50 or 6.3 percent. Using the estimated income elasticity of demand of 0.36, $[(1 + \Delta Y/Y)^{\beta_1}-1] = [(1.063)^{.36}-1] = 0.022$.

Table 2-8

PREDICTED EFFECT OF A
VARIABLE PERCENT OF RENT FORMULA[a]

HOUSEHOLD INCOME	INITIAL RENT BURDEN[b]	INITIAL RENT[c]	SUBSIDY RATE	INITIAL PAYMENT	CHANGE IN RENT		FINAL PAYMENT	FINAL RENT BURDEN[e]
					Percentage[d]	Amount		
$200	0.50	$100	0.667	$67	27.3%	$27	$85	0.21
300	0.38	114	0.500	57	16.5	19	67	0.22
400	0.32	128	0.333	43	9.3	12	47	0.23
500	0.28	140	0.167	23	4.1	6	24	0.24
600	0.25	150	0.000	0	0.0	0	0	0.25

a. Payment = $\left[1 - \frac{\text{Income}}{Y^*}\right]$ x rent, where Y* is set equal to $600 per month for a family of four.

b. From Appendix Table X-11.

c. Income times Initial Rent Burden.

d. Percentage change in rent = $[(1-a)^{\beta_2}-1]$ where β_2 is the price elasticity (-0.22) and "a" is the subsidy rate.

e. Final rent burden is defined as initial rent plus the change in rent minus the final payment divided by income.

allowance, the income effect is negative, -1.0 percent.[1] The income effect will counteract the price effect for any household with income above the needs allowance. Finally, the maximum subsidy limits the range of rents subsidized. Thus for rents above a certain level, the formula reduces to a simple income transfer.[2]

Table 2-9 illustrates the effect of the British rent allowance on various prototypical households.

Rent-conditioned Housing Gap. Another possible housing assistance plan that includes elements of price discounts is a "rent-conditioned Housing Gap" form, in which

$$(9) \qquad S = \begin{cases} \frac{R}{C^*}\,(C^*-bY) & \text{for } R \leq C^* \text{ and } Y < C^*/b \\ C^*-bY & \text{for } R > C^* \text{ and } Y < C^*/b \\ 0 & \text{for } Y \geq C^*/b \end{cases}$$

where C^* and b are parameters of the program (see Carlton and Ferreira, 1977). For rents above C^*, this form behaves as a Housing Gap formula or unrestricted cash grant, while for rents below C^*, it behaves like a Percent of Rent formula.

Table 2-10 illustrates the predicted effects of a program with C^* set at \$130 and the contribution rate set at 0.25. Households with incomes \$400 or below are receiving Percent of Rent subsidies at a rate $(C^*-bY)/C^*$.[3] The household with income of \$400, however, is spending \$128 on rent already, therefore, it will receive a Percent of Rent subsidy only for its next \$2 of expenditure on housing. After that it will receive only a Housing Gap type of subsidy, with the amount unaffected by its rent. Households with incomes up to \$520 (=C^*/b) will also receive Housing Gap subsidies, increasing their rent in response to this change in income.

Income-conditioned Percent of Rent. Alternatively, the demand function parameters can be used to design a rent allowance program of the type presented in Equation (6). As an illustration, assume that the government's policy

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[1] The subsidy leads to a decrease in income of 0.17 x (\$300-250) = \$8.50 or 2.8 percent of income; $[(1 + \Delta Y/Y)^{\beta}-1] = [0.972)^{.36}-1] = -0.010$.

[2] In this case the budget line is kinked at the maximum rent subsidized.

[3] For each additional dollar spent on rent, R, the increase in payment (dS/dR) is $(C^*-bY)/C^*$.

Table 2-9

PREDICTED EFFECT OF
BRITISH RENT ALLOWANCE FORMULA[a]

HOUSEHOLD INCOME	INITIAL RENT BURDEN[b]	INITIAL RENT[c]	INITIAL PAYMENT[d]	CHANGE IN RENT[d] Percentage[e]	CHANGE IN RENT[d] Amount	FINAL PAYMENT[d]	FINAL RENT BURDEN[d,f]
$200	0.50	$100	$60 (73)	9.9% (25.0)	$10 (25)	$60 (88)	0.25 (0.19)
300	0.38	114	60 (60)	6.8 (21.1)	8 (24)	60 (74)	0.21 (0.21)
400	0.32	128	51 (51)	11.3 (19.5)	15 (25)	60 (66)	0.21 (0.22)
500	0.28	140	42	18.5	26	57	0.22
600	0.25	150	31	17.8	27	47	0.22

a. $\text{Payment} = \begin{cases} 0.6 \text{ Rent} + 0.25\,(Y^* - \text{Income}) \text{ for Income} \leq Y^*, \text{ or} \\ 0.6 \text{ Rent} + 0.17\,(Y^* - \text{Income}) \text{ for Income} \geq Y^*, \end{cases}$

where Y^*, the "needs allowance" for a family of four, is set equal to $250 per month. The payment is subject to a maximum of $60.

b. From Appendix Table X-11.

c. Income times Initial Rent Burden.

d. Figures in parentheses show the effect if there were no restriction on the maximum payment.

e. Percentage change in rent = $(0.4)^{\beta_2}(1 + \frac{\Delta Y}{Y})^{\beta_1}$ where β_2 is the price elasticity (-0.22), β_1 is the income elasticity (0.36), 0.4 is one minus the subsidy rate of 0.6, and ΔY is the income term in the payment formula (e.g., 0.25 (Y^* - income) or 0.17 (Y^* - income)). The actual increase is limited by the maximum payment.

f. Final rent burden is defined as initial rent plus the change in rent minus the final payment divided by income.

Table 2-10

PREDICTED EFFECT OF A
RENT-CONDITIONED HOUSING GAP FORMULA[a]

HOUSEHOLD INCOME	INITIAL RENT BURDEN[b]	INITIAL RENT[c]	SUBSIDY RATE[d]	INITIAL PAYMENT	CHANGE IN RENT		FINAL PAYMENT	FINAL RENT BURDEN[f]
					Percentage[e]	Amount		
$200	0.50	$100	0.62	$62	23.7%	$24	$77	0.24
300	0.38	114	0.42	48	12.7	15	54	0.25
400	0.32	128	0.23	30	2.6	3	30	0.25
500	0.28	140	0.00	5	0.4	1	5	0.27
600	0.25	150	0.00	0	0.0	0	0	0.25

a. $$\text{Payment} = \begin{cases} \dfrac{\text{Rent}}{C^*}(C^* - b \cdot \text{Income}) & \text{for } R \leq C^* \text{ and } Y < C^*/b, \\ C^* - b \cdot \text{Income} & \text{for } R > C^* \text{ and } Y < C^*/b, \text{ or} \\ 0 & \text{for } Y \geq C^*/b, \end{cases}$$

where C*, the cost of standard housing, is set equal to $130 for illustration, and b, the contribution rate, is set equal to 0.25.

b. From Appendix Table X-11.

c. Income times Initial Rent Burden.

d. Rate at which payment increases for each additional dollar spent on rent, up to C* ($130).

e. If the change in rent is less than C* minus the initial rent, this is a pure price effect. If not, there is also (or instead) an income effect.

f. Final rent burden is defined as initial rent plus the change in rent minus the final payment divided by income.

target is a household rent burden of 25 percent. A simple payment formula which varies by income, a(Y), can be derived from the formula for rent burden:

$$\text{(10)} \qquad \text{Final rent burden} = \frac{R_0 + \Delta R - S}{Y}$$

where

R_0 = initial rent

ΔR = change in rent induced by the payment

S = payment, and

Y = income.

The payment, S, received by the household is

$$\text{(11)} \qquad S = a(Y) \cdot [R_0 + \Delta R].$$

The induced change in rent can be computed from

$$\text{(12)} \qquad \left[\frac{\Delta R}{R_0}\right] = \left[1-a(Y)\right]^{\beta_2} - 1$$

where β_2 is the price elasticity.

Using Equations (10) through (12),

$$\text{(13)} \qquad \text{Final rent burden} = \frac{(1-a)^{(\beta_2+1)} R_0}{Y}.$$

Given the policy target, the schedule a(Y) can be solved in terms of the price elasticity (β_2) and the initial rent burden (R_0/Y):[1]

$$\text{(14)} \qquad a(Y) = 1 - \left[\frac{.25Y}{R_0}\right]^{1/(\beta_2+1)}.$$

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[1]Alternatively a(Y) could be solved in terms of Y by using the estimated demand function to express R_0 as a function of the price of housing and income.

Table 2-11 presents the solutions to this equation for various income classes. The subsidy rate declines to zero as income rises because the rent burden declines to the policy target, 0.25. It is also worth noting that the derived rate is not very different for various values of the price elasticity, as computed at the extremes of the 95 percent confidence interval for the estimated elasticity.

Table 2-11

INCOME-CONDITIONED PERCENTAGE SUBSIDIES
NEEDED TO REDUCE RENT BURDEN TO 0.25
AS A FUNCTION OF INITIAL RENT BURDEN

MONTHLY INCOME	INITIAL RENT BURDEN[a]	PERCENTAGE OF RENT SUBSIDY[b]	"CONFIDENCE INTERVAL"[c]
$83.3 - 150	0.69	0.73	(0.69, 0.77)
151 - 250	0.50	0.59	(0.55, 0.63)
251 - 350	0.38	0.42	(0.38, 0.45)
351 - 450	0.32	0.27	(0.25, 0.30)
451 - 550	0.28	0.14	(0.12, 0.15)
551 - 650	0.25	0.00	--
651 +	<0.25	none	--

a. From Appendix Table X-11.

b. Computed using Equation (14) in the text, using a price elasticity of -0.22.

c. Computed using bounds of the 95 percent confidence interval for the estimated price elasticity: (-0.13, -0.30).

The Food Stamp Program

Applications of the estimated demand parameters are not limited to analyses of housing allowance strategies, as the following example demonstrates. Most federal income-tested programs mandate specific deductions from income.[1] These deductions can be classified as either work-related expenses or as expenses for "merit goods" (goods or services which those providing support

[1]See Hausman (1977).

deem worth providing to the recipient). The former category includes deductions for items such as child care, commuting costs, and union dues while the latter includes deductions for educational expenses, medical care, and housing. Exclusion of housing expenses from income is similar to a rent rebate in that the amount of the transfer is related to actual housing expenditures. This point is illustrated here by reference to the Food Stamp program.[1]

Until October 1978, the Food Stamp program based benefits on income net of numerous deductions. After subtracting from income itemized deductions for child and adult care, work-related expenses including taxes, medical care, disaster and casualty losses, and educational expenses, any shelter expenditures in excess of 30 percent of the remaining net income are also deducted from income.[2,3] The resulting net income determines the "purchase requirement" for food stamps and thus the amount of the subsidy to be received by a household.

The effect of such a program feature is to subsidize increases in housing expenditures at a rate determined by the "benefit reduction ratio" (the rate at which benefits fall per dollar of increased household income) implicit in the Food Stamp program. The benefit reduction ratio is approximately 30 percent.[4] Thus for every $1 of housing expense in excess of 30 percent of net income, adjusted income is reduced by $1, and Food Stamp benefits are increased by $0.30. A fraction of increased shelter expenditures is in effect given as a rent rebate to participating households, thereby creating an incentive to consume more housing.

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[1]Other government programs excluding part of rent from income are Aid to Families with Dependent Children (exclusion varies by state) and the National School Lunch and Other Child Nutrition Programs (see Hausman, 1977). A further example might be the Federal Income Tax, which provides deductions for mortgage interest and property taxes.

[2]Note also that since expenses are deducted from gross income before shelter expenses, the threshold at which net income is further reduced due to shelter expenditures is likely to be a much smaller proportion of gross income than 30 percent. If, for example, other deductions average 20 percent of gross income, the rent-to-gross income "threshold" would be 24 percent of gross income.

[3]The Food Stamp Act of 1977 revises this procedure somewhat, as discussed later in this section.

[4]The benefit reduction ratio is approximately 20 percent for single-person households. Estimated effects do not take this difference into account.

This program feature is likely to have a major impact on housing expenditures, given that a significant fraction of the population below the poverty line receives Food Stamps and have rent-to-income ratios in excess of 30 percent. Over time, increases in cost of housing would tend to be partially and automatically subsidized by increased Food Stamp benefits. On the other hand, elimination of the deductions for "excessive" housing expenditures would theoretically reduce the demand for housing, increase households' rent burden, and eliminate what amounts at present to an automatic adjustment to housing cost changes.[1]

This housing subsidy component in the Food Stamp program is substantial. According to the Food and Nutrition Service of the U.S. Department of Agriculture (USDA),[2] in September 1976, 5.03 million households were Food Stamp recipients. A large fraction of the Food Stamp households (74.3 percent) received a shelter deduction; the average shelter deduction claimed was \$73 a month (giving an average over all households in the program of \$54). Since the benefit reduction ratio was approximately 0.3, the additional governmental expenditure due to the shelter deduction can be computed:

$$\text{(5.03 million)} \times (\$54) \times (0.3) = \begin{array}{l}\$81.5\text{ million per month or}\\ \$977.8\text{ million per year.}\end{array}$$

In comparison, current Department of Housing and Urban Development (HUD) total annual contribution commitments are less than twice this figure (\$1.85 billion).[3]

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[1] It is interesting to note that the "housing subsidy" that occurs through Food Stamps is likely to benefit nonparticipants in federally subsidized housing more than participants, since tenant contributions in federal programs outside of Section 236 (without rent supplements) almost always result in rent to income ratios less than 30 percent--the point at which the Food Stamp "housing subsidy" begins. Thus while public housing participants get more housing subsidy, otherwise comparable poor households will tend to get greater Food Stamp benefits.

[2] The data are from U.S. Department of Agriculture (1977).

[3] U.S. Department of Housing and Urban Development (1977) as of September 30, 1976. Section 23 housing assistance commitments are \$23 million, Section 8 commitments are \$488.5 million, and leased housing commitments are \$269.5 million. The remainder are contributions to public housing projects. Of course, HUD has other commitments to housing programs in terms of loans and loan guarantees (\$5.28 billion).

Estimating the impact of the Food Stamp program on housing is, in theory, a fairly complex problem that would require information on the mean demand function for food, the cross-price elasticity of housing and food, and the distribution of food and housing consumption patterns, as well as the estimated mean demand function for housing.[1] In fact, the impact of Food Stamps on housing can be fairly well approximated using the estimated demand function for housing alone.

As indicated above, the Food Stamp program allows recipients to purchase a certain amount of food--the coupon allotment (determined by household size)--at a reduced price--the purchase requirement (determined by net income). The maximum Food Stamp bonus, B_m, is given by

$$B_m = A - \sigma[Y - S] \tag{15}$$

where

A = the coupon allotment (a function of household size)

σ = the benefit reduction rate (approximately 0.3)

Y = net income before the shelter deduction, and

S = the shelter deduction.

The shelter deduction is the amount spent on housing above 30 percent of net income:

$$S = \begin{cases} R - 0.3Y & \text{for } R \geq .3Y \\ 0 & \text{for } R < .3Y \end{cases} \tag{16}$$

where

R = rent.

Thus Equation (15) can be written

$$B_m = \begin{cases} A - \sigma(1.3Y-R) & \text{for } R \geq .3Y \\ A - \sigma Y & \text{for } R < .3Y. \end{cases} \tag{17}$$

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[1] See Appendix V for a more detailed discussion.

Notice that the maximum bonus value does not depend on the amount of food purchased. If the household purchases more food than its coupon allotment, the impact on housing can be estimated in terms of the effect of the additional income from the Food Stamp bonus and the reduced price of housing implied by the shelter deduction.

Households that want to purchase less food than their coupon allotment obtain a proportional reduction in cost--that is, they purchase some fraction, $\frac{p_F F}{A}$, of their allotment, A, at the cost, $\left(\frac{p_F F}{A}\right) \sigma$ (Y-S). Thus, their benefit is:

$$B = \left(\frac{p_F F}{A}\right) B_m \qquad \text{for } p_F F \leq A \tag{18}$$

where

B = the Food Stamp bonus

F = the amount of food purchased, and

p_F = the price of food.

For these households, the price of food is essentially reduced by the factor (B_m/A). In this case, then, the impact of the Food Stamp program on housing depends on the response of housing consumption to changes in income and the prices of both housing and food.

The rest of this section considers the impact of the Food Stamp program on the housing of recipients that spend at least their full coupon allotment for food. Fortunately, as discussed in Appendix V, at least 61 percent of Food Stamp recipients, and quite possibly more, fall into this category.[1] The analysis, carried out on the basis of estimated demand for housing alone, would appear to cover a major part of the Food Stamp program.

The impact of the Food Stamp program on housing can be decomposed into the income effect of the subsidy and the additional housing price effect of the shelter deduction. Data published by the Department of Agriculture for September 1976 give an average bonus value of $71 and an average shelter deduction of $54. Thus, $16 (30 percent of $54) of the $71 may be considered a housing price discount. The remaining amount, $55, is the income transfer component of the Food Stamp subsidy. The average household's net income was $224, implying a percentage increase in income due to the income transfer component of about 24 percent (55/224).

[1]See Appendix Table V-1. MacDonald (1977, p. 54) estimates that roughly two-thirds of all recipient households are effectively unconstrained by the program.

Using the estimated income elasticity of 0.36, the percentage change in expenditures for households that adjust their housing due to the income effect can be approximated by

$$(19) \qquad \left[\frac{\Delta R}{R}\right]_{\text{Income}} = \left(1 + \frac{\Delta Y}{Y}\right)^{\beta_1} -1 = \left(1.24\right)^{.36} -1 = 8.1 \text{ percent.}$$

The price effect can be computed in a similar way. For households eligible for a shelter deduction the price of housing is reduced by 30 percent (σ). Using the estimated price elasticity of demand of -0.22, the percentage change in expenditures due to the price effect for those households that adjust to the change in relative prices is

$$(20) \qquad \left[\frac{\Delta R}{R}\right]_{\text{Price}} = \left(1 + \frac{\Delta P}{P}\right)^{\beta_2} -1 = \left(.7\right)^{-.22} -1 = 8.2 \text{ percent.}$$

For an initial rent of \$120, the percentage change in expenditures due to the Food Stamp income transfer component is about \$10 and that due to the housing price subsidy (for those eligible) another \$10. Since only 74 percent of Food Stamp households received the price subsidy, the overall increase in housing expenditures due to both the income and price effects would be about 14.2 percent (8.1 percent plus 74 percent of 8.2 percent). For an initial rent of \$113,[1] the overall increase would be about \$16, divided into \$9 of income effect and \$7 of average price effect.

The Food Stamp program thus clearly provides an important form of housing assistance to participating households with high rent burdens. How much this assistance changes housing expenditures is, however, difficult to determine exactly. As discussed, the Food Stamp program increases recipient real income, which should increase their housing expenditures. In addition, it provides a 30 percent rent rebate for expenditures above 30 percent of net income, which, if households actually understand the connection between their housing expenditures and Food Stamp costs, should lead to increased housing expenditures in much the same way as the Percent of Rent rebates do.

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[1] The average shelter cost of Food Stamp households was \$128.50, which of course includes any income and price effect (\$128.50/1.142 = \$112.50).

The net effect will differ for different households. Since each household is likely to have different preferences, it is incorrect to attribute the average effect estimated here to all households. In particular, as discussed above, the Food Stamp recipients for whom the program also changes the price of food may behave quite differently. Finally, households can be expected to adjust their housing only occasionally, for example, when they move. The effect would then be limited only to households that move while in the Food Stamp program.

The Food Stamp Act of 1977 changed the rules for income deductions. After a standard deduction of 20 percent from gross income, additional deductions of up to a total of $80 are allowed for dependent care and for shelter expenses in excess of 50 percent of net income (i.e., 40 percent of gross income). This change will reduce the impact of Food Stamps on housing expenditure.

No statistics are available to estimate the impact precisely, but educated guesses can be made about the effects of the change. First, the average shelter deduction will decrease. Since an additional 20 percent of net income is now no longer deductible as a shelter deduction, the average shelter deduction (ignoring inflation) should decrease by about $45 (20 percent of average net income, $224), from $73 to $28.

No direct information on the percentage of households with rent burdens in excess of 40 percent of gross income is available. Annual Housing Survey (AHS) data for 1975 (U.S. Bureau of the Census, 1978) show that 49 percent of households with annual incomes of less than $10,000 had rent burdens in excess of 35 percent of gross income. Thus, 49 percent would seem to be an upper bound.[1] No lower bound is available, but one might be arbitrarily set at one-third. Using these bounds, the additional government expenditure due

[1] The tabulated data on rent burden are not broken down above 35 percent. Except for this problem, the Census probably provides a fairly good estimate. If the current deduction used in the Food Stamp program (before the shelter deduction) averages 20 percent, then the shelter deduction of rents above 30 percent of net income is equivalent to a deduction for rents above 24 percent of gross income. Seventy-four percent of Food Stamp households had these shelter deductions (USDA, 1977); likewise, the AHS data show 74 percent of households with annual incomes of less than $10,000 had rent burdens in excess of 25 percent of gross income.

to the shelter deduction under the new regulations (in 1976 dollars) will be reduced from $81.5 million per month to between $20.7 million per month[1] and $14.1 million per month[2]--a reduction of between 75 and 83 percent.

Similarly, the effect on the average household will be reduced as well. The average bonus value will be reduced. If the part of the subsidy not due to the shelter deduction remains unchanged, the income effect will also be unaffected. Fewer households will, however, be affected by the price discount. The overall increase in housing expenditure will average between 10.8 and 12.1 percent (an unchanged 8.1 percentage points of income effect and either 49 percent or one-third of the 8.2 percent price effect), instead of an average 14.2 percent.

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[1](5.03 million households) x (.49) x ($28) x (0.3).

[2](5.03 million households) x (.33) x ($28) x (0.3).

REFERENCES

Budding, David W., Housing Deprivation Among Enrollees in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., November 1978 (revised June 1980).

Carlton, Dennis W. and Joseph Ferreira, Jr., "Selecting Strategies for Housing Allowance Programs," Journal of Urban Economics, vol. 4, no. 3, July 1977, pp. 221-247.

Friedman, Joseph and Daniel H. Weinberg, Housing Consumption Under a Constrained Income Transfer: Evidence from a Housing Gap Housing Allowance, Cambridge, Mass., Abt Associates Inc., April 1979 (revised June 1980).

Hausman, Leonard, Characteristics of Selected Income-Tested Programs, Cambridge, Mass., Abt Associates Inc., 1977.

Lane, Terry S., Origin and Uses of the Conventional Rules of Thumb, Cambridge, Mass., Abt Associates Inc., 1977.

MacDonald, Maurice, Food Stamps and Income Maintenance, New York, Academic Press, 1977.

Ricketts, Martin, "The Economics of the Rent Allowance," Scottish Journal of Political Economy, vol. 23, no. 3, November 1976, pp. 235-260.

Trutko, John, Otto J. Hetzel and A. David Yates, A Comparison of the Experimental Housing Allowance Program and Great Britain's Rent Allowance Program, Washington, D.C., Urban Institute, 1978.

U.S. Bureau of the Census and U.S. Department of Housing and Urban Development, Annual Housing Survey: 1976, Part C: Financial Characteristics of the Housing Inventory, Washington, D.C., U.S. Government Printing Office, 1978.

U.S. Department of Agriculture, Food and Nutrition Service, Characteristics of Food Stamp Households, September 1976, Report FNS-168, September 1977.

U.S. Department of Housing and Urban Development, 1976 Statistical Yearbook, Report HUD-338-5-UD, December 1977.

CHAPTER 3

THEORETICAL CONSIDERATIONS AND EMPIRICAL ISSUES UNDERLYING THE ANALYSIS

This chapter presents the analytical framework used in the analysis of the effect of rent rebates on housing expenditures. Section 3.1 uses standard microeconomic theory to describe the rationale underlying analysis of housing response to a rent rebate. The key concept used is a demand function for housing. Section 3.2 discusses two alternate specifications, linear and log-linear demand functions, and their implications for the analysis of housing response. Section 3.3 briefly discusses the evidence from recent studies on the demand for housing. Finally, Section 3.4 presents the plan for the rest of the report.

3.1 CONSUMER DEMAND THEORY

The effect of a rent rebate on housing expenditures can be analyzed in a standard microeconomic framework, the theory of consumer behavior. In most empirical studies of housing consumption, housing expenditures depend on the price of housing relative to the price of other consumer goods, on household income, and on other household characteristics. Such a relationship is known as a demand function for housing. Since rent rebates effectively change the relative price of housing, their effects can be analyzed using a housing demand function.

Households in Percent of Rent plans receive a payment, P, equal to a fixed percentage, "a," of their gross housing expenditures (including utilities),[1]

[1] There were two minor limitations imposed. If average monthly disposable income was greater than 4.8 times the estimated cost of modest existing standard housing, C* (varied by household size and site), the percentage rent rebated was reduced on a sliding scale. This limitation was rarely encountered. At the end of two years, only 6 percent of the Percent of Rent households in Pittsburgh (23 out of 407) and 3 percent in Phoenix (9 out of 298) had reduced rebate rates. The analyses in this report do not take account of these reductions in the rebate rate. However, estimates of elasticities using the actual rebate rate simply excluding households with reduced rebates changed the estimated elasticities by less than 0.01.

A second limitation, that the rebate was not applied to housing expenditures in excess of C*/a, applied to only two households in Pittsburgh and one in Phoenix. This, too, has been ignored in the analysis.

(1) $$P = aR.$$

The household's net housing expenditure, R_n, thus consists of the difference between their gross expenditure and the allowance payment,

(2) $$R_n = R - P = (1-a)R.$$

Gross expenditures may be thought of as a quantity of housing services times the price per unit: $R = p_H H$.[1] For the same quantity of housing, the net outlay for Percent of Rent households is

(3) $$R_n = (1-a)R = (1-a)p_H H.$$

Thus, the rent rebate can be viewed as changing the effective relative price of housing from p_H to $(1-a)p_H$.

Household response to such a change in prices may be analyzed in terms of conventional economic theory. Assume that households value housing and other goods according to a utility function

(4) $$U = U(H,Z)$$

where

H = the amount of housing services consumed, and

Z = a composite commodity of all nonhousing goods,

and that households maximize their utility subject to a budget constraint (B_0), determined by the level of available income,

(5) $$Y = p_H H + p_Z Z$$

where

Y = household income[2]

p_H = the price of housing, and

p_Z = the price of nonhousing goods.

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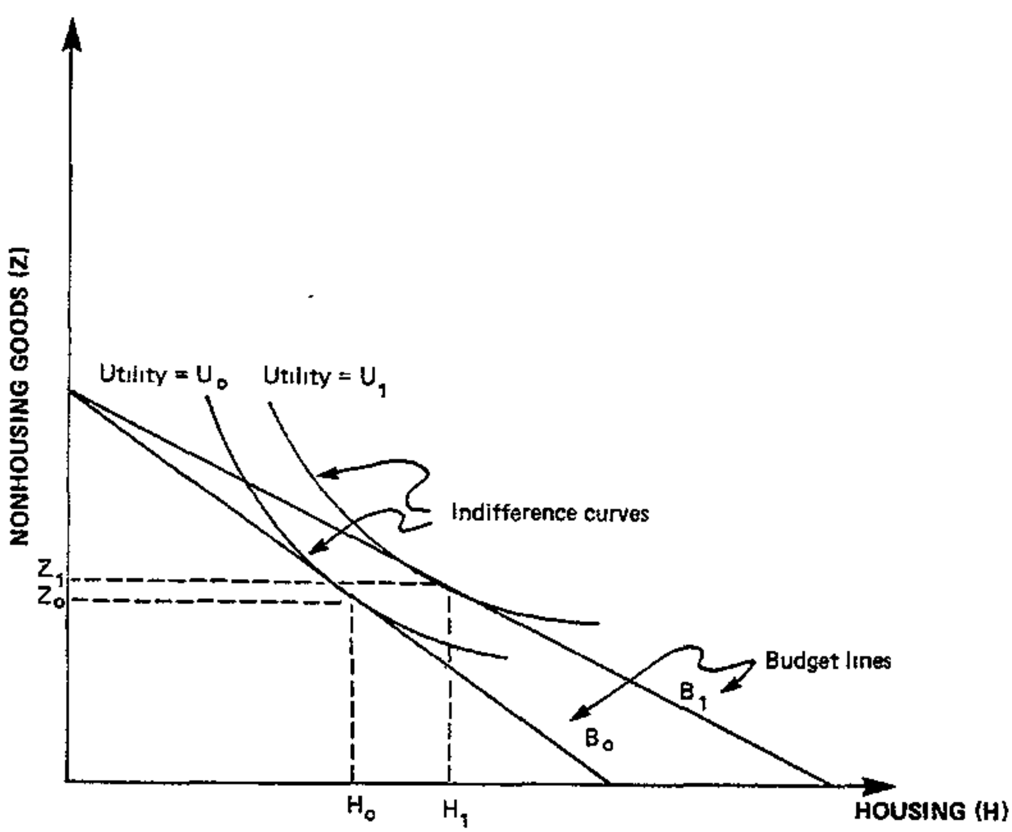
[1]The term housing services is used because renters do not actually buy a unit but only rent its use for a given period. Thus, what they buy is the housing services provided by the unit during the rental period. The housing consumption of homeowners can theoretically be analyzed on a basis comparable to renters by conceptually separating their purchase of an asset (their house) and their consumption of housing services while living in the house (see Kain and Quigley, 1972).

[2]Household income is often defined as "permanent" or "normal" income rather than current measured income. The household is viewed as making its budget plans based on expected normal income. Deviations of actual income from normal income are absorbed by changes in savings or discretionary purchases.

Figure 3-1 represents this situation, where U_0 is the maximum level of utility obtainable, with the household choosing what is termed the "optimal" amounts of housing and nonhousing goods, H_0 and Z_0, respectively.[1] The slope of the budget line B_0 is simply the negative of the relative price of housing, that is, $-p_H/p_Z$.

Figure 3—1
OPTIMAL HOUSING CONSUMPTION



[1]The lines $U = U_0$ and $U = U_1$, called indifference curves, show the combinations of housing and nonhousing goods needed to maintain a given level of utility. A key assumption is that indifference curves are concave from above--as housing consumption is reduced, it takes an increasing amount of nonhousing goods to leave the household as well off. See, for example, Henderson and Quandt (1971), for further discussion.

Introduction of rent rebates reduces the relative price of housing to the household, since it pays only $(1-a)p_H$ rather than p_H for each unit of housing services. In Figure 3-1, budget line B_1 represents the combination of housing and nonhousing goods obtainable by a household with a Percent of Rent housing allowance; the slope of B_1 is $-(1-a)p_H/p_Z$ and is thus less steep than B_0. If the household were then to maximize its utility, it would consume H_1 housing and Z_1 nonhousing goods, giving it a utility $U_1 = U(H_1,Z_1)$.

The functional relationship between the optimal amount of each good chosen and household income and prices is termed a demand function. The demand function for housing services can be expressed as

$$H = H(Y,p_H,p_Z). \tag{6}$$

Consumer demand theory provides some predictions about this function; in particular, if demand for housing increases as income increases $\left(\frac{\partial H}{\partial Y} > 0\right)$, then demand will decline as prices rise $\left(\frac{\partial H}{\partial p_H} < 0\right)$.

In addition to income and prices, other variables may also affect housing demand. Different demographic groups may have different relative preferences for housing versus other goods and services. Furthermore, policy interest is often focused on certain demographic groups, in particular minority and elderly households. The empirical work described in Chapter 4 examines several different types of characteristics: age of head of the household, household size, household type, and race of head. For simplicity, the exposition of functional forms in Section 3.2 below deals only with price and income, omitting any explicit discussion of other demographic variables.

3.2 THE FUNCTIONAL FORM OF HOUSING DEMAND

The exact impact of a rent rebate depends on the shape of the demand function for housing. The theory of consumer demand does not suggest a particular form for demand function, and the choice of the functional form is usually based on empirical considerations. Two different specifications are used in this report in order to gain some insights into the sensitivity of the estimates to the exact specification. Both relate the quantity of housing demanded (H) to a consumer's income (Y), housing prices (p_H), and nonhousing prices (p_Z). The first is the log-linear demand function, which has been widely used in empirical studies of housing demand. The second is a demand function that is linear in its parameters, where the parameters can be interpreted in terms of a Stone-Geary utility function.

Log-linear Demand Function

Since the rent rebate offered Percent of Rent households in effect reduces the price of housing, its impact may be expressed in terms of the price elasticity of demand for housing. The price elasticity of demand is defined as the ratio of the percentage change in quantity demanded to the percentage change in housing price. This can be expressed mathematically as

$$\eta_p = \frac{\partial H/H}{\partial p_H/p_H} = \frac{\partial \ln(H)}{\partial \ln(p_H)} . \tag{7}$$

If the price and income elasticities are constant, the demand function will be log-linear.[1] This log-linear demand function is written as[2]

$$\ln(H) = \beta_0 + \beta_1 \ln(Y) + \beta_2 \ln(p_H), \tag{8}$$

where β_0 is a constant and the coefficients β_1 and β_2 are, respectively, the income and price elasticity of demand for housing.

Equation (8) can be written in terms of rental expenditures rather than the abstract "quantity of housing services" by recognizing that rental expenditures are equal to the product of price and quantity.[3] In the log-linear form of the demand equation, this is done by adding the logarithm of price to both sides of the equation:

$$\ln(R) = \ln(p_H H) = \beta_0 + \beta_1 \ln(Y) + [(1 + \beta_2)\ln(p_H)]. \tag{9}$$

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[1] The income elasticity of demand is defined analogously to the price elasticity: $\eta_Y = \partial \ln(H)/\partial \ln(Y)$.

[2] In this equation, p_Z is normalized to equal one. The log-linear demand function could be written

$$\ln(H) = \beta_0 + \beta_1 \ln\left(\frac{Y}{p_Z}\right) + \beta_2 \ln\left(\frac{p_H}{p_Z}\right)$$

$$= \left[\beta_0 - (\beta_1 + \beta_2)\ \ln(p_Z)\right] + \beta_1 \ln(Y) + \beta_2 \ln(p_H).$$

If p_Z is unobservable and differs across sites, then the estimated constant term will differ as well.

[3] The possibility that the Percent of Rent offers altered the normal relationship between rent and the quantity and quality of housing obtained is explored in Chapter 5.

Equation (9) expresses the logarithm of housing expenditures, ln(R), as a linear function of the logarithms of income and of the relative price of housing. Note that the price elasticity of housing expenditures is equal to one plus the price elasticity of housing services.

The advantages of the log-linear form are several: it is simple to estimate using Ordinary Least Squares (OLS); it is widely used; its parameters are easily interpreted as (constant) price and income elasticities; and only the constant term is affected by changes in the units of measurement. Thus, inflation is easily accommodated in estimation by permitting the intercept, β_0, to change over time.[1] This attribute greatly facilitates comparisons over time and across cities. On the other hand, restricting the price and income elasticities to be constant may not be desirable, and the function itself cannot be derived from a known utility function.[2]

Linear Expenditure Function

As an alternative to the log-linear function, a linear expenditure function takes the form:[3]

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[1]This is a well-known feature of the logarithmic specification. To see this, let π denote the rate of general inflation in both housing and non-housing goods. Then, in terms of enrollment dollars, the relationships between rent and income at enrollment and at two years can be written as

$$\text{(i)} \qquad \ln(R_0) = \beta_0 + \beta_1 \ln(Y_0)$$

$$\text{(ii)} \qquad \ln(R_1/(1 + \pi)) = \beta_0 + \beta_1 \ln(Y_1/(1 + \pi))$$

where the subscripts indicate enrollment (t = 0) and two years after enrollment (t = 1).

Equation (ii) can be rewritten as

$$\text{(iii)} \qquad \ln(R_1) = [\beta_0 + (1 - \beta_1)\ln(1 + \pi)] + \beta_1 \ln(Y_1).$$

The expression, $[\beta_0 + (1 - \beta_1)\ln(1 + \pi)]$, is the new constant for the equation for the time t = 1.

[2]Indeed, the log-linear demand function is not compatible with any utility function over its entire range (except for the case of unitary elasticities).

[3]The demand function for housing corresponding to this linear expenditure function is

$$H = C + B\left(\frac{Y}{p_H}\right) + A\left(\frac{p_Z}{p_H}\right).$$

The expenditure function (10) is obtained by multiplying both sides of the demand function by p_H, using the normalizing assumption $p_Z = 1$.

(10) $$R = A + BY + Cp_H.$$

Just as the log-linear form expressed the logarithm of rent as a linear function of the logarithms of income and price, the linear form expresses rent as a linear function of income and price. It can also be estimated using Ordinary Least Squares.

For the linear expenditure function, income and price elasticities are not constant,[1] but vary with both price and income. The price elasticity is[2]

(11) $$\eta_p = \frac{-(A + BY)}{A + BY + Cp_H},$$

and the income elasticity is

(12) $$\eta_Y = \frac{BY}{A + BY + Cp_H}.$$

In contrast to the log-linear demand function, the linear expenditure function can be derived from a utility function. This utility function, known as the Stone-Geary utility function, is written as

(13) $$U(H,Z) = (H - \theta_1)^b (Z - \theta_2)^{1-b},$$

where b, θ_1, and θ_2 are parameters, $0 < b < 1$, $H \geq \theta_1$, and $Z \geq \theta_2$.[3]

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[1]They will be constant only in the special case of unitary elasticities.

[2]These formulas are derived from

$$\eta_p = \frac{\partial H}{\partial p_H} \cdot \frac{p_H}{H} \quad \text{and} \quad \eta_Y = \frac{\partial H}{\partial Y} \cdot \frac{Y}{H}$$

where

$$H = \frac{A + BY}{p_H} + C,$$

$$\frac{\partial H}{\partial p_H} = \frac{-(A + BY)}{p_H^2}, \text{ and}$$

$$\frac{\partial H}{\partial Y} = \frac{B}{p_H}.$$

[3]This function is more general than the Cobb-Douglas form, in which $\theta_1 = \theta_2 = 0$.

When this utility function is maximized subject to the budget constraint [Equation (5)] and is normalized by setting the price of the composite good, Z, equal to one ($p_Z = 1$), the equilibrium demand function is:[1]

(14) $$H = \theta_1 + \frac{b}{p_H}(Y - p_H\theta_1 - \theta_2).$$

In terms of rental expenditures, Equation (14) becomes

(15) $$R = p_H H = p_H\theta_1(1-b) + b(Y - \theta_2),$$

in form identical to Equation (10), where $A = -b\theta_2$, $B = b$, and $C = (1-b)\theta_1$. Moreover, in contrast to the log-linear form, since this function is derived directly from a utility function, it satisfies the theoretical constraints

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[1]The demand function is derived by taking the log of the utility function [Equation (13)] and defining the Lagrangian

$$L = b\ln(H-\theta_1) + (1-b)\ln(Z-\theta_2) + \lambda(Y - p_H H - p_Z Z).$$

The first order conditions are:

(i) $$\frac{dL}{dH} = \frac{b}{(H-\theta_1)} - \lambda p_H = 0$$

(ii) $$\frac{dL}{dZ} = \frac{(1-b)}{(Z-\theta_2)} - \lambda p_Z = 0$$

(iii) $$\frac{dL}{d\lambda} = Y - p_H H - p_Z Z = 0$$

From (i) and (ii),

$$\frac{b}{p_H(H-\theta_1)} = \frac{(1-b)}{p_Z(Z-\theta_2)}$$

or

$$b(p_Z Z - p_Z\theta_2) = p_H H - p_H\theta_1 - b(p_H H - p_H\theta_1)$$

This can be rewritten as

$$p_H H = p_H\theta_1 + b(p_H H + p_Z Z - p_H\theta_1 - p_Z\theta_2).$$

Finally, using (iii):

$$H = \theta_1 + \frac{b}{p_H}(Y - p_H\theta_1 - p_Z\theta_2),$$

which yields Equation (14) when p_Z is set equal to one. Thus, equilibrium rent ($p_H H$) can be interpreted as some minimum ($p_H\theta_1$) plus a constant fraction (b) of income above some minimum amount (supernumerary income).

on demand functions within certain ranges (see Phlips, 1974).[1]

The parameters θ_1 and θ_2 have been interpreted as minimum subsistence levels of housing and nonhousing goods, since the underlying utility function is defined only for values of H greater than or equal to θ_1 and Z greater than or equal to θ_2. This interpretation is untenable if the θs are negative, as will be true if the price elasticity of demand is greater than one (in absolute value).[2] Alternately, the parameters θ_1 and θ_2 can be viewed merely as parameters that affect the shape of the household demand function.

3.3 EVIDENCE FROM RECENT EMPIRICAL ESTIMATES OF HOUSING DEMAND[3]

This section presents some empirical evidence based on recent studies of the price and income elasticities of demand for rental housing. For the most part, housing demand analyses have ignored the role of housing price in influencing demand, choosing instead to focus on the role of income. For each analysis that estimates the price elasticity of demand there are several that estimate the income elasticity. The major reason for this focus is the difficulty of constructing accurate and generally applicable indices of housing price and the lack of time-series measurements of household housing demand under different housing prices.

The difficulties of measuring the "price" of housing are more severe than those of measuring the prices of most consumer goods. There is no single

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[1] The potential usefulness of the theoretical link to individual utility functions is largely lost in estimation. The constraints on the coefficients are those for the utility function--that for every household, $0 < b < 1$, $H \geq \theta_1$, and $Z \geq \theta_2$. These restrictions may in theory be maintained for every observation in either of two ways. First, if tastes are assumed to be the same for all households (so that the stochastic term represents disequilibrium housing expenditures), then parameters can be restricted so that no income and price observation yields a predicted expenditure level less than $p_H\theta_1$. Alternatively, a (restricted) stochastic distribution of parameters could be specified. Neither of these procedures is attempted in this report.

[2] This can be seen by rewriting Equation (11) in terms of the Stone-Geary parameters as

$$\eta_p = -1 + \frac{\theta_1(1-b)}{H} \lesseqgtr -1 \quad \text{as } \theta_1 \lesseqgtr 0.$$

[3] This section was adapted from an earlier report by Stephen K. Mayo (1977). See Mayo (forthcoming) for a more extensive review of recent studies.

price of housing. The percentage difference in cost of an identical one-bedroom unit between two cities may not be the same as the percentage difference in cost for an identical four-bedroom unit in those two cities. Most recent housing demand analyses that attempted to estimate price elasticities have relied on aggregate data from the City Worker's Family Budgets established by the Bureau of Labor Statistics (BLS). However, since the BLS budget is estimated only for a particular housing type, the index based on it may be misleading concerning price differences across housing in general.[1]

In addition, the type of household (as defined by household size, composition, or income, for example) that occupies the BLS prototypical unit may differ from place to place or over time, due to, among other things, differences in the price of housing. In this case, measurement errors in the price index may be systematically related to household characteristics. Unless such factors are explicitly accounted for in estimated demand relationships, the estimated price elasticity of housing demand based on the BLS index will subsume the effects of such household characteristics on housing demand and may produce misleading results.[2]

One further limitation of conventional housing price indices is that they typically apply to entire metropolitan areas, and consequently fail to account for housing price variations within those areas. There is growing evidence that intra-city price variations may be considerable, relative to between-city variations, as a result of geographical or ethnic submarkets, racial price discrimination, and spatial variations in land prices and rental unit operating expenses. Not only have such price variations been identified, but households have been found to adjust their housing consumption patterns rationally to intra-area price variations (see particularly Straszheim, 1975, and King, 1972). By ignoring such variations, conventional housing price indices are subject to what may be considerable

[1]The "rent shelter component of the (City Worker's) Budget refers to an unfurnished five-room unit (house or apartment) in sound condition and with a complete bath, a fully equipped kitchen, hot and cold running water, electricity, central or other installed heating, access to public transportation, schools, grocery stores, play space for children, and location in residential neighborhoods free from nuisances" (Gillingham, 1975).

[2]For a more extended discussion of this problem see Mayo and Fenton (1974), especially pp. 7-22. See also Polinsky (1977).

measurement error, thereby raising the possibility that estimates of price elasticities of housing demand are biased.

The inadequacies of conventional price indices provide an explanation for the wide variation in price elasticity estimates among studies that have used similar or even identical data but different empirical specifications of housing demand functions or different sets of explanatory variables. For example, three recent analyses have relied on data from the same panel survey, the "Panel Study of Income Dynamics" (PSID), administered by the University of Michigan Survey Research Center, and have all used BLS "rent shelter component" data as the basis for housing prices (Carliner, 1973; Fenton, 1974; and Lee and Kong, 1977). The major differences among the analyses are due to the different explanatory variables (other than housing price) included in the estimated demand function. The analyses produced strikingly different results. Carliner found that in no alternative demand function specification was the estimated price elasticity for renters significant at a high level; estimated magnitudes ranged from -0.1 to +0.02, depending on the specification. Fenton, on the other hand, observed uniformly significant price elasticity estimates ranging from -0.7 to -1.9 depending on which of several socioeconomic groups was being considered, and estimated the price elasticity for the entire renter population at -1.27. Further, Lee and Kong estimated statistically significant price elasticities of -0.6 for renters in two alternative specifications of housing and demand functions. From the results of these three analyses with nearly identical basic data, the specification of the housing demand function appears critical in influencing estimated price elasticities.[1]

Several other studies have found elasticities of about -0.7. DeLeeuw (1971), using BLS price data and 1960 Census data on renters, estimated a price elasticity of about -0.7, but conceded that the true value could be as high as -1.5 as a result of simultaneous determination of housing prices, quantities,

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[1]The estimated income elasticities are generally quite similar among the three analyses, despite some differences in specification. Carliner estimates income elasticities from about 0.4 to about 0.5 for renters, depending on the functional form and the definition of income. Fenton's income elasticity estimates also center on the 0.4 to 0.5 range for most socioeconomic groups. Lee and Kong estimate income elasticities ranging from about 0.3 to 0.7 for renters (depending on the income definition and estimation method); for their most carefully specified model, they obtain an estimate of about 0.5.

and rents. Nelson (1975) reproduced deLeeuw's analysis using 1970 Census data and found a price elasticity for renters of about -0.7.[1] One recent review of empirical analyses of housing demand (Polinsky, 1977) concludes that although biases on price and income elasticities may be serious in most extant analyses, by correcting for such biases a price elasticity of housing demand on the order of -0.75 is obtained. Despite Polinsky's analysis, there appears to be little consensus on an appropriate value for the price elasticity of housing demand. The disparate results of the three analyses of the PSID data (Carliner, Fenton, and Lee and Kong) illustrate most dramatically the range of uncertainty that surrounds the subject of price elasticity, particularly for renters.

Experimentally created variations in housing prices--the result of rent rebates offered Percent of Rent households--have the potential to reduce that uncertainty considerably for three main reasons. First, the percentage price reduction applies to all housing equally. Thus the price of every unit is reduced by the same proportion, so that the effect of a proportional change in prices can be estimated without having to know the base price of housing. Second, assignment of households to the Percent of Rent rebate groups is random, so that the "price" of housing created by the rebate should not be correlated with household characteristics that influence housing consumption, thereby alleviating one of the more serious problems associated with using conventional housing price indices in demand studies.[2] Third, the range of price variations resulting from the subsidy is large relative to variations in such housing price indices as the BLS index; thus housing consumption responses may be estimated over a broader range of prices than has been typical of nonexperimental analyses.

Experimental data present their own problems, however. The limited duration of the Demand Experiment may have affected household response to the allowance

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[1] Nelson found a price elasticity for homeowners of about -0.3. Other analyses of housing price elasticities for homeowners have estimated values of -0.3 (Carliner, 1973), -0.8 to -0.9 (Maisel, Burnham, and Austin, 1971), and -0.7 to -0.8 (Muth, 1971). The last two analyses were based on Federal Housing Administration (FHA) data on individual homeowners, and the first on the PSID.

[2] As noted above, because measurement errors in conventional price indices are likely to be systematically related to household characteristics, their use in estimating demand functions can result in biased price elasticity estimates.

payment. In addition, attrition from the sample may create problems of bias due to possible self-selection, resulting in a potentially noncomparable control group. Finally, households may misunderstand the rebate, and thus not respond completely. Such issues are examined in more detail in Chapter 6. While the evidence presented is not conclusive, it suggests that these potential problems were not in fact important.

The relationship between income and housing consumption has received considerable attention in recent empirical analyses of housing demand. An important review article (deLeeuw, 1971) cited several analyses that estimated income elasticities greater than one (indicating that housing consumption is highly sensitive to income changes), and only one analysis that found an income elasticity less than one (Lee, 1968). Since deLeeuw's review, however, many analyses have indicated income elasticities less than one; and no recent analysis has indicated an income elasticity for renters even approaching one. Some analyses, in fact, have indicated income elasticities as low as 0.1 and 0.3 (Kain and Quigley, 1975; Li, 1973; and Nelson, 1975). Several others have indicated elasticities from 0.4 to 0.6 (Carliner, 1973; Fenton, 1974; Lee and Kong, 1977; Mayo, 1973; and Straszheim, 1976).

The major source of the discrepancies between the results of the analyses reviewed by deLeeuw and of subsequent analyses is the level of aggregation of the data. Nearly all of the analyses cited by deLeeuw used data aggregated to at least the Census tract level, and most were based on Standard Metropolitan Statistical Area (SMSA) averages. The subsequent analyses have been based on individual household data.

Three recent analyses have indicated that biases in estimated income elasticities may be severe as a result of using aggregate data. In one (Maisel, Burnham, and Austin, 1971), demand functions were estimated for homeowners using FHA data--first for individual households, and then for SMSA averages of the same households. The disaggregated data produced an income elasticity estimate of about 0.45, whereas the SMSA-average data produced an elasticity of about 0.9. Polinsky (1977) argues that aggregation of the data and misspecification of demand relationships combine to account for the differences between income elasticity estimates using household data and those using aggregated data. He suggests that an appropriate value for the income elasticity is about 0.75, although the figure could be higher for homeowners and lower for renters. Nelson (1975), using data on individual households, estimated income elasticities (for renters) of about 0.28. When individual data were grouped randomly, income elasticity estimates were about 0.35. When they were grouped according to Census tracts, income elasticities were about 0.76--an increase of about 170 percent over estimates using individual data.[1] Estimated income elasticities may also be biased by errors in measuring household income. In particular, if households make decisions about housing expenditures on the basis of expectations concerning income to be received over a long period of time rather than on the basis of current income, then some measure of "permanent" or "normal" income will be more appropriate than current income to use in estimating demand functions (see Friedman, 1957). If households expect to rent a unit for an appreciable length of time, then they are likely to base their consumption decision on a more stable measure of income than current income, such as some permanent income measure. Use of a short-term income measure would then be likely to underestimate the income response, in that changes in short-run income would lead to housing changes only as they are reflected in changes in long-run (permanent) income.

In general, analyses that have used household data to estimate demand functions have attempted to estimate income elasticities with respect to permanent income rather than (or in addition to) elasticities with respect to current income. The methods used have varied greatly and have generally tended to be somewhat ad hoc. Two alternate income measures are examined in this report--current income and income averaged over three years, the latter chosen to approximate "permanent" income.[2]

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[1] There may be biases in estimates from household data as well. Polinsky (1977), for example, argues on theoretical grounds that many such estimates of income elasticities are based as a result of improper specification of housing price, that is, by using a metropolitan areawide index instead of an observation-based one. Since the Demand Experiment uses observation-based price variations, this is not a concern. Furthermore, empirical work by Polinsky and Ellwood (1977) suggests that despite the theoretical argument of Polinsky, the estimate of income elasticity is virtually unaffected by inclusion or exclusion of a price term.

[2] An additional measure of permanent income--one based on income predicted from an instrumental variable regression using socioeconomic characteristics--was tested but gave results similar to the average income measure. See Mayo (1977) for results using instrumental variables to estimate permanent income.

3.4 THE PLAN FOR THE REST OF THE REPORT

The major empirical results from the analysis of housing response to rent rebates are contained in the following two chapters. Chapter 4 shows how price and income elasticities can be estimated using the experimental percentage rebate as a price term and two measures of income--current and average income. It then presents the results for the housing expenditure equations, for both the log-linear and the linear (Stone-Geary) formulations. In addition, the effect of demographic variables is discussed in detail. Chapter 5 focuses on responses in terms of housing services and normative physical standards. Housing services are measured by an hedonic index--a weighted sum of numerous housing and neighborhood attributes. A discussion and analysis of problems and issues specific to experimental data are presented in Chapter 6.

REFERENCES

Carliner, G., "Income Elasticity of Housing Demand," Review of Economics and Statistics, vol. 55, no. 4, November 1973.

deLeeuw, Frank, "The Demand for Housing - A Review of the Cross-Section Evidence," Review of Economics and Statistics, vol. 53, no. 1, February 1971, pp. 1-10.

Fenton, Chester, "The Permanent Income Hypothesis, Source of Income and the Demand for Rental Housing," Analysis of Selected Census and Welfare Program Data to Determine Relations of Household Characteristics, and Administrative Welfare Policies to a Direct Housing Assistance Program, Cambridge, Mass., Joint Center for Urban Studies, July 1974.

Friedman, Milton, A Theory of the Consumption Function, Princeton, Princeton University Press, 1957.

Gillingham, Robert F., "Place-to-Place Rent Comparisons Using Hedonic Quality Adjustment Techniques," BLS Staff Paper No. 8, Washington, D.C., U.S. Government Printing Office, 1975.

Henderson, James M. and Richard E. Quandt, Microeconomic Theory: A Mathematical Approach, 2nd edition, New York, McGraw-Hill, 1971.

Kain, John F. and John M. Quigley, "Housing Market Discrimination, Homeownership, and Savings Behavior," American Economic Review, vol. 72, June 1972, pp. 263-277.

______________________________, Housing Markets and Racial Discrimination: A Microeconomic Analysis, New York, National Bureau of Research, 1975.

King, A. Thomas, "Land Values and the Demand for Housing," unpublished Ph.D. dissertation, Department of Economics, Yale University, 1972.

Lee, T.H., "Housing and Permanent Income: Tests Based on a Three Year Reinterview Survey," Review of Economics and Statistics, November 1968, p. 487.

Lee, Tong Hun and Chang Min Kong, "Elasticities of Housing Demand," Southern Economic Journal, vol. 44, no. 2, October 1977, pp. 298-305.

Li, Mingche M., "An Analysis of Housing Consumption with Implications for the Design of a Housing Allowance Program," Analysis of Selected Census and Welfare Program Data to Determine Relations of Household Characteristics and Administrative Welfare Policies to a Direct Housing Assistance Program, Cambridge, Mass., Joint Center for Urban Studies, September 1973.

Maisel, Sherman J., James B. Burnham, and John S. Austin, "The Demand for Housing: A Comment," Review of Econometrics and Statistics, vol. 53, no. 4, November 1971, pp. 410-413.

Mayo, Stephen K., Housing Allowance Demand Experiment: Housing Expenditures and Quality Part 1: Housing Expenditures Under a Percent of Rent Housing Allowance, Cambridge, Mass., Abt Associates Inc., 1977.

_______________, "Theory and Estimation in the Economics of Housing Demand," Journal of Urban Economics, forthcoming.

_______________, "Welfare and Housing," Analysis of Selected Census Data to Determine Relation of Household Characteristics, Housing Market Characteristics, and Administrative Welfare Policies to a Direct Housing Assistance Program, Cambridge, Mass., Joint Center for Urban Studies, 1973.

Mayo, Stephen K., and Chester Fenton, Alternative Mechanisms for Determining the Cost of Standard Housing, Cambridge, Mass., Abt Associates Inc., December 1974.

Muth, Richard F., "The Derived Demand for Urban Residential Land," Urban Studies, vol. 8, no. 3, October 1971, pp. 243-54.

Nelson, David, "Income Elasticity of Housing Demand," unpublished Ph.D. dissertation, Department of Economics, University of Oregon, 1975.

Phlips, Louis, Applied Consumption Analysis, New York, American Elsevier, 1974.

Polinsky, A. Mitchell, "The Demand for Housing: A Study in Specification and Grouping," Econometrica, vol. 45, no. 2, March 1977, pp. 447-461.

Polinsky, A. Mitchell and David J. Ellwood, "An Empirical Reconciliation of Micro and Grouped Estimates of the Demand for Housing," Harvard Institute of Economic Research Discussion Paper, Number 567, August 1977.

Straszheim, Mahlon, An Econometric Analysis of the Urban Housing Market, New York, National Bureau of Economic Research, 1975.

CHAPTER 4

EMPIRICAL ESTIMATES OF HOUSING EXPENDITURE FUNCTIONS

Chapter 3 presented consumer demand theory and applied its hypotheses to housing. This chapter analyzes responses to rent rebates within that framework, using the sample of Percent of Rent and Control households, and presents estimates of elasticities of demand. Section 4.1 presents the empirical specifications of the housing demand functions described in Chapter 3. Section 4.2 describes the estimated model of housing demand, focusing on households that moved during the first two years of the Demand Experiment. The effect of demographic variables on housing expenditures is discussed in Section 4.3.

4.1 EMPIRICAL SPECIFICATION OF HOUSING EXPENDITURES FUNCTIONS

This section provides the empirical specification for the log-linear and the linear housing expenditures functions. The log-linear housing expenditures function is written as

$$\ln(R) = \ln(p_H H) = \beta_0 + \beta_1 \ln(Y) + (1+\beta_2)\ln(p_H), \tag{1}$$

where

R = housing expenditures

p_H = price of housing

H = quantity of housing, and

Y = household income.

The coefficients β_1 and β_2 are interpreted, respectively, as income and price elasticities of demand for housing. Equation (1), however, includes one important variable, p_H, which is not observable on the household level.[1] However, because of the experimental variation in prices due to the Percent of Rent rebates, it is not necessary to observe p_H.

[1] As discussed in Section 3.3, several researchers have circumvented this problem by using the Bureau of Labor Statistics housing budget index computed on a metropolitan basis as a proxy for housing price. However, Polinsky (1977) has shown that such a proxy is theoretically likely to lead to biased estimates of both income and price elasticities.

As shown in Chapter 3, the price of housing faced by Percent of Rent recipients changes from p_H to $(1-a)p_H$. Substituting $(1-a)p_H$ for p_H in Equation (1) gives

$$\ln[(1-a)p_H H] = \beta_0 + \beta_1 \ln(Y) + (1+\beta_2)\ln[(1-a)p_H]. \tag{2}$$

Equation (2) can be rearranged as

$$\ln[(1-a)p_H H] = [\beta_0 + (1+\beta_2)\ln(p_H)] + \beta_1 \ln(Y) + (1+\beta_2)\ln(1-a). \tag{3}$$

Equation (3) is in terms of net rent. An alternative is to transform the equation to be in terms of gross rent. Subtracting ln(1-a) from both sides of Equation (3) yields

$$\ln(p_H H) = [\beta_0 + (1+\beta_2)\ln(p_H)] + \beta_1 \ln(Y) + \beta_2 \ln(1-a). \tag{4}$$

Here, the dependent variable is the logarithm of the actual (gross) rent. The only difference in parameters between Equations (3) and (4) is the coefficient of ln(1-a). In Equation (4), the coefficient of ln(1-a) is equal to the price elasticity of housing demand, whereas in Equation (3) it is equal to one plus this price elasticity.

Equation (4) contains the unobservable variable, p_H, the price of housing services. In order to be estimated, the equation must be rewritten in terms of observable variables as

$$\ln(R) = \beta_0' + \beta_1 \ln(Y) + \beta_2 \ln(1-a) + \varepsilon, \tag{5}$$

where[1]

$$\beta_0' = [\beta_0 + (1+\beta_2)\ln(p_H)], \text{ and}$$

$$\varepsilon = \text{a stochastic error term.}$$

As long as Y and (1-a) are independent of the unobserved variable p_H, the parameters of Equation (5) may be estimated using an Ordinary Least Squares (OLS) regression. Experimental households were assigned to rent rebate categories at random, assuring that the "a" level is stochastically

[1] If the relative price of housing differs across sites, the estimated constant term will differ since it is a function of that unobserved variable. If p_H differs within sites as suggested in Chapter 3, variations around the mean are included in the stochastic term, ε.

independent of the unobserved price p_H.[1] Likewise, there is no reason to believe that income is significantly correlated with the overall unit price of housing services.[2]

The linear housing expenditures function is written as:

$$R = p_H H = A + BY + Cp_H, \tag{6}$$

where the coefficients can be interpreted in terms of the parameters b, θ_1, and θ_2 of a Stone-Geary utility function (presented in Chapter 3, Equation (13)):

$$b = B,$$

$$\theta_1 = \frac{C}{1-B}\text{, and}$$

$$\theta_2 = \frac{-A}{B}.$$

Rent rebates can be introduced in a way identical to the log-linear case. Replacing p_H with $(1-a)p_H H$ in Equation (6) yields,

$$(1-a)p_H H = A + BY + C(1-a)p_H. \tag{7}$$

An equation in terms of gross rental expenditures is obtained by dividing both sides of Equation (7) by (1-a):[3]

$$R = p_H H = A\left(\frac{1}{1-a}\right) + B\left(\frac{Y}{1-a}\right) + C' + \varepsilon. \tag{8}$$

---

[1] The Percent of Rent plan with a 60 percent rebate was only offered to households in the lower third of the income distribution of the eligible population, while the 20 percent plan was only offered to households in the upper two-thirds. Since income is included as a variable in the demand equation, this will not bias the results (assuming that the form of Equation (5) is correctly specified).

[2] Some models of residential location have implied that p_H and Y are negatively correlated (that is, higher income households pay less per unit of housing than lower income households). In that case, β_1 would be misestimated. This particular objection is not applicable here, since those location models separate locational attributes from housing services. In the analysis presented above, the commodity "housing" includes location and accessibility. If minorities pay more for a given housing unit than do nonminorities, then income and p_H may be correlated because income and race are usually correlated. Merrill (1977), however, found no evidence of any large price differences in the Demand Experiment sites.

[3] Note that $C' = Cp_H = p_H\theta_1(1-b)$. The term $p_H\theta_1$ can be interpreted as the dollar value of θ_1. Since H, the "quantity of housing services," is an abstract measure, its units can be defined so that $p_H = 1$.

In Equation (8), the term $1/(1-a)$ enables estimation of the parameters of the Stone-Geary utility function (b, θ_1, and θ_2), using individual household data.

Introduction of the rent rebates also modifies the formulas for the price and income elasticities of demand (Equations (11) and (12) of Chapter 3). The price elasticity becomes

$$\eta_p = \frac{-(A + BY)}{A + BY + C'(1-a)} \tag{9}$$

and the income elasticity becomes

$$\eta_y = \frac{BY}{A + BY + C'(1-a)} \tag{10}$$

4.2 ELASTICITY ESTIMATES

This section presents estimated price and income elasticities based on Percent of Rent and Control households. Both the log-linear and linear specifications described in Section 4.1 are used. The section begins with estimates based on all Percent of Rent and Control households still enrolled in the experiment at the end of two years.[1] The discussion focuses on the similarity of the estimated log-linear and linear forms. The similarity of estimates for the two sites and differences from estimates in other analyses are also noted.

The section then turns to estimates based on households that moved during the experimental period. Again, the two specifications give very similar results, and the estimated elasticities for the two sites are almost identical. A pooled site equation is then estimated and further alternative specifications examined. Finally the estimated income elasticities based on the nonexperimental variations in household income are compared with estimates obtained using the sample of Unconstrained households, which received an experimental income supplement.

Two income variables were used in estimation--a current income measure and a permanent income measure (three-year average income). Since the theoretical arguments reviewed in Section 3.3 suggest that response to the average income measure is more interesting as it reflects longer-term adjustments,

[1]Potential bias from attrition is examined in Section 6.2.

average income will be discussed in the text.[1] Table 4-1 presents the estimated price and income elasticities in the overall Percent of Rent and Control sample, for both the log-linear and the linear models.[2] The log-linear specification constrains each elasticity estimate to a single value for all ranges of income and prices.[3] By contrast, under the linear specification the elasticities vary with price and income.[4]

The two numbers presented for comparison represent derived linear price and income elasticities. They are computed from the estimated parameters of the linear demand function using the mean monthly income and mean relative price, (1-a), for the sample, and also the mean of the elasticities computed for individual households.[5] Even though the linear elasticities rise (in absolute value) with income, the mean linear elasticity is close to the log-linear estimate. That the linear and log-linear estimates are so close for the low-income Demand Experiment population suggests that if a single elasticity estimate is needed, the log-linear demand function provides a reasonable approximation for the mean of the sample. Accordingly, it will be focused on for much of the rest of the report. For some applications, one should nevertheless realize that the log-linear price elasticity estimate may be affected by the level and distribution of income in the sample.

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[1] The current income estimates are presented in Appendix X. If households respond less to a temporary change in income than to a permanent change, the estimated current income elasticities will be smaller than the permanent elasticities. The estimated current elasticities are indeed somewhat less than those estimated for average income.

[2] Appendix Tables X-13 and X-14 present the demand function estimates for the log-linear and linear models, respectively. Neither the linear nor the log-linear form fit the data better in both sites (using actual rent).

[3] A log-linear equation was also estimated using ln(income) and five dummy variables (for the five different percentage rebate levels) instead of the term ln(1-a). In both sites, the F-tests suggest that the specification with the five dummy variables is not preferable to the one with the term ln(1-a); the F-statistics were less than 1.0 (see Appendix Table X-15). A different method for computing response based on normal behavior is presented in Appendix VI.

[4] Except for the special case of unitary elasticities.

[5] Since the linear elasticities are computed from ratios of the parameters obtained from the estimated demand equation, their variance does not exist if the error term, and hence the estimates, are normally distributed. An approximate asymptotic variance can be computed, however, based on the asymptotic distribution of the estimators (see, for example, Kmenta, 1971, pp. 444-445). The standard error of the mean of the elasticities is reported also.

Table 4-1

PRICE AND INCOME ELASTICITY ESTIMATES
FOR THE OVERALL SAMPLE

	PITTSBURGH	PHOENIX
ELASTICITIES	ELASTICITY ESTIMATE	ELASTICITY ESTIMATE
Price Elasticity		
Log-linear	-0.178** (0.038)	-0.234** (0.049)
Linear		
At mean income and price[a]	-0.164** (0.042)	-0.213** (0.051)
Mean of individual estimates	-0.172 (0.005)[c]	-0.211 (0.007)[c]
Income Elasticity[b]		
Log-linear	0.333** (0.028)	0.435** (0.032)
Linear		
At mean income and price	0.291** (0.021)	0.377* (0.024)
Mean of individual estimates	0.323 (0.006)[c]	0.404 (0.008)[c]
SAMPLE SIZE	(674)	(532)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, Appendix Tables X-13 and X-14.

NOTE: Standard error in parentheses.

a. Mean monthly household income = $417 for Pittsburgh and $434 for Phoenix. Mean price = 0.75 for Pittsburgh and 0.77 for Phoenix.

b. Three-year average income is used here as a measure of permanent income.

c. Standard error of the mean.

** t-statistic significant at the 0.01 level.

It is difficult to distinguish the two forms. Figure 4-1 shows predicted rent in each site as a function of price, using the estimated log-linear and linear expenditure functions.[1] Only for very high and for very low incomes do the curves diverge, and then only for low rebate levels (the mean monthly average income was \$417 in Pittsburgh and \$434 in Phoenix). Figure 4-2 compares predictions as a function of income, controlling for the price level. Again, predicted values are generally close, beginning to diverge only for high incomes.

The linear specification, allowing interpretation of the parameters as Stone-Geary parameters, is theoretically appealing as the demand function can be derived from a known utility function (see Chapter 3). Plausible estimates do result when individual household data are used for estimation. However, the estimates were not constrained to satisfy (and for a good part of the sample do not satisfy) the utility function constraint, $R \geq p_H\theta_1$.[2] The price elasticity point estimates for the total sample are about -0.18 in Pittsburgh and about -0.23 in Phoenix; the income elasticity estimates are about 0.33 in Pittsburgh and 0.44 in Phoenix. Both the price and income elasticity estimates are in the lower range of estimates reported in the economic literature (see Section 3.3). The income elasticity estimates,

[1]The predicted rent for the linear form is simply [from Equation (8)]

(i) $$\hat{R} = \hat{A}\left(\frac{1}{1-a}\right) + \hat{B}\left(\frac{Y}{1-a}\right) + \hat{C}'.$$

For the log-linear form, predicted rent is [from Equation (5)]

(ii) $$\widehat{\ln R} = \hat{\beta}_0' + \hat{\beta}_1 \ln(Y) + \hat{\beta}_2 \ln(1-a)$$

and

(iii) $$\hat{R} = \exp[\widehat{\ln(R)} + \frac{1}{2}\hat{\sigma}_\varepsilon^2]$$

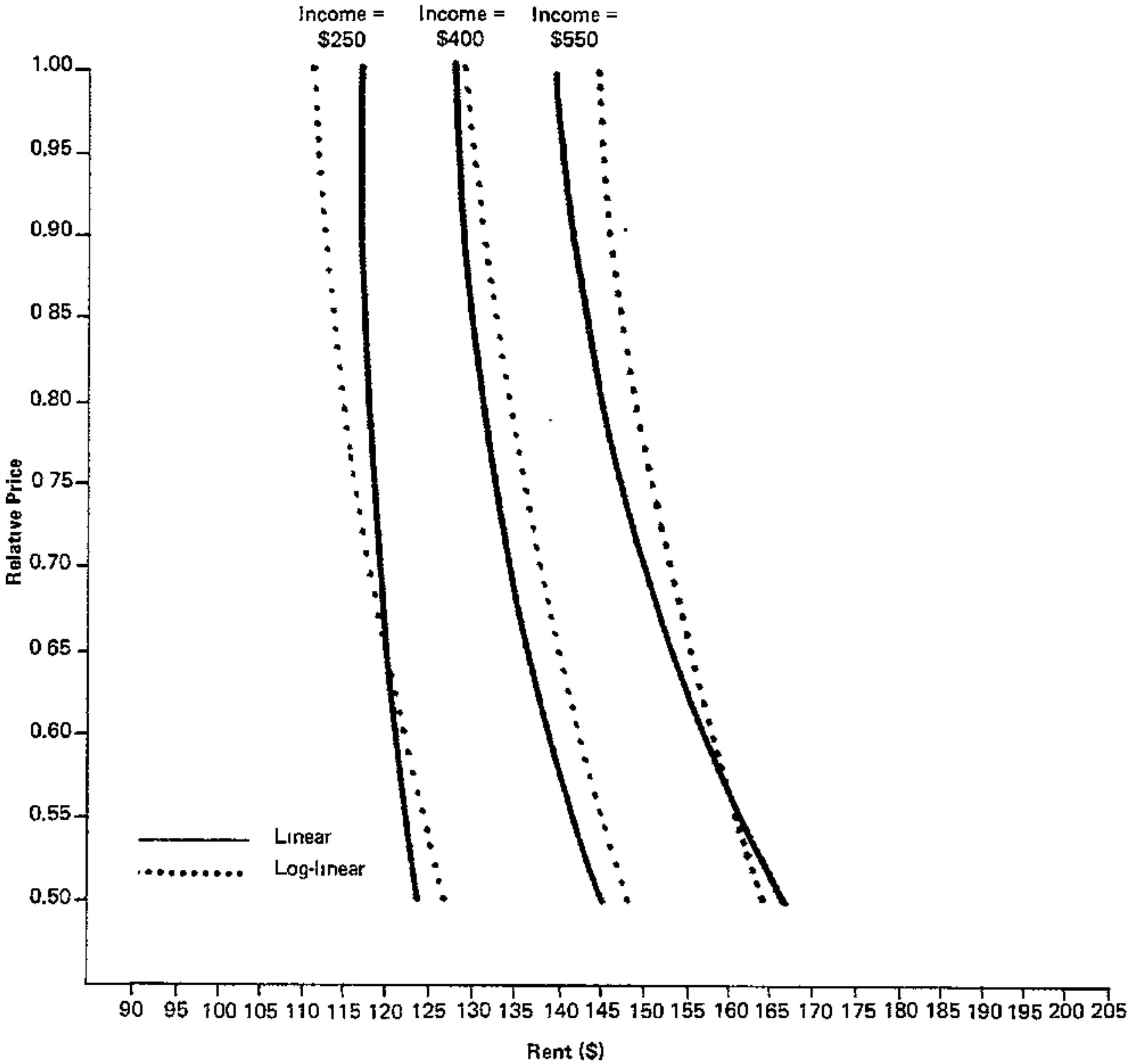
where $\hat{\sigma}_\varepsilon^2$ is the estimated variance of the log-linear error term. This predictor follows from the fact that if Z is lognormally distributed, the expected value of Z is

(iv) $$E(Z) = \exp[\mu + \frac{1}{2}\hat{\sigma}^2],$$

where μ and σ^2 are the mean and variance, respectively, of ln(Z). (See Hastings and Peacock, 1975, pp. 84-89.)

[2]The estimates of $p_H\theta_1$ were \$134 in Pittsburgh and \$148 in Phoenix while the mean rent for Control households at two years was \$134 in Pittsburgh and \$144 in Phoenix. The estimated demand function represents a relationship describing a "representative" household's taste for housing. If tastes differ across households, then it is not surprising that the constraint is not satisfied for all households.

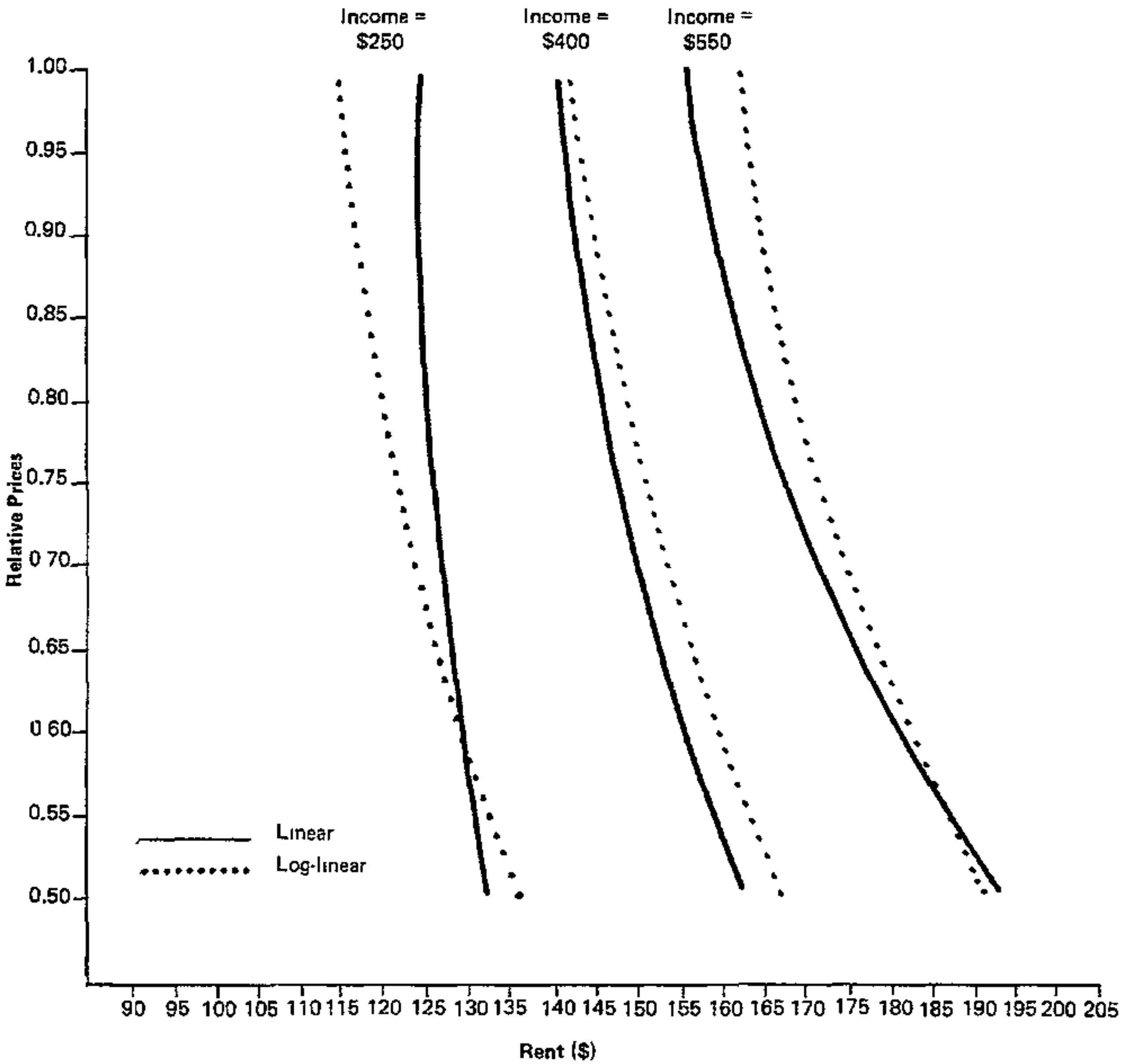
Figure 4—1
EXPENDITURE FUNCTIONS: RENT VS. PRICE
(Pittsburgh)



SAMPLE. Pittsburgh Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligiblity limits and those living in their own homes or in subsidized housing

DATA SOURCES. Initial and monthly Household Report Forms, and payments file.

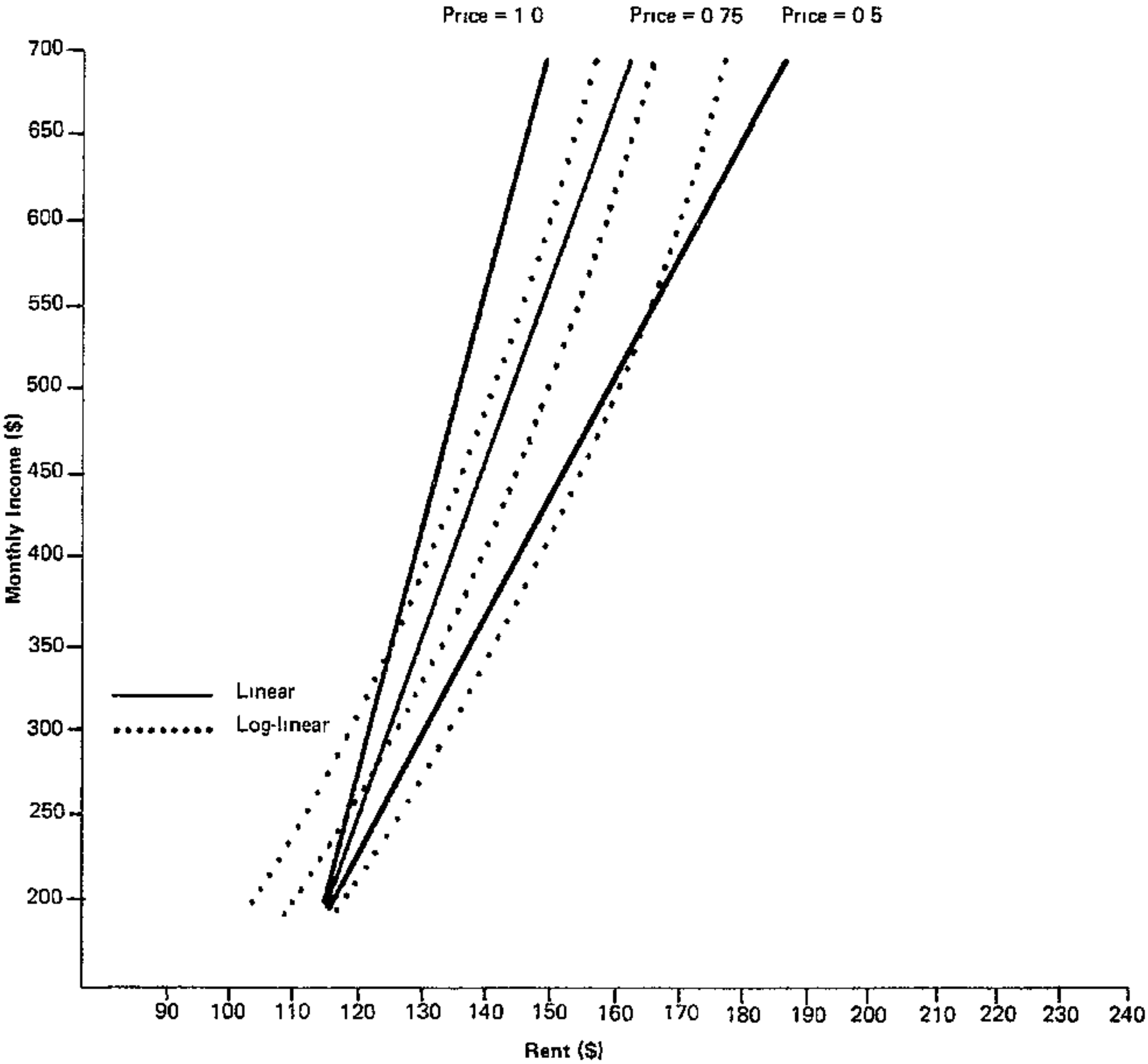
Figure 4–1 (continued)
EXPENDITURE FUNCTIONS: RENT VS. PRICE
(Phoenix)



SAMPLE: Phoenix Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing

DATA SOURCES Initial and monthly Household Report Forms, and payments file.

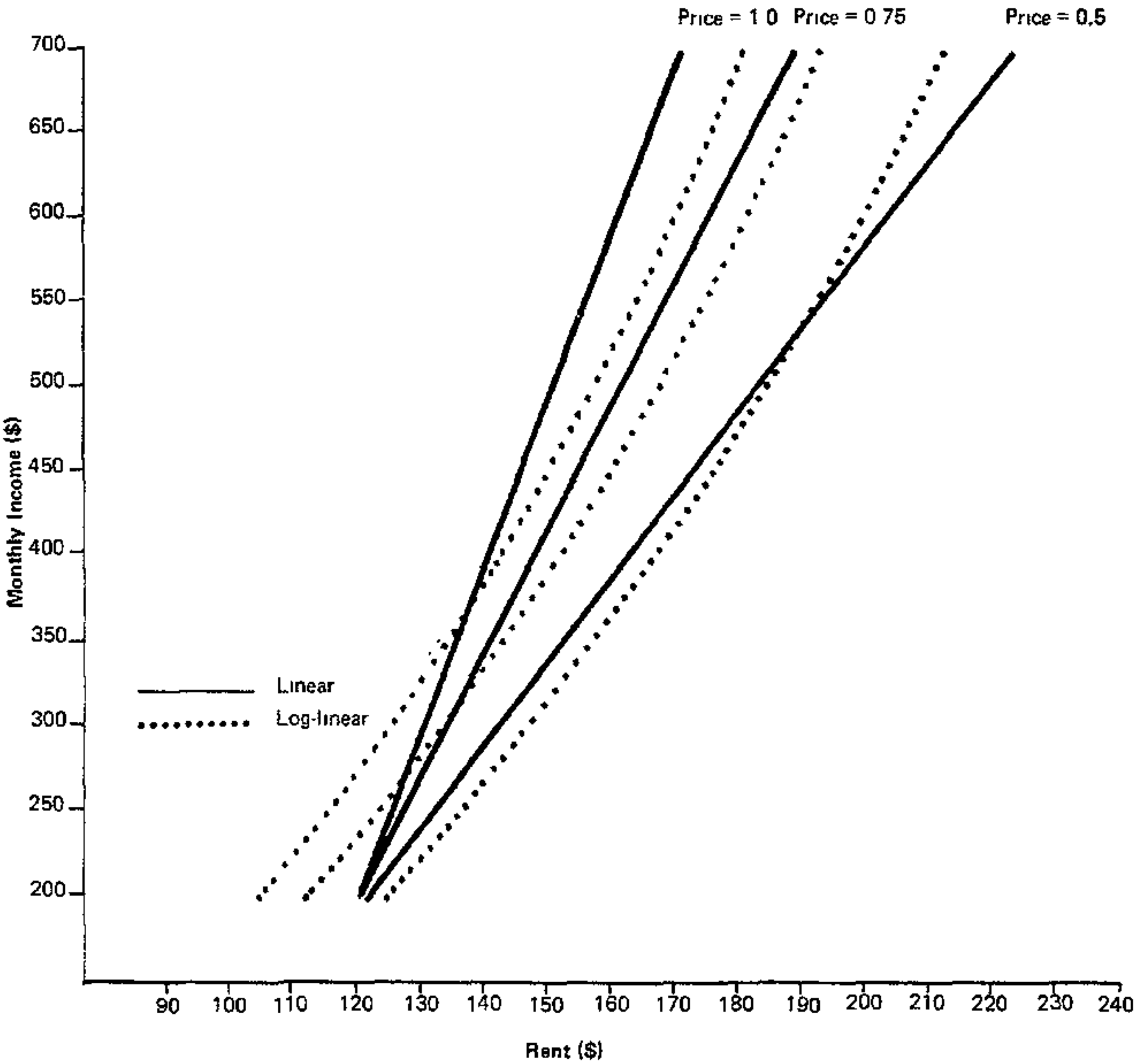
Figure 4–2
EXPENDITURE FUNCTIONS: RENT VS. INCOME
(Pittsburgh)



SAMPLE. Pittsburgh Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligiblity limits and those living in their own homes or in subsidized housing.

DATA SOURCES Initial and monthly Household Report Forms, and payments file.

Figure 4—2 (continued)
EXPENDITURE FUNCTIONS: RENT VS. INCOME
(Phoenix)



SAMPLE: Phoenix Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing

DATA SOURCES. Initial and monthly Household Report Forms, and payments file.

though low, are more closely comparable to estimates in the literature than are the price elasticity estimates.[1] Indeed, among the studies cited in Chapter 3 based on individual household data, three found lower income elasticities (in the 0.1 to 0.3 range) and five found higher ones (in the 0.4 to 0.6 range). In contrast, estimated price elasticities have ranged from -0.1 to -1.9, with most studies giving values of -0.7 or lower. As noted in Chapter 3, nonexperimental estimates of price elasticities are hampered by problems involved in estimating price differences across cities or over time. Thus the estimates provided by the Demand Experiment would appear to be more reliable. Chapter 6 discusses some reasons why the estimated price elasticity might be biased downward from the true elasticity, though no evidence of bias can be found.

The similarity in estimates between the sites in both income and price elasticity[2] is somewhat in contrast to the findings reported by Mayo (1977) using preliminary, first-year data from the Demand Experiment. He found a somewhat lower price elasticity in Pittsburgh.[3]

Selection of Movers

The entire sample of renters may not be the best sample to use to estimate the demand functions. The housing demand and expenditure functions discussed in Sections 3.1 and 3.2 were in theory based on the household's choice of

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[1] The linear specification suggests that elasticities will be lower for lower-income populations. However, the estimated coefficients for the linear expenditure function indicate only small differences in elasticities over a considerable range of income. The median income for the U.S. renter population in 1975 was $7,900 (Annual Housing Survey, 1975), while the median income of households in the Demand Experiment was $4,578 in Pittsburgh and $5,199 in Phoenix (using the Census definition of income). The implied elasticities from the linear form at the U.S. median income (with no rent rebate) are only:

	Pittsburgh	Phoenix
Price	-0.23	-0.29
Income..................	0.32	0.40

[2] Despite the similarity of estimated coefficients, the hypotheses of homogeneity for the two sites is rejected (see Appendix Table X-15).

[3] Mayo's estimates (based on two-year average income) were -0.109 in Pittsburgh and -0.234 in Phoenix for the price elasticity, and 0.338 in Pittsburgh and 0.400 in Phoenix for the income elasticity (p. 81). The somewhat larger price elasticity shown in Table 4-1 largely reflects further changes in expenditures during the second year of the experiment. For details, see Appendix IX.

optimal, utility-maximizing, amounts of housing under the implicit assumption that the search and moving costs of adjusting housing consumption to changed household circumstances are negligible. However, these costs may be significant. Households may not adjust immediately to correct imbalances in their consumption of housing and nonhousing goods. Thus, unless they have moved recently, they may not be consuming their desired amount of housing.[1] Such deviations may involve both over- and underspending for housing and might tend to cancel out in general. However, the price changes created by the rent rebates were in one direction. Thus estimates of price elasticities based on all households may underestimate the true elasticity. This suggests that it is desirable to estimate a separate demand function solely for movers.

If renters generally adjust their housing by moving, then households that did not move would be expected to show little change in housing expenditures in response to the Percent of Rent rebates.[2] As these households move, they may respond more like the households that moved during the experimental period.[3] Thus, estimates for movers may provide a better estimate of the underlying demand function and the eventual response to a rent rebate than would estimates based on the entire sample.

The idea that the psychological and financial costs of moving may lead some households to consume nonoptimal amounts of housing for long periods of time (see, for example, Muth, 1974) raises several other issues relevant to the estimation of demand functions.[4] Thus, for example, households may attempt to base their current housing purchases on their best notion of what their income and prices are likely to be over some period of time. In particular, they might either adjust slowly to the price changes offered by the Percent of Rent rebates or they might discount these rebates because the experiment lasted for only three years. These factors would suggest that even the

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[1]Some adjustments may be made by repairs or alterations to the household's current unit, without moving. These entail their own difficulties and in any case are likely, for renters at least, to be confined to relatively minor items.

[2]Nonmovers' rental expenditures may change due to inflation or as a result of landlord improvements to the dwelling unit.

[3]Evidence developed by MacMillan (1978) suggests that most low-income renter households will move within a period of five years.

[4]Appendix VII explores the implications of housing disequilibrium and moving costs for mobility.

responses of movers observed during the experiment might be lower than the eventual response to a permanent program.

On the other hand, households that move may have the greatest long-run response to the rent rebate offer and hence the greatest incentive to adjust their housing. This would mean that the responses of movers would tend to overestimate the eventual response to a long-term program. Chapter 6 discusses these and other issues in the analysis, and develops evidence that they do not in fact pose serious problems in using households that moved to estimate household responses to changes in price and income.

Table 4-2 presents the elasticities estimated for the sample of households moving between enrollment and two years after enrollment. The estimated point elasticities for price are -0.21 in Pittsburgh and -0.22 in Phoenix, while for income, they are identical: 0.36 in both sites. The site similarity is striking, especially since Mayo's (1977) results for movers using first-year data showed a markedly lower price elasticity in Pittsburgh.[1] Indeed, the close similarity suggests that one demand equation can be estimated for the entire mover sample (pooled across the sites).

When a site-specific intercept is allowed, the hypothesis that price and income elasticities are the same in the two sites is not rejected.[2] (The

[1] Mayo's estimates for first-year movers of the price and income elasticities of demand based on two-year average income are (p. 82)

	Pittsburgh	Phoenix
Price elasticity	-.045	-.354
Income elasticity	.365	.348

The difference in the price elasticity estimates is largely due to the behavior of movers during the second year of the experiment (see Section 6.1). For further details, see Appendix IX.

[2] A site-specific intercept allows housing and nonhousing prices to vary between the sites. This can be seen by rewriting Equation (1) for each site separately, including the price of nonhousing goods (p_Z):

$$\text{(i)} \qquad \ln(R_{PGH}) = \beta_0 + \beta_1 \ln\left(\frac{Y}{p_Z^{PGH}}\right) + \beta_2 \ln\left(\frac{p_H^{PGH}}{p_Z^{PGH}}\right) + \ln\left(p_H^{PGH}\right) \qquad \text{(PITTSBURGH)}$$

and

$$\text{(ii)} \qquad \ln(R_{PHX}) = \beta_0 + \beta_1 \ln\left(\frac{Y}{p_Z^{PHX}}\right) + \beta_2 \ln\left(\frac{p_H^{PHX}}{p_Z^{PHX}}\right) + \ln\left(p_H^{PHX}\right). \qquad \text{(PHOENIX)}$$

(footnote continued)

Table 4-2

PRICE AND INCOME ELASTICITY ESTIMATES
FOR THE MOVERS SAMPLE

	PITTSBURGH	PHOENIX
ELASTICITIES	ELASTICITY ESTIMATE	ELASTICITY ESTIMATE
Price Elasticity		
Log-linear	-0.211** (0.063)	-0.219** (0.059)
Linear		
At mean income and price[a]	-0.222** (0.069)	-0.198** (0.061)
Mean of individual estimates	-0.227 (0.008)[c]	-0.216 (0.008)[c]
Income Elasticity[b]		
Log-linear	0.363** (0.052)	0.364** (0.042)
Linear		
At mean income and price	0.375** (0.038)	0.330** (0.029)
Mean of individual estimates	0.403 (0.011)[c]	0.380 (0.010)[c]
SAMPLE SIZE	(236)	(292)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, Appendix Tables X-13 and X-14.

NOTE: Standard error in parentheses.

a. Mean monthly household income = $416 for Pittsburgh and $430 for Phoenix. Mean price = 0.75 for Pittsburgh and 0.80 for Phoenix.

b. Three-year average income is used here as a measure of permanent income.

c. Standard error of the mean.

** t-statistic significant at the 0.01 level.

hypothesis of homogeneity of all regression coefficients in the two sites (including the intercept) was rejected.) The price elasticity estimated by this pooled log-linear regression with different site intercepts is -0.22, and the income elasticity is 0.36, both significantly different from zero at the 0.01 level (see Table 4-3).

The linear form of the expenditures equation requires that price and income elasticities increase as income rises (except for the case of unitary elasticities). As a further test for nonconstant elasticities, the sample was split in half according to average income and a log-linear expenditures equation estimated for each half. The results for the elasticities are summarized in Table 4-4. The estimates for each half are close (all households are of course relatively low-income). The price elasticities for both sites are slightly higher for the upper half of the income distribution. The income elasticities are larger for the higher income group in Phoenix

(footnote continued)

Rewriting Equation (ii) in terms of Pittsburgh prices and rearranging terms

$$\text{(iii)}\qquad \ln(R_{PHX}) = \beta_0 + \beta_1 \ln(Y) + (1+\beta_2) \ln\left(P_H^{PGH}\right) - (\beta_1+\beta_2) \ln\left(P_Z^{PGH}\right) + (1+\beta_2) \ln\left(\frac{P_H^{PHX}}{P_H^{PGH}}\right) - (\beta_1+\beta_2) \ln\left(\frac{P_Z^{PHX}}{P_Z^{PGH}}\right).$$

Subtracting (i) from (iii), the difference between the logarithm rent in Phoenix and in Pittsburgh for the same household is

$$\text{(iv)}\qquad \ln(R_{PHX}) - \ln(R_{PGH}) = (1+\beta_2) \ln\left(\frac{P_H^{PHX}}{P_H^{PGH}}\right) - (\beta_1+\beta_2) \ln\left(\frac{P_Z^{PHX}}{P_Z^{PGH}}\right).$$

This should equal the coefficient of the dummy variable included to represent Phoenix prices. The approximate ratios of housing and nonhousing prices are available from the BLS City Worker intermediate budgets for 1975 for Pittsburgh and from Inside Phoenix 1977 for Phoenix. (The latter only reports total housing budget rather than the more desirable total rental budget.) These ratios are 1.028 and 0.955 for housing and nonhousing prices, respectively, implying a site-specific intercept 0.029 higher in Phoenix. The actual estimate was 0.098 with a standard error of 0.026, a good deal larger. If the BLS data for total housing underestimate the ratio of rental prices and the true ratio is in the range 1.05 - 1.10 (as computations by Merrill, 1977, p. 114, suggest), then the implied coefficient would be between 0.045 and 0.082, closer to the estimated coefficient.

Table 4-3

PRICE AND INCOME ELASTICITY ESTIMATES
FOR THE MOVERS SAMPLE
(Pooled Sites)

	ELASTICITY ESTIMATE
Price elasticity (log-linear)	-0.216** (0.043)
95 percent confidence interval	[-0.301, -0.131]
Income elasticity[a] (log-linear)	0.364** (0.033)
95 percent confidence interval	[0.299, 0.429]
SAMPLE SIZE	(528)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligiblity limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, Appendix Table X-16.

NOTE: Standard error in parentheses.

a. Three-year average income is used here as a measure of permanent income.

** t-statistic significant at the 0.01 level.

Table 4-4

DEMAND ELASTICITIES USING SAMPLES STRATIFIED BY MEDIAN MONTHLY INCOME

ELASTICITIES	PITTSBURGH		PHOENIX	
	LOWER HALF OF INCOME DISTRIBUTION	UPPER HALF OF INCOME DISTRIBUTION	LOWER HALF OF INCOME DISTRIBUTION	UPPER HALF OF INCOME DISTRIBUTION
Price elasticity	-0.167* (0.082)	-0.268** (0.010)	-0.218** (0.081)	-0.222** (0.087)
Income elasticity	0.439** (0.121)	0.427** (0.123)	0.357** (0.096)	0.415** (0.129)
SAMPLE SIZE	(118)	(118)	(136)	(156)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, and Appendix Table X-17.

NOTES: Standard errors in parentheses. Median income was $378 per month in Pittsburgh and $415 per month in Phoenix.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

and smaller in Pittsburgh. None of the differences is larger than the error of estimate. A log-linear spline function that allowed the estimated income coefficient to differ for each half of the income distribution was also estimated.[1] The results showed no significant difference in elasticities at different income levels, at least within the income range of experimental households (see Table 4-5). Further investigation of a sample showing wider income variability would be useful.

Unconstrained Households

Payments to households in the Unconstrained plan were designed to equal the difference between the estimated cost of modest, existing standard housing for their household size, and 25 percent of their income.[2] Recipients were free to spend the payments, which were unrelated to their actual housing, as they wished. Thus, the payment's effect on housing expenditures provides direct evidence on the way an unconstrained income transfer payment is likely to be allocated to housing. Because of the direct functional relationship between household income and the unconstrained allowance payment, a housing expenditure function should not be used to estimate directly the expenditure elasticity of an income transfer payment.[3]

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[1] A spline function permits the estimated elasticity to vary smoothly from one regression regime to another without a discontinuity. The spline function estimated was

$$\ln(R) = \beta_0 + \beta_1 \ln(Y) + \beta_1^1 D[\ln(Y) - \ln(\hat{Y})] + \beta_z \ln(1 - a)$$

$$\text{where } D = \begin{cases} 0 \text{ if } Y \leq \hat{Y}, \\ 1 \text{ if } Y > Y, \text{ and} \end{cases}$$

$$\hat{Y} = \text{median income.}$$

Fur a further explanation of spline functions, see Suits, et al (1978).

[2] The payment formula was

$$S = C^* - 0.25Y$$

where

S = monthly payment

C^* = estimated cost of modest, existing standard housing, varied by household size, and

Y = monthly household income.

[3] For example, in the linear expenditure function $R = \alpha + \beta Y + \gamma S$, S and Y are definitionally related through the payment formula.

Table 4-5

INCOME ELASTICITIES USING SPLINE FUNCTION

HOUSEHOLD GROUP	PITTSBURGH INCOME ELASTICITY	PHOENIX INCOME ELASTICITY
Lower half of income distribution	0.375** (0.103)	0.342** (0.077)
Upper half of income distribution[a]	0.351* (0.158)	0.395* (0.145)
SAMPLE SIZE	(236)	(292)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, and Appendix Table X-18.

NOTES: Standard errors in parentheses. Median income was $378 per month in Pittsburgh and $415 per month in Phoenix.

a. The difference in elasticity is not significant.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

Several tests were carried out to see whether the Unconstrained households treated the payment as income and, if so, whether their response to income changes was the same as the income response estimated for Percent of Rent and Control households. First, rent for Unconstrained movers at two years was predicted using the log-linear demand equations estimated for Percent of Rent and Control movers treating the allowance payment as income--the fit was as good or better than for Percent of Rent and Control households.[1] Next, two log-linear demand equations were estimated for Unconstrained and Control movers, first to test whether a dummy variable for Unconstrained households indicated a further experimental effect when the allowance payment is included in the income variable, and second, to test whether the income elasticity differed between Unconstrained and Control movers. The results are presented in Table 4-6. The estimated income elasticities (using average income) are 0.29 in Pittsburgh and 0.34 in Phoenix, not significantly different from the estimates obtained for Percent of Rent and Control movers. Furthermore, the separate variables allowing for differences in the level and income elasticity of housing expenditures between Unconstrained and Control households were not significant. This suggests that the responses of Unconstrained households are adequately characterized in terms of additions to income that are treated like any other income.

Finally, a model used by Hymans and Shapiro (1974) to investigate the elasticity of food expenditures with respect to transfer income, was estimated. In that model, the composition of income is assumed to affect the elasticity. The expenditure equation, adapted to the present case, is

$$(11) \qquad \ln(R) = \alpha_0 + \alpha_1 \ln(Y+S)$$

where Y is average income, and S is the allowance payment, and

$$(12) \qquad \alpha_1 = \eta_1 + \eta_2\left(\frac{S}{Y+S}\right),$$

where η_1 is the elasticity with respect to average income, and η_2 measures the extent to which the income elasticity changes with changes in the composition of income.

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[1]For Unconstrained movers, the R^2 equaled 0.22 in Pittsburgh and 0.41 in Phoenix compared to 0.18 and 0.23, respectively, for the combined Percent of Rent and Control household sample.

Table 4-6

ESTIMATES OF A LOG-LINEAR DEMAND EQUATION
WITH UNCONSTRAINED HOUSEHOLDS

INDEPENDENT VARIABLE	PITTSBURGH DUMMY VARIABLE MODEL	PITTSBURGH INTERACTION MODEL	PHOENIX DUMMY VARIABLE MODEL	PHOENIX INTERACTION MODEL
Constant	3.172** (0.475)	3.176** (0.474)	2.960** (0.407)	2.961** (0.408)
ln(income[a] + payment)	0.292** (0.078)	0.292** (0.078)	0.340** (0.067)	0.340** (0.067)
Unconstrained household	0.029 (0.067)	--	0.067 (0.074)	--
Unconstrained household x ln(income + payment)	--	0.005 (0.011)	--	0.010 (0.012)
Adjusted R^2	0.110	0.110	0.169	0.168
Sample Size	(116)	(116)	(144)	(144)

SAMPLE: Unconstrained and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Standard error in parentheses.

a. Income measured as average income.

** t-statistic significant at the 0.01 level.

If households respond to the allowance payment as they would to income, η_2 should equal zero. When estimated, the null hypothesis, $H_0:\eta_2 = 0$, could not be rejected in either site, confirming the earlier finding that households respond to the payment as they would to income from other sources.[1] The estimates of the income elasticity were 0.28 in Pittsburgh and 0.35 in Phoenix, once again not significantly different from the estimates for Percent of Rent and Control movers.

In sum, it appears that low-income households do respond to both rent rebates and income subsidies by increasing their housing expenditures. In response to a 10 percent decrease in prices, these households, when they move, will increase their expenditures on average by approximately 2.2 percent. In response to a 10 percent increase in income, these households, when they move, will increase their expenditures on average by approximately 3.6 percent.

4.3 DEMOGRAPHIC VARIABLES AFFECTING DEMAND FOR HOUSING

The preceding two sections discussed price and income elasticities based on housing expenditure functions that included only price and income as independent variables. Other variables may also affect housing demand, since different demographic groups may have different relative preferences for housing versus other goods and services. Furthermore, policy interest is often focused on certain demographic groups, in particular, minority or elderly households.

The data collected during the Demand Experiment enable detailed characterization of each household in terms of demographic attributes. A combination of statistical tests, consideration of sample sizes, and judgment was used to reduce the relevant demographic characteristics to two statistically significant and policy-relevant variables: minority status and household composition.[2] Minority status indicates whether the head of the household

[1] The estimates of η_1 and η_2 using Unconstrained and Control movers were:

	Pittsburgh	Phoenix
η_1	0.285	0.352
	(0.082)	(0.066)
η_2	-0.007	0.062
	(0.073)	(0.051)

[2] Age, sex, and educational attainment of the head of household, as well as household size (without composition) were also tested. These had no significant effect on the estimated parameters of the demand function or on the overall fit when included as covariates in the same equation as minority status and household composition.

is a member of a minority group (black in Pittsburgh, black or Spanish American in Phoenix). Household composition indicates whether the household consists only of a single person (restricted by program rules almost exclusively to elderly persons); is a single head of household (with children or other family members present); is a couple (with or without children).[1] These three types of household are denoted single-person, single-headed with others present, and couple, respectively.

Two alternative methods for determining the importance of demographic characteristics in the housing demand functions were used: (1) the characteristics were included as variables (covariates) in the expenditure function, thus permitting the intercept to vary, or (2) the sample was stratified to permit the elasticities to vary as well. The results of this investigation are discussed below for the sample of movers.[2] Because the results for the log-linear and the linear equations are very similar, only the former are discussed. In addition, the income measure used, as in Section 4.2, is average income.

Despite the nearly identical estimates obtained for movers in each site in Section 4.2, the discussion starts with separate analysis for each site. This is done partly for comparability with the analysis of Chapter 5 and partly because it seemed plausible that demographic differences in response may exist between the sites. In fact, different patterns of demographic effects do emerge in the two sites. In the end, however, it appears that, from a statistical viewpoint, the sites can still be pooled. The only consistently important demographic difference in income and price elasticities is between minorities and nonminorities.

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[1] Since there is a particular policy interest in elderly households, variance ratio tests were carried out to examine whether the elderly and nonelderly single-person households comprise a homogeneous group, that is, whether their housing demand functions are the same. This hypothesis could not be rejected, mainly because there were so few nonelderly single-person households in the sample. There were too few elderly couples to analyze separately. Secondly, since in Phoenix the minority group consists of both black and Spanish American households, variance ratio tests were used to test whether there is a difference in behavior between these two minority groups. Again, the hypothesis of homogeneity could not be rejected, probably because the sample of black households in Phoenix is small. Accordingly, all single-person and all minority households are examined, rather than separating the groups.

[2] Section 4.2 discussed the reason for choosing this sample as being more suitable for the estimation of demand functions. The results for the overall sample are nevertheless presented and discussed in Appendix VIII.

Demographic Variables as Covariates

Under this approach, demographic variables were included as dummy variables in the demand equation. As a consequence, only the intercepts can differ among groups. The variables included were those indicating minority status and household composition. Models that included just a minority variable, just household composition variables, and combinations of the two were estimated; these are presented in Appendix Table X-19.[1]

Different demographic variables are important at the two sites. In Pittsburgh, no demographic covariate has an effect on the housing expenditures of movers. The household composition variables increase the adjusted value of R^2 slightly (this model is presented in Table 4-7), but once these variables are included in the specification, there is no further gain by adding the minority status variables.

In Phoenix, the household composition variables are not significant by themselves but minority status is. Interaction between the two variables is indicated; the complete interaction model has the highest adjusted R^2. This model (also presented in Table 4-7) indicates that there is not much difference among nonminority mover households in Phoenix by household composition and that (with the possible exception of minority single-person households) minority households spend less on housing.

Complete Stratification

The covariate analysis showed that the demographic groups should have separate intercepts. The specification discussed in the covariate analysis implicitly assumes that all the groups have the same price and income elasticities. Stratification allows these to vary among groups. Each equation was estimated for nonminority and minority households, for single-person households, households headed by a couple, and for households headed by a single person with others present. In addition, each equation was estimated for the subsamples created by combining the minority and the household composition criteria. These equations (presented in Appendix Table X-19) were used to test whether elasticities differed among the groups.

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[1]The excluded classes (represented by the constant term) are nonminorities for regressions with a minority variable, couples (with and without children) for regressions with household composition variables, and nonminority couples (with and without children) for regressions with combined minority/household composition variables.

Table 4-7

LOG-LINEAR DEMAND FUNCTIONS USING DEMOGRAPHIC VARIABLES AS COVARIATES FOR THE MOVER SAMPLE

INDEPENDENT VARIABLE	PITTSBURGH	PHOENIX
Constant	2.540** (0.401)	2.915** (0.299)
Income elasticity	0.391** (0.064)	0.365** (0.048)
Price elasticity	-0.219** (0.064)	-0.226** (0.58)
Single-person households	0.031 (0.067)	--
Single head of household with others present	0.075† (0.043)	--
Nonminority single-person households	--	-0.080 (0.071)
Nonminority single head of household with others present	--	-0.064 (0.049)
Minority single-person households	--	-0.065 (0.139)
Minority single head of household with others present	--	-0.105† (0.058)
Minority households headed by a couple	--	-0.289** (0.054)
Adjusted R^2	0.188	0.285
Sample Size	(234)	(285)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, Appendix Table X-19.

NOTE: Standard error in parentheses.

† t-statistic significant at the 0.10 level.

** t-statistic significant at the 0.01 level.

Analysis of minority status. In Pittsburgh, minority (black) and nonminority households have approximately the same equilibrium demand for housing. This is indicated by an insignificant coefficient on the minority dummy variable,[1] as well as by an insignificant variance-ratio test statistic on the difference in elasticities (see Table 4-8). Moreover, minority and nonminority households spent approximately the same amount on rent at enrollment (see Appendix Table X-20).

In Phoenix, where minority households are predominately Spanish American, minority and nonminority households appear to have different equilibrium demand functions. A variance-ratio test for homogeneity of the estimated elasticities, given different intercepts for minority and nonminority households, rejects that hypothesis. Minority households in Phoenix have much lower price and income elasticities than do nonminority households (see Table 4-8).[2] Further, minority households there start out in less expensive housing. The lower elasticities found for minority households in Phoenix appear to reflect lower elasticities for Spanish American households in partiuclar, but sample sizes are too small to allow conclusive results. While the estimated elasticities for Spanish American households are lower than for any other group and are not significantly different from zero, the errors of estimate are too large for a conclusive finding of difference. The estimates for Spanish American households are also not significantly different from the overall estimates (which are significantly different from zero).[3]

Analysis of household composition. In Pittsburgh, the equation with household composition dummy variables (Appendix Table X-19) indicated that intercepts may vary among the three household types. Table 4-9 presents the results of stratifying the sample by household type. A variance ratio test of homogeneity of the elasticities, given different intercepts, rejects the homogeneity hypo-

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[1]See Appendix Table X-19.

[2]Note in particular that the overall estimated income elasticity in Phoenix (0.37) does not fall in the 95 percent confidence interval of the minority estimate in that site (0.18).

[3]Mayo (1977) found that minority households were at least as responsive as nonminority households, and perhaps more responsive. His results depend on the particular model used in that report--a partial adjustment model for all households. Since MacMillan (1978) found a significant racial effect on mobility, it is likely that Mayo's results to some extent reflect differences in mobility.

Table 4-8

EXPENDITURE ELASTICITIES BY MINORITY STATUS

HOUSEHOLD GROUP	PITTSBURGH PRICE ELASTICITY	PITTSBURGH INCOME ELASTICITY	PITTSBURGH SAMPLE SIZE	PHOENIX PRICE ELASTICITY	PHOENIX INCOME ELASTICITY	PHOENIX SAMPLE SIZE
All households	-0.213** (0.064)	0.359** (0.053)	(234)	-0.219** (0.060)	0.370** (0.043)	(285)
Nonminority households	-0.210** (0.069)	0.386** (0.057)	(196)	-0.287** (0.068)	0.431** (0.047)	(185)
Minority households[a]	-0.204 (0.179)	0.212 (0.148)	(38)	-0.179† (0.105)	0.177* (0.083)	(100)
Black households	---[b]	---[b]		-0.255 (0.217)	0.224 (0.168)	(28)
Spanish American households[c]	---	---		-0.137 (0.122)	0.133 (0.101)	(72)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, and Appendix Table X-21.

NOTE: Standard error in parentheses.

a. A variance-ratio test could not reject the hypothesis of homogeneity between nonminority and minority households in Pittsburgh (F(2,227) = 0.50) but could in Phoenix (F(2,279) = 4.42), (critical value = 3.00 at the 0.05 level).

b. Minority households in Pittsburgh are all black.

c. A variance-ratio test could not reject the hypothesis of homogeneity between Spanish American and black households in Phoenix (F (2,94) = 0.49), critical value = 3.11 at the 0.05 level).

† t-statistic significant at the 0.10 level.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

Table 4-9

EXPENDITURE ELASTICITIES BY HOUSEHOLD COMPOSITION

HOUSEHOLD GROUP	PITTSBURGH			PHOENIX		
	PRICE ELASTICITY	INCOME ELASTICITY	SAMPLE SIZE	PRICE ELASTICITY	INCOME ELASTICITY	SAMPLE SIZE
All households	-0.213** (0.064)	0.359** (0.053)	(234)	-0.219** (0.060)	0.370** (0.043)	(285)
Single-person households	-0.077 (0.189)	0.274 (0.184)	(33)	-0.245† (0.138)	0.480** (0.080)	(32)
Single-headed households with others present	-0.156† (0.092)	0.165 (0.102)	(98)	-0.128 (0.087)	0.342** (0.072)	(121)
Households headed by a couple	-0.364** (0.096)	0.613** (0.090)	(103)	-0.327** (0.100)	0.383** (0.083)	(132)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, and Appendix Table X-21.

NOTES: Standard error in parentheses. A variance-ratio test could reject the hypothesis of homogeneity among household types in Pittsburgh ($F(4,225) = 3.20$) but could not in Phoenix ($F(4,277) = 1.62$), (critical value = 2.37 at the 0.05 level).

† t-statistic significant at the 0.10 level.

** t-statistic significant at the 0.01 level.

thesis. Examination of the estimates (presented in Table 4-9) shows large apparent differences among elasticities by family type. Households headed by a couple have the largest elasticities with respect to income (0.61)[1] and with respect to price (-0.36) (see Table 4-9). The other two groups have lower elasticities. However, the estimated coefficients have large standard errors, and the equations have low R^2 (see Appendix Table X-21).[2] Pairwise comparisons of the elasticities among the three demographic groups showed only one significant difference (between the income elasticities for single-headed households and couples in Pittsburgh).

In contrast, though, in Phoenix, the hypothesis of homogeneity of the demand elasticities by household type cannot be rejected once the different intercepts noted earlier are taken into account.

Pooling the sites was reasonable for the complete mover sample (see Section 4.2). Although the individual examination of the two sites above identified somewhat different demographic patterns in each site, variance ratio tests cannot reject the hypotheses that the two sites can be pooled when stratified by either race or by household composition (allowing for site-specific intercepts). Table 4-10 presents these estimated elasticities. Further, once the sites are pooled, homogeneity across demographic groups is rejected for race/ethnicity, but not for household types (despite the wide variation in coefficients among the different groups).

In conclusion, the statistical evidence indicates that due to the fairly large variances of some of the elasticity estimates, the two sites can still be pooled when estimates are obtained stratified by demographic groups. It appears that minorities have smaller responses to price and income than nonminorities. This effect is especially marked in Phoenix. In addition, while there is evidence of differences in elasticities across household types in Pittsburgh, these are not statistically significant for the pooled-site estimates or for Phoenix alone.

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[1] The overall estimated income elasticity in Pittsburgh (0.36) does not fall in the 95 percent confidence interval of the couple estimate in that site (0.61).

[2] A further test of homogeneity with respect to household composition is possible within the nonminority subsample. (Such a test is not meaningful for the minority subsample because of small sample sizes.) As with the overall sample of movers, the hypothesis of homogeneity of the elasticities for nonminority households in Pittsburgh among household types can be rejected. (The test statistic is $F(4,187) = 3.44$, with a critical value of 2.37 at the 0.05 level.)

Table 4-10

PRICE AND INCOME ELASTICITY ESTIMATES
FOR POOLED SITES BY DEMOGRAPHIC CHARACTERISTICS

HOUSEHOLD GROUP	PRICE ELASTICITY	INCOME ELASTICITY	VARIANCE-RATIO F-STATISTIC[a]	SAMPLE SIZE
All movers	-0.217** (0.044)	0.366** (0.033)	0.017	(519)
White households	-0.249** (0.048)	0.413** (0.036)	0.437	(381)
Minority households	-0.183* (0.089)	0.184** (0.071)	0.023	(138)
Single-person households	-0.175 (0.116)	0.426** (0.083)	0.723	(65)
Single head of household with others	-0.137* (0.063)	0.294** (0.058)	0.999	(219)
Households headed by a couple	-0.327** (0.070)	0.468** (0.061)	1.665	(235)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, Appendix Table X-22.

NOTE: Standard error in parentheses. Variance-ratio tests indicate that once pooling across sites is performed, pooling across household types is possible ($F(6,507) = 1.90$, critical value = 2.10 at the 0.05 level) but pooling across races is not ($F(3,511) = 9.17$, critical value = 2.60 at the 0.05 level).

a. Testing site homogeneity allowing site-specific intercepts.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

REFERENCES

Hastings, N.A.J. and J.B. Peacock, Statistical Distributions, New York, John Wiley and Sons, 1975, pp. 42-43.

Hymans, Saul and Harold Shapiro, "The Allocation of Household Income for Food Consumption," in James N. Morgan (ed.) Five Thousand American Families--Patterns of Economic Progress, Vol. II, Ann Arbor, University of Michigan Survey Research Center, 1974.

Kmenta, Jan, Elements of Econometrics, New York, The MacMillan Company, 1971.

MacMillan, Jean, Mobility in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., June 1978 (revised June 1980).

Mayo, Stephen K., Housing Allowance Demand Experiment: Housing Expenditures and Quality Part 1: Housing Expenditures Under a Percent of Rent Housing Allowance, Cambridge, Mass., Abt Associates Inc., 1977.

Merrill, Sally R., Hedonic Indices as a Measure of Housing Quality, Cambridge, Mass., Abt Associates Inc., December 1977 (revised June 1980).

Muth, Richard F., "Moving Costs and Housing Expenditure," Journal of Urban Economics, vol. 1, 1974, pp. 108-125.

Polinsky, A. Mitchell, "The Demand for Housing: A Study in Specification and Grouping," Econometrica, vol. 45, no. 2, March 1977, pp. 447-461.

Suits, Daniel B., Andrew Mason, and Louis Chan, "Spline Functions Fitted by Standard Regression Methods," Review of Economics and Statistics, vol. 60, no. 1, February 1978, pp. 132-139.

U.S. Bureau of the Census and U.S. Department of Housing and Urban Development, Annual Housing Survey 1975, Part C, Washington, D.C., U.S. Government Printing Office, 1977.

CHAPTER 5

THE DEMAND FOR HOUSING SERVICES

Chapter 4 demonstrated that households responded to the Percent of Rent rent rebates by increasing their housing expenditures. However, increased expenditures may not always lead to real changes in housing. If allowance recipients are unable to act effectively in the private market or if they shop less carefully, then they might end up spending more for the same housing than they otherwise would. There is no reason to expect differences in effectiveness between Percent of Rent and Control households. The rent rebate may, however, affect shopping behavior.[1]

A person looking for a rental housing unit in a particular neighborhood is likely to find that similar units rent for varying amounts of money. In other words, different households end up paying different amounts of rent for the same level of housing services. This situation may be expressed mathematically as:

$$R = p_H H + \varepsilon \qquad (1)$$

where R = rent

p_H = the average price of housing services

H = amount of housing services, and

ε = a stochastic term, with zero mean and variance σ_ε^2.

A unit with $\varepsilon<0$ will normally be considered a "good deal" or a "bargain," while a unit with $\varepsilon>0$ will normally be considered a "bad deal." Competitive market forces will tend to reduce the variance of ε, but will probably not reduce the variance to zero.

In this context, shopping for rental housing may be viewed as looking for units with negative ε (bargains). However, Percent of Rent households were already paying less out-of-pocket than market rent since their net rent payments were reduced by 20 to 60 percent, depending on the rent rebate plan

[1]General inflation also implies higher dollar expenditures without any change in the housing services provided by a dwelling unit. Since inflationary changes apply to all households, the impact on expenditures estimated in Chapter 4 accounted for inflation by including Control households in the sample, so that this posed no problem there.

they were enrolled in. For a household with a 50 percent rebate, for example, finding a unit that rents for $10 more or less than another only makes a difference of $5 in the out-of-pocket cost to the household. Thus, Percent of Rent households might be expected to have shopped for new housing less vigorously than Control households. This can be tested by estimating the effects of the rent rebates on housing services and comparing these effects with the effects already estimated for housing expenditures.

In contrast to expenditures, housing services are not easy to measure. Housing services are, at least in part, subjective. Two kinds of housing quality measures are used in this chapter--normative measures and hedonic indices. The normative measures used involve physical housing standards developed for the Demand Experiment. These standards were based on the American Public Health Association/Public Health Service model housing code and are similar in type to standards used in existing housing programs such as Section 8. Hedonic indices, on the other hand, do not attempt to rate units in the sense of determining their adequacy. Rather they provide estimates of the average market rent of a unit in terms of its physical characteristics and location. Comparison of the hedonic value of a unit with the actual rent charged can be used to sort out the extent to which households are paying above average rents and thus provide estimates of the real change in participant housing.

Section 5.1 discusses these measures and examines the tabular evidence of household response to the Percent of Rent rebates as measured by the change in proportion of households meeting housing standards and the percentage change in the hedonic index of housing services. Section 5.2 then uses the demand theory developed in Chapters 3 and 4 to estimate a demand function for housing services. Differences in household response between expenditures and quality (as measured by the hedonic index) emerge and several alternate explanations for the divergence are tested. Section 5.3 concludes the chapter with a brief summary of findings.

5.1 HOUSING QUALITY CHANGES

There is no generally agreed-upon way of measuring housing quality. Measures range from the simple Census measure of substandardness to more complex measures of dilapidation and deterioration.[1] These measures strive to achieve an objec-

[1] See Budding (1978) for a detailed discussion of various extant housing quality measures.

tive measure that policy-makers can agree measures the presence or absence of adequate housing. As such, they become normative measures. The normative measures used here to measure housing quality include two physical standards --"low" housing standards and "program" housing standards--and one occupancy standard based on the Minimum Standards requirements and for certain parts of the Demand Experiment, as well as two physical standards based on analysis of housing adequacy by Budding (1978).[1] Percent of Rent households were not required to meet these standards and were probably not aware of their existence. Moreover, the standards may not be consistent with what the households themselves might consider "better quality," because the standards include only a limited number of dwelling unit components and did not include any neighborhood component. Therefore, the Percent of Rent rebates may have enabled recipient households to improve their housing in ways that are not measured by these normative standards (particularly if these included various quality or neighborhood components not included in the standard).

The hedonic index offers a different method for estimating the impact of Percent of Rent rebates on housing services. The hedonic index, developed for the Demand Experiment sites by Merrill (1977), gives a dollar value for the amount of housing services provided by a unit. The measure can be interpreted as the expected or average market rent of units with given location, size, and other physical characteristics. In terms of Equation (1), the hedonic index gives the expected rent of a unit if it is neither a good nor a bad deal ($\varepsilon=0$).[2]

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[1] The physical quality of the units was evaluated at least annually coincident with enrollment and the Second and Third Periodic Interviews. The housing evaluations measured numerous quality items including such items as surface and structure characteristics, light and ventilation, etc.

"Program" standards reflect the physical housing requirements that households in another part of the experiment--the Housing Gap Minimum Standards plans--had to meet in order to receive payments (see Appendix I for a description of the Housing Gap plan). The occupancy standard is defined as no more than two people per "adequate" bedroom, with "adequate" defined in accordance with the physical standards. The "low" housing standards were less stringent than those applied for "program" eligibility for Housing Gap Minimum Standards households. A more detailed description of the "low" and the "program" housing standards is found in Appendix III. The measure of overall adequacy developed by Budding (1978) is described further below.

[2] For a detailed discussion of the use of hedonic indices to measure housing quality, see Merrill (1977) and Kennedy and Merrill (1979).

The hedonic index takes into account a wide variety of physical and locational characteristics, which account for from two-thirds to four-fifths of the observed variation in rents. Furthermore, as discussed in Section 5.2 below and in Merrill (1977) and Merrill and Kennedy (forthcoming), tests of its validity support the contention that it measures housing services with a high degree of accuracy. Nevertheless, it would be unreasonable to claim that the hedonic index captures all of the variation in housing services across units. As a consequence, changes in hedonic indices of housing will generally be smaller than changes in expenditures. Given the supporting evidence on the accuracy of the measure, the differences should not be large, however.

In addition, it is possible to test whether differences between changes in hedonic indices and associated changes in expenditures due to the Percent of Rent offers follow the normal pattern of rent-hedonic index differences. If they do, then it can be concluded that the expenditure changes induced by the Percent of Rent offers led to concommitant real changes in housing services. If they do not (if, for example, the changes in hedonic indices for Percent of Rent households are much smaller than those that would normally accompany the expenditure changes for these households), then it would appear that Percent of Rent households did not obtain the real improvements in their housing that would normally have accompanied their increased expenditures.

Tabulations of the normative standards for Percent of Rent and Control households are presented in Table 5-1. There seems to be no clear evidence that the Percent of Rent program either encouraged or made it possible for households to improve their dwelling units above the level existing at enrollment as measured by the normative standards. Moreover, there is no evidence that differences in the percentage rebate were associated with the incidence of units passing the standards.[1] Nor, when moving and nonmoving households were analyzed separately, did movers increase their housing quality as measured by these three measures significantly more than did nonmovers.[2,3]

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[1]See Appendix Table X-23 through X-25.

[2]See Appendix Tables X-26 through X-31.

[3]As noted earlier, Percent of Rent households may have obtained improvements in their housing not reflected in the normative standards. While more expensive units do tend to meet the Minimum Standards housing requirements more often, the relationship is not strong. Thus it seems quite reasonable that changes in specific dwelling unit attributes to meet a normative standard cannot be induced without explicitly requiring them of households (see Merrill et al., 1975, pp. 161ff).

Table 5-1

CHANGES IN DWELLING UNIT
PHYSICAL AND OCCUPANCY STANDARDS

	PERCENT PASSING ENROLLMENT	PERCENT PASSING TWO YEARS	CHANGE	SAMPLE SIZE
		PITTSBURGH		
<u>Low Standard</u>				
Percent of Rent households	81%	84%	+3	(391)
Control households	81	80	-1	(299)
<u>Program Standard</u>				
Percent of Rent households	37	34	-3	(391)
Control households	33	29	-4	(299)
<u>Occupancy Standard</u>				
Percent of Rent households	49	47	-2	(390)
Control households	46	41	-5	(299)
		PHOENIX		
<u>Low Standard</u>				
Percent of Rent households	72%	75%	+3	(279)
Control households	66	74	+8	(258)
<u>Program Standard</u>				
Percent of Rent households	33	41	+8	(279)
Control households	28	36	+8	(258)
<u>Occupancy Standard</u>				
Percent of Rent households	43	55	+12	(279)
Control households	38	53	+15	(258)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Form and Housing Evaluation Forms.

NOTE: See Appendix III for a full description of the measures used here.

Budding (1978) created a measure of housing adequacy, derived from the individual housing evaluations performed for each dwelling unit. This measure classifies units into one of three categories:

> If there was clear evidence that a dwelling unit contained one or more serious housing deficiencies, the unit is classified as clearly inadequate.
>
> If the unit passed every one of the indicators intended to measure serious housing deficiencies and received an overall evaluator rating consistent with such a classification, the unit is classified as at least minimally adequate.
>
> Otherwise, the unit is classified as ambiguous.

The measure will tend to understate to some unknown degree both the number of persons in clearly inadequate housing and the number of persons in at least minimally adequate housing.[1] This measure is closely related to the Minimum Standards measure in that the adequacy measure includes all but one (bathroom window adequacy) of the Minimum Standards indicators and only two additional indicators (presence of rate and window condition). The key difference is the presence of the ambiguous category which allows a finer distinction to be made between adequate and inadequate housing than that permitted by the Minimum Standards measure.

The use of this measure does not, however, change the basic conclusions reached with the other measures. Table 5-2 indicates that Percent of Rent households did not obtain more adequate housing than did Control households, measured as change in either percentage of households in minimally adequate units or the percentage of households in clearly inadequate units.[2,3] These results do not change when households are stratified by mobility status, with the exception

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[1]The category "clearly inadequate" encompasses a range of housing, including both dwelling units that are completely dilapidated with multiple deficiencies and units with a single major defect. The category "at least minimally adequate" is subject to the limitations of the data base, and it seems likely that of these some of these units have serious housing problems that went unmeasured in the Demand Experiment. Finally, the ambiguous category undoubtedly contains both units that are properly classified as clearly inadequate and units that are properly considered at least minimally adequate. The ambiguous category exists because there was not sufficient information to make either classification.

[2]Appendix Table X-32 presents these results for each percentage rebate level.

[3]Changes from minimally adequate to ambiguous approximately balance those in the reverse direction.

Table 5-2

CHANGES IN HOUSING ADEQUACY
FROM ENROLLMENT TO TWO YEARS FOR
CONTROL AND PERCENT OF RENT HOUSEHOLDS

TREATMENT GROUP	PERCENTAGE IN MINIMALLY ADEQUATE HOUSING			PERCENTAGE IN CLEARLY INADEQUATE HOUSING			SAMPLE SIZE
	At Enrollment	At Two Years	Change[a]	At Enrollment	At Two Years	Change[a]	
PITTSBURGH							
Percent of Rent households	31%	28%	-3	41%	35%	-6	(391)
Control households	29	25	-4	38	35	-3	(301)
PHOENIX							
Percent of Rent households	36	39	+3	44	39	-5	(284)
Control households	35	37	+2	45	41	-4	(256)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluations Forms.

a. Percentage points.

of Percent of Rent movers in Pittsburgh, which show a larger increase in percentage minimally adequate than do Control movers but only a slightly larger decrease in percentage clearly inadequate (see Appendix Tables X-33 and X-34).[1]

Changes in the mean value of the hedonic index for Percent of Rent and Control households are presented in Table 5-3. While the index increased for Percent of Rent households at both sites, neither the overall level of change for nor the difference in change between Percent of Rent and Control households is as large as for expenditures.[2]

At least three factors contribute to the lower overall change in the index between enrollment and two years after enrollment. First, since households with long tenure in a unit receive a rent discount (see Merrill, 1977), movers must by necessity increase expenditures more than the increase in housing services obtained merely to overcome the loss of the discount.[3] Second, rent changes include an adjustment for increased utility costs over the two-year period, while the hedonic index does not. This latter factor accounts for approximately 2 to 4 percentage points of the difference between changes in expenditures and changes in housing service.[4] Finally, rent changes include inflationary adjustments whereas the hedonic index does not.

However, none of these factors explain why the net change in the index for Percent of Rent households in comparison to Control households was smaller than for expenditures. The quality of housing, as evaluated by the hedonic indices, rose in Pittsburgh by an average of 9 percent for the Percent of Rent households, and 6 percent for the Control households. In Phoenix, the average increase was 16 percent for the Percent of Rent and 17 for the Control households (see Table 5-3). There thus appears to be only a small net experimental effect in Pittsburgh and no net effect at all in Phoenix.

Figure 5-1 illustrates that, as might be expected, movers at both sites increased the hedonic values of their residences much more than did nonmover

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[1] Nonmovers tend to show a decrease in housing adequacy.

[2] Sample sizes for hedonic index computations compared to earlier chapters are typically smaller due to the increased data requirements. Appendix Table X-35 presents the changes for each rebate level.

[3] That is, a household moving into a unit generally pays more than the previous tenants would have had to pay merely because they are "new" tenants.

[4] Adjustments vary according to the unit size and the utilities purchased.

Table 5-3

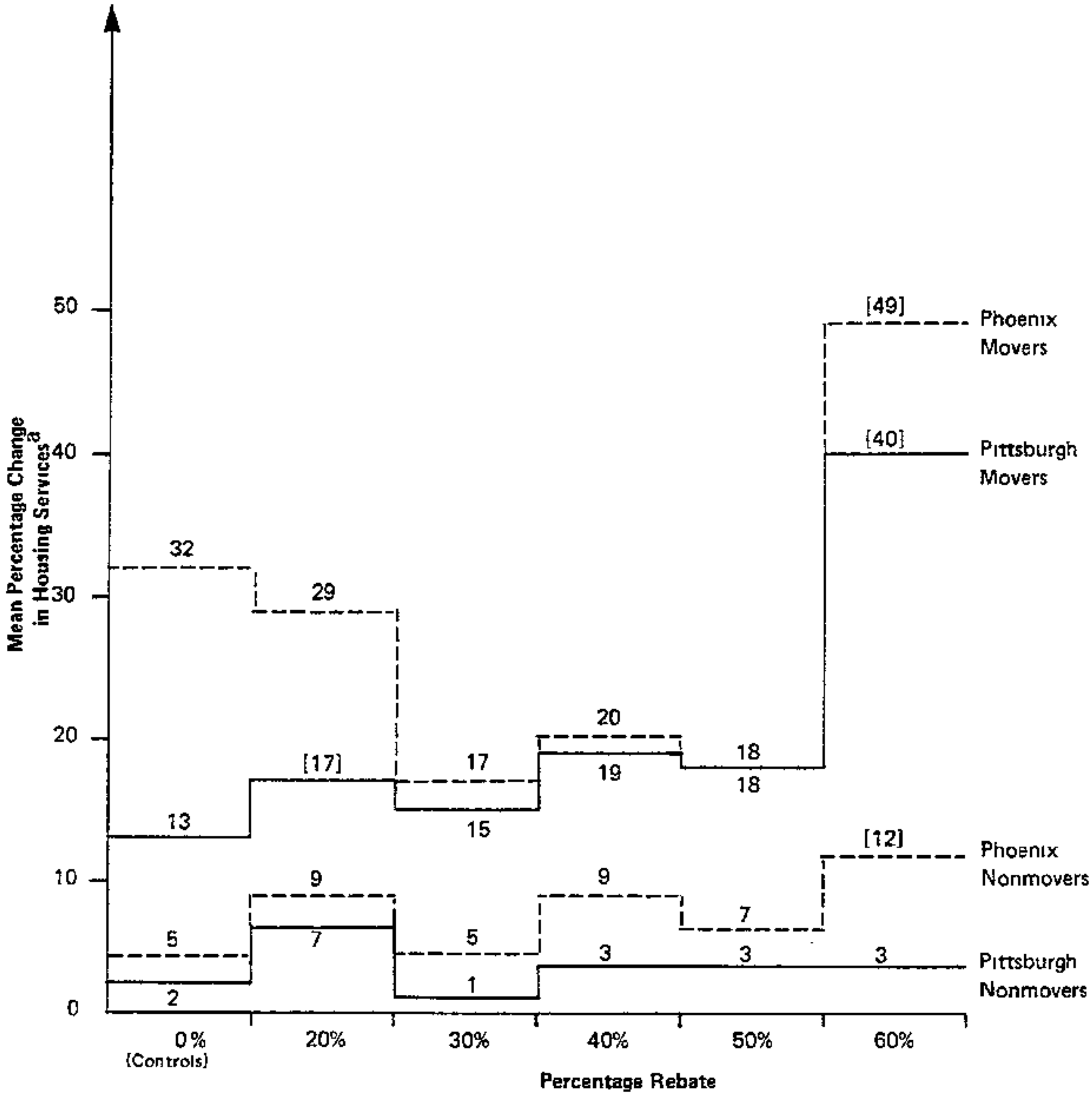
CHANGES IN HEDONIC HOUSING QUALITY

TREATMENT GROUP	MEAN HEDONIC INDEX		MEAN CHANGE		SAMPLE SIZE
	At Enrollment	At Two Years	Amount	Percentage	
			PITTSBURGH		
Percent of Rent households	$114	$121	$ 7	9%	(353)
Control households	114	120	5	6	(273)
			PHOENIX		
Percent of Rent households	132	149	17	16	(241)
Control households	128	144	16	17	(231)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Periodic Interviews.

Figure 5–1
MEAN PERCENTAGE CHANGE IN HOUSING SERVICES BETWEEN ENROLLMENT AND TWO YEARS AFTER ENROLLMENT



SAMPLE. Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing

DATA SOURCES Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Periodic Interviews.

NOTE. Brackets indicate entries based on 15 or fewer observations.

[a]Percentage change in housing services is defined as the mean of the ratio of the change in housing services to housing services at enrollment.

households.[1] There is still, hwoever, no clear difference in the increase for Percent of Rent households as compared to Control households. In Pittsburgh, Percent of Rent households that moved had an overall 19 percent increase in the hedonic index over time while the nonmover Percent of Rent households only increased their hedonic value by 3 percent. Increases for Control households were slightly lower for both groups--13 percent if they moved and only 2 percent when they did not. In Phoenix, Percent of Rent movers had an increase of 22 percent in the hedonic value of their housing while nonmovers showed a 7 percent increase. For Control households in Phoenix, the increase was 32 percent if they moved and only 5 percent if they did not (that is, Phoenix Control movers had a larger mean increase than did Percent of Rent movers).

In all, the results indicate that an increase in housing expenditures for a household does not always imply an increase in housing services. Movers do improve their housing in terms of the hedonic indices relatively more than do nonmovers. Yet there seem to be only small differences between the hedonic values for the Control and Percent of Rent households, indicating that rent subsidies may not be very effective in helping Percent of Rent households increase the quality of their housing units (at least as measured by the Minimum Standards housing requirements or by the hedonic index of housing services). In order to control for differences in income (and other characteristics) between Experimental and Control households, Section 5.2 analyzes the housing services response of Percent of Rent households in the context of a demand function.

5.2 THE DEMAND FOR HOUSING SERVICES

The hedonic index, described in Section 5.1, is used as the dependent variable in a demand equation in order to estimate the responsiveness of a household's consumption of housing services to changes in income and price. The log-linear form of the demand function is used, estimated for the sample of movers. As in Chapter 4, average income is used as the measure of permanent income. The estimates of price and income elasticities for both expenditures and the hedonic index are presented in Table 5-4.[2] In Phoenix, the income

[1] Appendix Tables X-36 and X-37 present the data for this figure.

[2] The sample is somewhat smaller than that used in Chapter 4 due to the extra data requirements of the hedonic index. The expenditure estimates are consequently slightly different.

Table 5-4

COMPARISON OF PRICE AND INCOME ELASTICITIES
ESTIMATED USING HOUSING EXPENDITURES
AND AN HEDONIC INDEX OF HOUSING SERVICES
(Movers Sample)

ELASTICITIES	PITTSBURGH	PHOENIX
Price Elasticity		
Expenditures estimate	-0.230** (0.065)	-0.215** (0.064)
Hedonic estimate	-0.113* (0.057)	-0.045 (0.060)
Income Elasticity		
Expenditures estimate	0.338** (0.054)	0.353** (0.046)
Hedonic estimate	0.226** (0.047)	0.375** (0.043)
SAMPLE SIZE[a]	(214)	(257)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Periodic Interviews.

NOTE: Standard error in parentheses.

a. Sample size differs from the expenditure estimates in Chapter 4 due to the extra data requirements of the hedonic index.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

elasticity estimates are the same for expenditures and housing services; in Pittsburgh, the income elasticity of housing services is lower than that for expenditures but is still reasonably large. Rather striking differences are evident in the price elasticity estimates, however. The estimated price elasticity for housing services in Phoenix is not significant. In Pittsburgh the estimated price elasticity of housing services is only one-half of the estimated price elasticity of expenditures. These results confirm the findings of Section 5.1--in response to a decrease in the price of housing, households increased their housing services by less than their expenditures. Moreover, in Phoenix the change in housing services for Percent of Rent households was no larger than that for Control households.

Several explanations are possible for these results. A rent rebate program such as a Percent of Rent allowance that provides no direct incentive for households to increase their housing quality may lead to inefficiency in shopping behavior; households would no longer be paying full market price for each additional unit of housing services and would possibly be willing to accept less housing services per dollar than the market provides on the average. If households do in fact act this way, the rent subsidy may permit households to reduce search costs.

On the other hand, the hedonic index may be subject to several types of specification bias. For example, if important attributes of the housing bundle were omitted from the estimating equation, the index would not adequately reflect the unit's housing services.[1] If important positively-valued attributes of dwelling unit or neighborhood quality are missing from the hedonic estimates, the estimated price and income elasticities for housing services would be biased downward from the true elasticities.

Next, if the housing market in Pittsburgh or Phoenix is segmented, that is, if different groups of households (central city versus suburban or racial differences, for example) face different housing prices, the same set of relative attribute prices estimated by an overall index may not be applicable to all submarkets. Finally, the attribute weights estimated during the baseline period may not be applicable after two years due to changing market

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[1] Omitted variables increase the estimated standard error of the hedonic index.

conditions or, more likely, to decisions made by movers to rent units in areas unlike those included in the original sample.[1]

These issues can be addressed in a formal framework. As described in Section 5.1, the hedonic housing services index was derived by regressing rent on housing unit and neighborhood characteristics and on conditions of tenure at enrollment:

(2) $$\ln(R) = \alpha + X\beta + Z\gamma + \mu$$

where

R = rent

X = a vector of housing unit and neighborhood characteristics, where $(\alpha+X\beta)$ is the hedonic index of housing services

Z = a vector of tenure characteristics such as length of the household's residence in the unit and whether the landlord lives in the building, and

μ = a stochastic error.

When rent at two years is predicted using the estimated coefficients, the estimated residual, μ, may represent omitted quality variables, omitted tenure variables, experimentally induced shopping inefficiency, and luck or other random effects.

Several hypotheses can be tested to determine the correct interpretation of the estimated residual, $\hat{\mu}$. If the residual involves some omitted quality, then it should be positively correlated with household income and possibly with household satisfaction. If the residual reflects changes in shopping behavior, then the search behavior of Percent of Rent households should show some differences from Control households. These specification issues have been assessed in detail by Merrill (1977) (in the development of the hedonic index), and Kennedy and Merrill (1979) (in analysis of the index's behavior over the experimental period). The remainder of this section summarizes some of these analyses and provides some hypotheses concerning the reasons

---

[1] The housing units of all enrolled households were used to estimate the hedonic index. The sample is not a random sample of all dwelling units since those households all have low or moderate incomes. See Merrill (1977). Further, Census tracts with low concentrations of rental units ($\leq$ 5 percent of housing units) were excluded from the sampling frame. These tracts might possibly have rental units with higher average quality.

for the differences in the elasticity estimates for expenditures and housing services.

Analysis of the Hedonic Residual

If the hedonic residual (μ) contains only omitted quality items, then analysis of housing quality should examine the sum of the hedonic index and the residual ($\alpha + X\beta + \mu$) rather than just the index alone. On the other hand, if the residual is not only omitted quality, then analysis of the price response should take account of possible shopping inefficiencies.

If the hedonic residual includes some omitted quality (i.e., quality unmeasured by the hedonic index), then to the extent that satisfaction is positively related to the level of housing quality the residual should be positively related to the household's satisfaction with its dwelling unit. If, on the other hand, the hedonic residual is due largely to price effects rather than omitted quality, the association with satisfaction is expected to be negative--that is, that satisfaction increases as the amount of quality relative to expenditures increases. To test these assumptions, the change in hedonic quality and the change in the hedonic residual over the two years of the experiment were each regressed on the change in dwelling unit satisfaction, for Control households.[1] The results showed that the change in quality and satisfaction have a significant and positive relationship in both sites. Further, in both sites the change in satisfaction and the change in the hedonic residual have the expected significant and negative relationship.[2] Thus it seems that the hedonic residual is not solely due to omitted quality items.[3]

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[1]It is often unclear what a question about household satisfaction actually measures because households quite possibly have different reference points. Change in dwelling unit satisfaction is a measure internally consistent within a household. Further, while demographic characteristics may affect household satisfaction, they are unlikely to affect the change in satisfaction (except insofar as they affect housing change).

[2]For movers, all relationships were in the same direction as those for all households and were significant (except for the residual and unit satisfaction in Phoenix). The same model was also tested for neighborhood satisfaction. In Phoenix, an increase in hedonic quality results in an increase in neighborhood satisfaction for both movers and all households. None of the other relationships were significant.

[3]Locational attributes are apparently accounted for adequately by the hedonic index; no discernible pattern to the residuals by location emerged (Merrill, 1977).

Similar hypotheses were tested concerning the relationship of search effort to quality and price effects. If the hedonic residual reflects price heterogeneity, then a diligent search will result in a better deal (more quality per dollar) than would a haphazard search. If true, the hedonic residual will be negatively associated with search effort. Unfortunately, there is some evidence that some households that do not search obtain good deals by luck--being referred to a unit by friends or relatives (Vidal, 1978). Tests were conducted accounting for this "windfall search" as well as more active search.[1] One measure of the search effort is the number of days spent searching for housing. Increased search time does in fact result in getting a better deal, that is, more quality per dollar of expenditures in both Pittsburgh and Phoenix. Search time is also associated with a larger change in the quality index in Pittsburgh.[2]

Part of the smaller increase in housing services relative to expenditures for Percent of Rent households in both Phoenix and Pittsburgh may be due to a conscious decision on their part to use less effort in searching for a new unit. Since there is a significant association between increased search time and obtaining more housing services per dollar of expenditures, if Percent of Rent households search less than Control households, then the price discount will have a smaller effect on their housing services than on their expenditures.

There is some weak evidence that decrease in search effort occurred--Percent of Rent movers spent fewer days looking for a unit than did Control movers, though not significantly so (97 versus 119 days in Pittsburgh, 34 versus 46 days in Phoenix).[3]

Another approach to analyzing the residual is direct estimation of demand for the residual and for the quality and tenure components. During the development of the hedonic index, extensive analysis of the residual was carried out using the entire enrolled sample (see Merrill, 1977). The hedonic residuals and the percent deviation of predicted and actual rent were regressed on household income, race, household size, and age and education of head of the household. The major hypothesis tested was the following:

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[1] See Kennedy and Merrill (1979) for additional detail.

[2] There is no relationship between quality and other measures of search effort (the number of units looked at or the number of units called).

[3] See Appendix Table X-38.

if important quality attributes were omitted, there would be a significant positive relationship between the residual and income and perhaps education. The income coefficients were in fact significant but were extremely small in both Pittsburgh and Phoenix.

A series of similar models have been estimated for households remaining active in the experiment for two years. In logarithmic form, Equation (2) becomes

$$\text{(3)} \qquad \ln(R) = \ln(Q) + \ln(T) + \ln(\varepsilon)$$

where

$\ln(Q) = (\alpha + X\beta)$, the hedonic index of housing services abstracting from tenure characteristics

$\ln(T) = Z\gamma$, the value of tenure characteristics, and

$\ln(\varepsilon) = \mu$, the stochastic error.

If each component of Equation (3) ($\ln(R)$, $\ln(Q)$, $\ln(T)$, and $\ln(\varepsilon)$) is regressed on the logarithms of price and income, it will be true that Equation (3) implies the sum of the price (or income) elasticities for Q, T, and ε will equal the price (income) elasticity of R:[1]

$$\text{(4)} \qquad \eta^R = \eta^Q + \eta^T + \eta^\varepsilon.$$

These elasticities may be estimated using log-linear regressions of the residual, the quality index, tenure adjustments, and rent adjustments on price and income; they are summarized in Table 5-5.[2] In Pittsburgh, both the price and income elasticities of housing services fall relative to those for expenditures. The difference is accounted for almost entirely by the hedonic residual and not the tenure characteristics. Since there is a significant positive income elasticity for the residual in Pittsburgh, it

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[1]From Equation (3),

$$\frac{\partial \ln(R)}{\partial \ln(P)} = \frac{\partial \ln(Q)}{\partial \ln(P)} + \frac{\partial \ln(T)}{\partial \ln(P)} + \frac{\partial \ln(\varepsilon)}{\partial \ln(P)}$$

and these elasticities are the estimated coefficients of log-linear demand functions for R, Q, T, and ε.

Actually, since the rent definition used for the hedonic analysis and the rent definition used for the housing consumption analysis are slightly different, there is another term representing this adjustment. The adjustment has no impact on any of the findings reported here.

[2]Additional equations, estimated including demographic covariates, did not change the results. (See Kennedy and Merrill, 1979.)

Table 5-5

PRICE AND INCOME ELASTICITY ESTIMATES
FOR RENT COMPONENTS

DEPENDENT VARIABLE	PITTSBURGH PRICE ELASTICITY	PITTSBURGH INCOME ELASTICITY	PHOENIX PRICE ELASTICITY	PHOENIX INCOME ELASTICITY
Rent (expenditures definition)	-0.230** (0.065)	0.338** (0.054)	-0.215** (0.064)	0.353** (0.046)
Hedonic index	-0.113* (0.057)	0.226** (0.047)	-0.045 (0.060)	0.375** (0.043)
Hedonic residual	-0.159** (0.047)	0.089* (0.039)	-0.193** (0.048)	-0.021 (0.034)
Tenure characteristics	0.027* (0.013)	0.019† (0.010)	0.017 (0.011)	0.001 (0.008)
Definitional difference[a]	0.016 (0.013)	0.004 (0.010)	0.005 (0.007)	-0.002 (0.005)
SAMPLE SIZE	(214)		(257)	

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, Baseline and Periodic Interviews, and Appendix Table X-39.

NOTE: Standard error in parentheses.

a. Difference between the analytic rent variable used for the expenditure analysis and that used in the derivation of the hedonic index.

† t-statistic significant at the 0.10 level.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

becomes plausible to assume that the residual in that site at least partially represents omitted quality variables. The presence of a significant price elasticity for the residual in both sites suggests that price factors are also present in the residual.

The ratio of the elasticities can also provide some information on the relative importance of omitted quality and price effects. The significant income elasticity in Pittsburgh suggests that, in that site at least, the hedonic residual does include some omitted quality. In this case, the estimated price and income elasticities based on the hedonic index would underestimate the true elasticities of housing services; at least part of the change in the hedonic residual would represent real changes in housing in addition to the changes reflected by the index.

One way to correct this problem may be to use the income elasticity of the hedonic residual. If the income elasticity of the hedonic residual represents increased expenditure for housing services not included in the hedonic index, then households allocate increased expenditures between included and omitted items in the proportion $(\eta_y^{\varepsilon}/\eta_y^{Q})$, where η_y^{ε} and η_y^{Q} are the income elasticities of the hedonic residual and hedonic index, respectively. Since the rent rebates offered by Percent of Rent apply to both included and omitted quality, it seems reasonable to suppose that the allocation of increased expenditures between the items included in the hedonic index and those included in the hedonic residual would be the same as that for increases arising from higher incomes.[1] One can then write the following:

$$\frac{\tilde{\eta}_p^{\varepsilon}}{\eta_p^{Q}} = \frac{\eta_y^{\varepsilon}}{\eta_y^{Q}} \tag{5}$$

where

$\tilde{\eta}_p^{\varepsilon}$ = the (unknown) price elasticity of omitted items

η_p^{Q} = the price elasticity of housing services included in the hedonic index

η_y^{ε} = the income elasticity of the hedonic residual, and

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[1] See Kennedy and Merrill (1979) for a detailed discussion of the condition under which this will be true.

η_y^Q = the income elasticity of housing services included in the hedonic index.

In words, the ratio of the price elasticities for omitted items to that for housing services is assumed to be the same as the ratio of the income elasticities, where the income elasticity for omitted quality is approximated by the income elasticity for the hedonic residual. Equation (5) can be solved to give the estimated price elasticity of omitted items as a function of the estimated hedonic index price and income elasticities and the estimated hedonic residual income elasticity:

$$(6) \qquad \tilde{\eta}_p^{\varepsilon} = \frac{\eta_p^Q \cdot \eta_y^{\varepsilon}}{\eta_y^Q} .$$

Put another way, Equations (5) and (6) essentially accept the income elasticity of expenditures as a benchmark for the normal relation between changes in expenditures and changes in the hedonic index (ignoring tenure characteristics and definitional differences, which have only a small effect). The adjusted price elasticity ($\tilde{\eta}_p^{\varepsilon}$) incorporates this normal relation. The difference between the expenditure price elasticity and the adjusted price elasticity thus measures the extent to which the rent rebates altered the normal relationship between housing expenditures and housing services. It is worth emphasizing the arbitrary nature of this procedure. Other methods of correction are possible.

Table 5-5 implies a value for $\tilde{\eta}_p^{\varepsilon}$ in Pittsburgh of -0.045. Since the total price elasticity of housing services is the sum of the hedonic elasticity and the elasticity of omitted items, this implies an overall price elasticity in Pittsburgh of -0.158. Since the expenditures price elasticity is -0.230, this implies a shopping effect of -0.072--that is, only about two-thirds of the expenditure increase induced by the Percent of Rent plans goes to increased housing services.[1]

In conclusion, the evidence in Phoenix seems most consistent with viewing the hedonic residual solely as a price effect, representing changes in shopping behavior, and not as omitted quality. The income elasticity estimates are the same for the quality index and rent, and zero for the residual. Almost

[1] In Phoenix, the income elasticity is small, negative, and not significantly different from zero. Furthermore, the model behind Equation (6) only considers the possibility of a positive income elasticity for the residual (reflecting omitted quality). Therefore, no adjustment in the Phoenix housing services elasticity is indicated.

all of the difference in price elasticity estimates is found in the residual. On the other hand, the residual in Pittsburgh represents both some omitted quality and some price behavior changes.

Demographic Stratification

As was seen in Section 4.3, expenditure elasticities differ among certain demographic groups. In particular, the estimated minority price and income elasticities were lower than those for nonminorities. Stratification by household composition was indicated in Pittsburgh, and stratification by race was indicated in Phoenix. Since expenditures elasticities were not uniform across demographic groups, housing service elasticities probably will not be either. Appendix Table X-44 presents hedonic estimates cross-classified by these demographic characteristics for movers.[1] Variance ratio tests indicate that, as for expenditures, price and income elasticities differ by household composition in Pittsburgh but not in Phoenix (see Table 5-6). The overall estimated housing services price elasticity for Pittsburgh movers is -0.11 (significantly different from zero only at the 0.10 level). The estimates for the different types of households vary a great deal. The price elasticity of housing services was insignificant for single-person and single-headed households. In contrast, the price elasticity is -0.25 for households headed by a couple (still smaller than the expenditures estimate of -0.36, though within that estimates 95 percent confidence interval). The housing services income elasticities are much closer to each other. The largest estimate is that for households headed by a couple: 0.49 (again within the 95 percent confidence interval of the expenditures estimate of 0.61). Indeed all the estimated housing services elasticities by household type fall within the 95 percent confidence intervals of the corresponding expenditure estimates (compare Tables 5-6 and 4-9).

In contrast to housing expenditures where racial stratification was important only in Phoenix, this stratification yields significant differences at both sites for housing services (see Table 5-7). Minority households have an insignificant and positive estimated price elasticity in both sites, while nonminority households, even in Phoenix (which has an insignificant overall elasticity), have a negative and significant price elasticity. On the other hand, minority households have zero or very low price and income elasticities (though the estimated housing service income elasticity for Phoenix minority

[1]The estimated equations for all households are presented in Appendix Table X-40.

Table 5-6

HOUSING SERVICES ELASTICITIES
BY HOUSEHOLD COMPOSITION

HOUSEHOLD GROUP	PITTSBURGH PRICE ELASTICITY	PITTSBURGH INCOME ELASTICITY	PITTSBURGH SAMPLE SIZE	PHOENIX PRICE ELASTICITY	PHOENIX INCOME ELASTICITY	PHOENIX SAMPLE SIZE
All households	-0.113† (0.057)	0.226** (0.047)	(214)	-0.045 (0.060)	0.375** (0.043)	(257)
Single-person households	-0.118 (0.168)	0.241 (0.163)	(32)	-0.366† (0.197)	0.464** (0.101)	(29)
Single-headed household with others present	-0.038 (0.085)	0.181† (0.095)	(87)	0.045 (0.081)	0.416** (0.067)	(111)
Households headed by a couple	-0.246** (0.080)	0.489** (0.076)	(95)	-0.121 (0.098)	0.365** (0.082)	(117)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, Baseline and Periodic Interviews, and Appendix Table X-41.

NOTE: Standard error in parentheses. A variance-ratio test could reject the hypothesis of homogeneity among household types in Pittsburgh ($F(4,205) = 6.27$), but could not in Phoenix ($F(4,248) = 1.69$), (critical value = 2.37 at the 0.05 level).

† t-statistic significant at the 0.10 level.

** t-statistic significant at the 0.01 level.

Table 5-7

HOUSING SERVICES ELASTICITIES
BY MINORITY STATUS

HOUSEHOLD GROUP	PITTSBURGH PRICE ELASTICITY	PITTSBURGH INCOME ELASTICITY	PITTSBURGH SAMPLE SIZE	PHOENIX PRICE ELASTICITY	PHOENIX INCOME ELASTICITY	PHOENIX SAMPLE SIZE
All households	-0.113† (0.057)	0.226** (0.047)	(214)	-0.045 (0.060)	0.375** (0.043)	(257)
Nonminority households	-0.143* (0.057)	0.269 (0.048)	(180)	-0.129* (0.065)	0.440** (0.045)	(168)
Minority households[a]	0.067 (0.201)	-0.012 (0.151)	(34)	0.023 (0.106)	0.154† (0.085)	(89)
Black households	---[b]	---[b]		-0.138 (0.218)	0.159 (0.165)	(27)
Spanish American households[c]	---	---		0.116 (0.121)	0.100 (0.102)	(62)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, Baseline and Periodic Interviews, and Appendix Table X-41.

NOTE: Standard error in parentheses.

a. A variance-ratio test rejected the hypothesis of homogeneity between nonminority and minority households in both Pittsburgh ($F(3,208) = 3.48$) and in Phoenix ($F(3,251) = 16.96$), (critical value = 2.60 at the 0.05 level).

b. Minority households in Pittsburgh are all black.

c. A variance-ratio test did not reject the hypothesis of homogeneity between Spanish American and black households in Phoenix ($F(3,83) = 1.07$), (critical value = 3.30 at the 0.05 level).

† t-statistic significant at the 0.10 level.
* t-statistic significant at the 0.05 level.
** t-statistic significant at the 0.01 level.

movers is very close to the expenditures estimate and is significant at the 0.10 level).[1]

As noted from Table 5-5, the hedonic residual has a significant income elasticity in Pittsburgh but an insignificant (and negative) income elasticity in Phoenix. One possible explanation for this is that the index is less accurate in Pittsburgh than in Phoenix. It was previously suggested that measurement error in housing services elasticities may be adjusted for by computing

$$(7) \qquad \begin{cases} \eta_y = \eta_y^Q + \eta_y^\varepsilon \\ \eta_p = \eta_p^Q + \eta_p^Q \dfrac{\eta_y^\varepsilon}{\eta_y^Q} \end{cases}$$

where

η_y = the "true" income elasticity of housing services, and

η_p = the "true" price elasticity of housing services.

The first expression in Equation (7) is simply the income elasticity of expenditures (except for minor effects due to tenure characteristics and rent definition)--that is, all differences in expenditures associated with differences in income are assumed to reflect real changes in housing services. The second expression gives an adjusted estimate of the price elasticity. Table 5-8 gives "corrected" price elasticities for the two sites stratified by household type and by minority status.

The results for the two sites are quite different. In Phoenix, the income elasticities of the hedonic residual are uniformly small and insignificant for all demographic groups (see Appendix Table X-43). As a result, the adjusted housing services price elasticities in Phoenix are close to the unadjusted values, indicating that the Percent of Rent offers did indeed have a substantial effect on the shopping behavior of recipients.

In Pittsburgh, on the other hand, there are several large hedonic residual income elasticities. Adjusted price elasticities are all closer to the expenditure elasticities than are the unadjusted ones. This confirms the

[1] Further, minority households in Phoenix (but not in Pittsburgh) start out with lower levels of housing services (see Appendix Table X-42).

Table 5-8

"CORRECTED" PRICE ELASTICITIES FOR HOUSING SERVICES
COMPARED TO EXPENDITURE ESTIMATES BY DEMOGRAPHIC CHARACTERISTICS

HOUSEHOLD GROUP	PITTSBURGH				PHOENIX			
	CORRECTED HOUSING SERVICES PRICE ELASTICITY[a]	EXPENDITURE PRICE ELASTICITY	DIFFERENCE	SAMPLE SIZE	CORRECTED HOUSING SERVICES PRICE ELASTICITY	EXPENDITURE PRICE ELASTICITY	DIFFERENCE	SAMPLE SIZE
All households	-0.158	-0.230	-0.072	(214)	-0.045[c]	-0.215	-0.170	(257)
Single-person households	-0.188	-0.055	+0.133	(32)	-0.375	-0.404	-0.029	(29)
Single-headed households with others	-0.038[c]	-0.216	-0.178	(87)	0.045[c]	-0.073	-0.028	(111)
Households headed by a couple	-0.289	-0.349	-0.060	(95)	-0.123	-0.356	-0.233	(117)
Nonminority households	-0.181	-0.233	-0.052	(180)	-0.129[c]	-0.290	-0.161	(168)
Minority households	-0.207[c]	-0.207	0	(34)	0.027	-0.154	-0.181	(89)
Black households	---[b]	---[b]			-0.141	-0.277	-0.136	(27)
Spanish American households	---	---			0.183	-0.081	-0.264	(62)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, Baseline and Periodic Interviews, and Appendix Table X-43.

a. See Equation (7) for the method of correction.

b. Minority households in Pittsburgh are all black.

c. The corrected price elasticities are computed as indicated in Equation (7) with the following exceptions First, the correction only applies in theory when the income elasticity of the residual is positive (when the hedonic income elasticity is less than the expenditure income elasticity). Cases other than this are assumed to represent stochastic error, with a true value of η_y^{ϵ} of zero (so that the hedonic price elasticity is not changed). In addition, minority households in Pittsburgh present a special case. In this instance the hedonic income elasticity is near zero. This suggests that the index captures little or no quality change for minority households in Pittsburgh and the expenditure price elasticity was accepted as the corrected housing services elasticity.

earlier findings that the Percent of Rent offers in Pittsburgh had only a small effect on the shopping behavior of recipients.

Substantial shopping effects are indicated in Phoenix for all the demographic strata (except for single-person and single-headed households). Minorities and single-headed households in particular seem to have almost no price response in terms of housing services. These groups also have lower expenditure response, however, so that the difference between expenditure and hedonic price elasticities is similar for minorities and nonminorities in Phoenix.

When minority households in Phoenix are further divided into black and Spanish American groups, it is clear that it is the Spanish American households that did not increase their expenditures in response to these changes either (compare Table 5-7 and 4-8). Further, the fit for both expenditures and housing services is very poor ($R^2 = 0.02$ and $R^2 = 0.03$, respectively).

Apparently, then, the estimated equations do not describe the behavior of Spanish American households in particular very well. The price and income elasticity estimates for minority households in Phoenix, particularly for Spanish American households, strongly suggest that these households did not respond to the Percent of Rent rebates by increasing their consumption of housing services or their housing expenditures. One possible explanation for this is that minority households face market barriers that prevent them from purchasing an average amount of housing services per dollar of additional expenditure or that prevent them from entering into areas with higher rent and higher quality units. If minority households face a different structure of housing attribute prices due to market segmentation or only have access to a limited range of housing choices (perhaps due to racial or ethnic discrimination) then use of an hedonic index with implicit attribute prices based on the full sample would misestimate the actual housing services consumed by minorities.

A series of tests to assess market segmentation (different relative attribute weights) were made during the development of the hedonic index (Merrill, 1977). In Phoenix, separate equations were estimated for white households and Spanish American households and comparison of these regressions did not indicate the existence of market segmentation.[1] The F-test for the existence of a submarket was not significant for the semilog form of the hedonic index used in this report. Furthermore, the standard errors of the full sample and

[1] There were too few black households in Phoenix to estimate a separate submarket index for them.

submarket equations differ by less than 1 percent, an amount that is operationally unimportant (Merrill, 1977, p. 130).[1] Even though overall differences are minor, however, several important prices, particularly for space, do differ.

As an additional assessment of submarket effects, therefore, a separate hedonic index, based on estimated attribute prices for Spanish American households, has been computed. Separate estimates of price and income elasticities have been made using this subsample index. Estimation based on the Spanish American subsample index does not change the results for any group (see Appendix Table X-44). This may be interpreted as an indication that specification bias due to misestimated attribute prices for Spanish American households is apparently not responsible for the insignificant housing services price and income elasticities.

Two additional potential explanations for the difference between Spanish American and white households deserve attention. First, quality variables may be omitted from the hedonic index which are systematically associated with the purchases of Spanish American households but not white households. Secondly, minority Experimental households may have searched less than minority Control households.

It is not at all clear which variables, if any, might be systematically associated with minority or Spanish American housing consumption. In order to determine if omission of data on building type, private yard, and their interaction was important for minority households, the hedonic residuals were regressed on these variables (Merrill and Kennedy, forthcoming).[2]

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[1]Merrill (1977) found no evidence of price discrimination against Spanish American or black households in Phoenix; that is, minorities do not pay more than whites for the same housing.

[2]Examination of the data reveal that Spanish Americans are much more likely than white households to live in single family units and less likely to live in larger multifamily units. Further, it has also been suggested that the Spanish American households in Phoenix have a strong preference for yard space. The full sample hedonic equation does include a dummy variable for multifamily buildings with five or more units but no other variables indicating building type or presence of a yard were significant.

None of these variables appear to be related to quality for white households. Spanish American households appear to prefer private yards, especially if associated with a small multifamily unit. It is not likely, however, that given the small coefficient for the yard variable, the omission would bias the price elasticity estimate sufficiently to make it zero. Further, since income is not significantly related to the hedonic residual in Phoenix for Spanish American movers, even at two years after enrollment, the evidence of systematic bias due to omitted variables seems rather slim.

The last investigation concerns the effect of search effort on obtaining an amount of housing services per dollar of expenditure. As suggested above, part of a smaller increase in housing services relative to expenditures for Experimental households in both Phoenix and Pittsburgh may be due to a conscious decision on their part to use less effort in searching for a new unit. Spanish American movers receiving a Percent of Rent rebate did spend significantly fewer days searching (28 days) than did Control households (76 days) (see Appendix Table X-29).

Atkinson et al. (1979) noted that Spanish American Percent of Rent movers were less likely to leave their initial neighborhood than were Control Spanish American movers. They suggest that this may result from a chance grouping in the Percent of Rent category of households that were strongly interested in remaining in their initial neighborhood. If the initial neighborhood has a limited range of units available, these households may be prevented from obtaining improved housing by supply constraints. There is not strong evidence for this constraint, however, as the variance in the hedonic value of units occupied by Spanish American households at enrollment and at two years is almost identical to that of nonminority households.

In sum, there is a general pattern of reduced shopping effectiveness in Phoenix. The extent of this shopping effect is similar for all demographic groups (with the exception of single-person and single-headed households). There is also some evidence of reduced effectiveness in Pittsburgh, but it is not widespread.

Minorities in Phoenix, and especially Spanish American households, showed little or no real change in housing or rent in response to the Percent of Rent offers. No clear reason for this lower response--with the possible exception of reduced search effort--has been found. Indeed, the error of estimate for this group is large enough that the very low response estimates could simply reflect stochastic error.

Furthermore, in contrast to housing expenditure functions, variance ratio tests reject the possibility of pooling the sites, even when the combined housing services function includes a site-specific intercept. The hypothesis of homogeneity across sites of the demand for housing services was rejected for all mover households and for the mover subsamples stratified by race (see Table 5-7). The different results with respect to pooling the sites between expenditures and housing services is due to the different shopping behavior in the two sites. Part of the increase in expenditures in Phoenix was due to inefficient shopping, while no evidence of inefficiency was present in Pittsburgh.

5.3 CONCLUSIONS

The housing services response of Percent of Rent households to the price discount offered to them was smaller than the expenditures response. This is ture not only for all movers, but for most demographic groups as well. Increased expenditures on housing combine two changes: increases in the amount of housing services that the household consumes and/or increases in the price per unit of housing services that the household pays. The hedonic index was designed to measure the increase in housing services. The consistent difference between changes in housing services and the larger changes in expenditures across all groups investigated prompted further investigation into the nature of the hedonic index. It seems likely that some quality components were omitted from the Pittsburgh hedonic index. Nevertheless, adjusting for omitted items still results in a significant estimated effect on the prices paid by nonminority households.[1]

In Phoenix, there was little evidence of omitted quality, implying that Percent of Rent households have shopped inefficiently and received less housing services per dollar than Control households. This shopping effect was much the same for all demographic groups except single-person and single-headed households. In addition, it appears that single-headed households and minorities had little real change in housing in response to the Percent of Rent offers. This was especially marked for Spanish American households.[2] They also appear to have had little or no change in expenditures. These low response levels may, however, reflect stochastic error rather than a genuine difference in behavior.

[1] See Kennedy and Merrill, 1979, Table 4-2.

[2] The sample of black movers was too small to examine individually.

REFERENCES

Atkinson, Reilly, William Hamilton, and Dowell Myers, Economic and Racial/Ethnic Concentration in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., January 1979 (revised June 1980).

Budding, David W., Housing Deprivation Among Enrollees in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., November 1978 (revised June 1980).

Merrill, Sally R., Hedonic Indices as a Measure of Housing Quality, Cambridge, Mass., Abt Associates Inc., December 1977 (revised June 1980).

Kennedy, Stephen D. and Sally R. Merrill, "The Use of Hedonic Indices to Distinguish Changes in Housing and Housing Expenditures: Evidence From the Housing Allowance Demand Experiment," Paper presented at the Research Conference on the Housing Choices of Low-Income Families, Washington, D.C., March 1979.

Merrill, Sally R., Stephen K. Mayo, Margaret Dewar, Lucina Vernazza, "Housing Consumption," Chapter 4 in Working Paper on Early Findings: Experimental Housing Allowance Program, Demand Experiment, Cambridge, Mass., Abt Associates Inc., 1975, pp. 75-186.

Vidal, Avis, The Search Behavior of Black Households in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., July 1978 (revised June 1980).

CHAPTER 6

ISSUES IN USING EXPERIMENTAL DATA

This chapter discusses three issues involved in estimating demand equations using the data from the Demand Experiment: (1) the dynamics of behavior over time, (2) possible bias in estimation due to sample selection, and (3) the extent to which households understood the Percent of Rent offers. Housing dynamics are important because estimated responses to changes in the price of housing presented in this report are based on the responses of households during the first two years of the Demand Experiment. Economic theory suggests that under certain circumstances this could underestimate the eventual response to a permanent price reduction. Section 6.1 examines the pattern of expenditures over the two years of the experiment for evidence of any systematic trend that would indicate a larger eventual response.

Sample selection can also bias estimates based on experimental data. Not all households offered enrollment in the Percent of Rent plans accepted the offer. Nor did all enrolled households remain in the experiment for the full two years. Again, economic theory suggests that Percent of Rent households that did enroll and remain in the experiment may have tended to spend more for housing than other households. If this were the case, the estimated responses for these households would overestimate the response of the population as a whole. In addition, much of the analysis is based on households that moved during the experiment. Theory suggests that some of these households may be ones with especially large expenditure changes so that later movers would not change their housing expenditures to the same extent. Section 6.2 compares the housing of the samples used in analysis with that of households offered enrollment to determine whether there is any evidence of such selection effects.

Program understanding may also have affected the estimation. If some households did not understand the Percent of Rent offer, their responses might misestimate the eventual response to a well-understood price reduction or rent rebate program. Section 6.3 examines evidence from interview data about program understanding and its effect on household responses.

6.1 DYNAMIC SPECIFICATION OF HOUSING DEMAND

Chapter 4 presented estimates of an equilibrium model of housing demand based on the assumption that movers adjust completely to the Percent of Rent rebates. Once a household moved, it was assumed to allocate its income between housing and other goods according to its equilibrium demand for housing. No further change was expected until the household's circumstances changed again.

Another approach to demand analysis is based on the idea that consumption (of any good) involves aspects of habit formation, inertia, ignorance, uncertainty, and costs of change, which lead households to respond only gradually to changes in prices and income. The two best known such models are the Partial Adjustment and the Adaptive Expectations Models.[1] While these models vary in some detail, they both lead to the same reduced form equation (though with different error structures). This can be seen as follows.

Under the Partial Adjustment Model, actual rent is adjusted by some fraction of the difference between desired rent and the previous period's actual rent. This occurs as the household gradually feels its way to its optimal consumption pattern.[2] Thus, under this model (ignoring for the moment changes in price),

(1a) $$\ln(R_t^*) = \alpha + \beta\ln(Y_t), \text{ and}$$

(1b) $$\ln(R_t) - \ln(R_{t-1}) = \gamma[\ln(R_t^*) - \ln(R_{t-1})] + \nu_t,$$

where

R_t^* = the household's desired expenditure on housing in period t

Y_t = income (current or permanent)

R_t = actual housing expenditure in period t

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[1] See Johnston (1972), pp. 300-320, or Intriligator (1978), pp. 235-248 for detailed description of these models.

[2] Mayo (1977) showed that the Partial Adjustment Model will also arise if households fully adjust their consumption, but do not all adjust immediately. Thus if households adjust fully when they move, but do not all move immediately, an estimated demand function for the entire population will have the form of Equation (1b). This possibility is dealt with in this report by separate estimation of the responses of movers.

γ = the "coefficient of adjustment," and

ν_t = a stochastic error term.

Combining Equations (1a) and (1b) and rearranging terms, the Partial Adjustment Model can be written

$$(2) \qquad \ln(R_t) = \alpha\gamma + \beta\gamma \ln(Y_t) + (1-\gamma)\ln(R_{t-1}) + \nu_t.$$

Under the Adaptive Expectations Model, expectations about permanent income are adjusted by some fraction of the difference between current income and the previous period's permanent income.[1] This arises because households are uncertain about their future income. Expectations about permanent income and the housing expenditures based on it are only developed gradually. Thus, under this model,

$$(3a) \qquad \ln(R_t) = \alpha + \beta\ln(Y_t^*) + \mu_t, \text{ and}$$

$$(3b) \qquad \ln(Y_t^*) - \ln(Y_{t-1}^*) = \delta[\ln(Y_t) - \ln(Y_{t-1}^*)]$$

where

Y_t^* = measures of permanent or normal income expected to prevail as of period t

δ = the "coefficient of expectations," and

μ_t = a stochastic error term.

Combining Equations (3a) and (3b) and rearranging terms, the Adaptive Expectations Model can be written

$$(4) \qquad \ln(R_t) = \alpha\delta + \beta\delta\ln(Y_t) + (1-\delta)\ln(R_{t-1}) + [\mu_t - (1-\delta)\mu_{t-1}].$$

Equations (2) and (4) are identical except for the error terms.

The difference between Equation (2) or (4) and the Complete Adjustment Model discussed in Chapter 4 for movers is the presence of the lagged rent term, R_{t-1}, and the resulting interpretation of the coefficients. Under the models of Equations (2) and (4), households would initially adjust to a change in income, $\Delta\ln Y$, by the amount $\beta\gamma(\Delta\ln Y)$ or $\beta\delta(\Delta\ln Y)$, respectively. The term $\beta\gamma$ (or $\beta\delta$) is the immediate or short-run income elasticity. If the change in income

[1] This process can be extended to other variables as well.

is maintained over time, however, households will eventually change their income by $\beta(\Delta \ln y)$, where β is the long-run income elasticity. This suggests that long-run responses might be estimated more accurately by Equation (2) or (4) than by the model used in Chapter 4. Unfortunately, it is almost impossible empirically to distinguish these gradual adjustment models from quite different models based on serial correlation.

Serial correlation between the error terms of two consecutive years is almost inevitable. There may be several reasons for such serial correlation, the most convincing of which is that some unobservable variable determining behavior, such as taste for housing, will remain more or less constant over a span of years when households are observed over time. If the true model is the Complete Adjustment Model of Chapter 4, serial correlation implies that

(5a) $$\ln(R_t) = \alpha + \beta \ln(Y_t) + \varepsilon_t, \text{ and}$$

(5b) $$\varepsilon_t = \rho\varepsilon_{t-1} + \eta_t,$$

where ε_t is the error term in time t, η_t is random error, and ρ is the serial correlation coefficient. Combining Equations (5a) and (5b) gives

(6) $$\ln(R_t) = \alpha(1-\rho) + \beta[\ln(Y_t) - \rho\ln(Y_{t-1})] + \rho\ln(R_{t-1}) + \eta_t.$$

It is difficult to distinguish Equation (6) from Equations (2) or (4) empirically. Indeed, if income is measured as three-year average income, $\bar{Y}$, Equation (6) becomes

(7) $$\ln(R_t) = \alpha(1-\rho) + \beta(1-\rho)\ln(\bar{Y}_t) + \rho\ln(R_{t-1}) + \eta_t,$$

which is identical to Equation (2).

Both the Demand Experiment data and a longer time series of data from the Panel Study of Income Dynamics were insufficient to distinguish among the three models. Therefore, in testing for dynamic response patterns, it was assumed that the dynamic model containing $\ln(R_{t-1})$ as an independent variable could also involve serial correlation. The equation estimated is then (including the price term)

(8) $$\ln(R_t) = A + B\ln(Y_t) + C\ln(1-a) + D\ln(R_{t-1}) + e_t.$$

where the e_t are serially correlated.

The problem in estimating Equation (8) is that in the presence of serial correlation, R_{t-1}, which includes e_{t-1}, will be correlated with e_t. Thus the estimated coefficient of $\ln(R_{t-1})$ may reflect the bias due to serial correlation rather than any gradual adjustment process. This problem can be addressed by using a two-stage procedure that substitutes a predicted value of the log lagged rent, $\widehat{\ln(R_{t-1})}$ for $\ln(R_{t-1})$.[1] The variable $\widehat{\ln(R_{t-1})}$ is predicted from a regression $\ln(R_{t-1})$ on lagged values of exogenous variables and is, by construction, uncorrelated with e_t and highly correlated with $\ln(R_{t-1})$.[2] This procedure yields consistent estimators of the parameters.

The instruments used to predict enrollment rent were enrollment income, Y_{t-1}, and length of residence at the enrollment dwelling unit, L_{t-1}. Enrollment income is by itself too highly correlated with subsequent income to serve as an effective instrument (that is, if enrollment income alone is used as the instrument, the values of $\widehat{\ln(R_{t-1})}$ are too correlated with $\ln(Y_t)$ to distinguish their effects; the error of estimate of D in Equation (8) becomes very large). Length of residence, L_{t-1}, provides enough independent variation in $\widehat{\ln(R_{t-1})}$ to overcome this. Form an econometric viewpoint, L_{t-1} is a convenient instrument; it is correlated with R_{t-1} but not with R_t (since all movers have zero length of tenure in their new unit), and hence is independent of e_t.

It must be admitted, however, that length of residence is an inappropriate instrument for the Adaptive Expectations Model and may not be appropriate for the Partial Adjustment Model. Length of residence apparently affects expenditures because households with longer tenures enjoy exceptionally good deals, paying less for comparable units than new tenants (Merrill, 1977).[3]

If the Partial Adjustment Model is developed in terms of housing services, H, rather than housing expenditures, R, Equation (2) becomes

(2)′
$$\ln(H_t) = \alpha\gamma + \beta\gamma \ln(Y_t) + (1-\gamma) \ln(H_{t-1}) + \nu_t.$$

---

[1] See Griliches (1967), p. 41. Mayo (1977), in estimating a Partial Adjustment Model for the preliminary first-year data, ignored the possibility of simultaneous equation bias.

[2] The two-equation system is recursive and $\widehat{\ln(R_{t-1})}$ can be predicted using Ordinary Least Squares.

[3] This may arise because landlords offer discounts to retain tenants and avoid the costs of turnover or because tenants with good deals tend to hold onto their units.

To write Equation (2)′ in terms of expenditures, the term $\ln(P_t)$, the log of housing price, is added to both sides of the equation. However, if because of the tenure discount, the housing price at any period, P_t, varies with length of tenure, then

(9) $$\ln(P_t) = \ln(P_t^o) + \lambda \ln(L_t + 1)$$

where

P_t = the price of housing

P_t^o = the price of housing for new tenants, and

L_t = the length of tenure.

Using this specification of price, Equation (2)′ becomes

(10) $$\ln(R_t) - \ln(P_t) = \alpha\gamma + \beta\gamma \ln(Y_t) + (1-\gamma)\ln(R_{t-1}) - (1-\gamma)\ln(P_{t-1}) + \nu_t \; .$$

Collecting price terms and substituting Equation (9) into Equation (10) gives

(11) $$\ln(R_t) = [\ln(P_t^o) - (1-\gamma)\ln(P_{t-1}^o) + \alpha\gamma] + \beta\gamma\ln(Y_t) + (1-\gamma)\ln(R_{t-1}) + \lambda\ln(L_t+1) - (1-\gamma)\lambda\ln(L_{t-1}+1) + \nu_t .$$

Since households that move all have L_t equal to zero, Equation (11) becomes

(12) $$\ln(R_t) = \alpha' + \beta\gamma\ln(Y_t) + (1-\gamma)\ln(R_{t-1}) - (1-\gamma)\lambda\ln(L_{t-1}+1) + \nu_t$$

where

$$\alpha' = [\ln(P_t^o) - (1-\gamma)\ln(P_{t-1}^o) + \alpha\gamma] .$$

Thus, L_{t-1} should be included in the estimated equation to begin with and is thus insufficient as an instrument. However, if L_{t-1} acts not as a price adjustor, but only helps to characterize housing expenditures at enrollment, it may be used as an instrument. This could arise, for example, if the relation between length of tenure and enrollment rent in part reflects the fact that households with long tenure have not adjusted their housing expenditures for some time. In this case, length of tenure would reflect the extent of a household's disequilibrium (with an overall negative correlation with rent if household incomes tend to drift up over time) and be an ideal instrument for the Partial Adjustment Model.

In the Adaptive Expectations Model, lagged rent arises through substitution of $(\ln(R_{t-1}) - \alpha - \mu_{t-1})$ for $\beta\ln(Y^*_{t-1})$, using Equation (3a). If the appropriate specification of Equation (3a) is

$$\text{(3a)}' \qquad \ln(R_{t-1}) = \alpha + \beta\ln(Y^*_{t-1}) + \theta\ln(L_{t-1}+1) + \mu_{t-1}$$

then Equation (4) becomes

$$\text{(4)}' \qquad \ln(R_t) = \alpha\delta + \beta\delta\ln(Y_t) + (1-\delta)[\ln(R_{t-1}) - \theta\ln(L_{t-1}+1)] + [\mu_t - (1-\delta)\mu_{t-1}].$$

Thus the lagged rent variable should be net of the effects of tenure discount for the Adaptive Expectations Model.

The empirical results are summarized in Table 6-1. In both sites the "adjustment coefficient" is high, and in Pittsburgh it is not significantly different from one. For this reason the estimated long-run elasticities are very similar to the estimated short-run elasticities, and both are similar to those presented in Chapter 4. The evidence therefore does not suggest the superiority of either the Partial Adjustment or the Adaptive Expectations Models. The data are consistent with viewing the Complete Adjustment Model as an adequate theoretical description of the behavior of low-income renters.[1]

The dynamics of response to price changes need not be the same as those of response to income changes. However, there may also be gradual adjustment to the price change, so that price response would increase over time. In this case, estimated responses based on the first two years of the experiment would understate the eventual response.[2] If such gradual adjustment takes place, then one would expect (under an Adaptive Expectations Model) that later movers would have larger responses than earlier movers or at least (under a Partial Adjustment Model) that repeat movers would respond more on the second

[1] The high correlation between R_t and R_{t-1} can be used to improve prediction of R_t if R_{t-1} is known and thus improve estimates of piece elasticities as discussed in Appendix VI.

[2] In fact, the estimated price elasticities presented in Chapter 4 are fairly low and are less than most of the estimates based on nonexperimental data discussed in Section 3.3.

Table 6-1

PARAMETER ESTIMATES FOR A
DYNAMIC MODEL OF HOUSING DEMAND

	PITTSBURGH ESTIMATES	PHOENIX ESTIMATES
Short-run income elasticity	0.302** (0.049)	0.268** (0.040)
Short-run price elasticity	-0.201** (0.060)	-0.215** (0.052)
Adjustment coefficient	0.848[a] (0.166)	0.693[b] (0.117)
Long-run income elasticity	0.368	0.387
Long-run price elasticity	-0.237	-0.310
SAMPLE SIZE	(236)	(291)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Standard error estimated using Two-Stage Least Squares. The instruments used for lagged rent were enrollment income and length of residence at enrollment dwelling unit. Current income was used for the income measures. Standard errors in parentheses. The estimated elasticities from a static model (see Appendix Table X-12) were: in Pittsburgh 0.324 for income and -0.195 for price; in Phoenix 0.325 for income and -0.219 for price.

a. Not significantly different from one at the 0.10 level.

b. Significantly different from one at the 0.01 level.

** t-statistic significant at the 0.01 level.

move than on the first.

Unfortunately, these patterns might be offset by the effects of the limited duration of the experiment. If moving costs are substantial, then households may be reluctant to move to housing so expensive as to require that they vacate it when the experiment ended. In this case, households would be less likely to respond toward the end of the experiment, when the period over which payments would be received was smaller.[1] This would be especially true in Pittsburgh where households generally move less often (so that the prospect of having to move might pose a more important barrier). If both of these factors--gradual adjustment and experimental duration--were important, then they conceivably offset each other in the second year. While the overall response would be lower, first and second year responses would not be very different.

Table 6-2 presents the estimates of the price elasticities for movers during each of the three time periods and for combinations of the periods. The results are ambiguous--the largest response is for the latest movers in Pittsburgh (those moving only in the second year) and the earliest in Phoenix (those moving in the first six months). Response increases for movers in Pittsburgh (-0.16 for first year only movers to -0.37 for second year only movers) but decreases in Phoenix (-0.29 to -0.10 for the same two groups).

One additional test for problems due to duration is based on expected mobility. There is a strong connection between prior mobility and subsequent mobility (see MacMillan, 1978). Thus, households that moved frequently in the years before the experiment are more likely to move in the next several years. But if a household is likely to move in any case, it should be less concerned with the prospect of having to move at the end of the experiment. If experimental duration is a factor, the responses of households with high levels of prior mobility should be larger than those of households with lower prior mobility. As is illustrated in Table 6-3, this is true for households moving only in the first year, but not for households moving only in the second year or in both years. Nor does controlling for prior mobility make the pattern of response for movers reflect either of the patterns expected if either the Partial

[1] Further, if households did not expect to remain eligible for the allowance payment for long (as their incomes increased), then they may have preferred to retain the allowance as savings rather than respond.

Table 6-2

PRICE ELASTICITIES OF DEMAND
FOR DIFFERENT MOVER GROUPS

MOVER GROUP	PITTSBURGH ELASTICITY	PITTSBURGH SAMPLE SIZE	PHOENIX ELASTICITY	PHOENIX SAMPLE SIZE
Moved during the two years	-0.211 (0.063)	(236)	-0.219 (0.059)	(292)
Moved during the first year	-0.132 (0.074)	(166)	-0.273 (0.069)	(213)
Moved during the first six months	-0.189 (0.111)	(99)	-0.364[a] (0.083)	(151)
Moved during the second six months	-0.140 (0.108)	(88)	-0.264 (0.090)	(129)
Moved during the first year only	-0.163 (0.085)	(127)	-0.291 (0.110)	(129)
Moved during the second year	-0.260 (0.095)	(109)	-0.201 (0.069)	(185)
Moved during the first year and the second year	0.035 (0.142)	(36)	-0.285 (0.089)	(94)
Moved during the second year only	-0.366[a] (0.122)	(69)	-0.100[a] (0.115)	(79)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file.

NOTE: Price elasticities were estimated using average income. Standard error in parentheses below the elasticities.

a. The estimate does not fall within the 95 percent confidence interval of the estimate for all households that moved during the two years: (-0.334, -0.088) in Pittsburgh and (-0.335, -0.103) in Phoenix.

Table 6-3

PRICE ELASTICITY ESTIMATES
BY PRIOR MOBILITY

MOVER GROUP	PITTSBURGH LOW PRIOR MOBILITY[a]	PITTSBURGH HIGH PRIOR MOBILITY[b]	PHOENIX LOW PRIOR MOBILITY[a]	PHOENIX HIGH PRIOR MOBILITY[b]
Moved during the first year only	-0.110 (0.100)	-0.352 (0.155)	-0.178 (0.150)	-0.448 (0.166)
Sample size	(80)	(47)	(49)	(58)
Moved during the second year only	-0.393 (0.153)	-0.341 (0.230)	-0.091 (0.176)	-0.120 (0.149)
Sample size	(43)	(26)	(41)	(38)
Moved during both the first and second years	-0.073 (0.240)	0.107 (0.198)	-0.357 (0.180)	-0.238 (0.097)
Sample size	(18)	(22)	(34)	(72)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, and Baseline Interview.

NOTE: Price elasticities estimated using average income. Standard error in parentheses below coefficient.

a. One or fewer moves during the three years prior to the Baseline Interview.

b. Two or more moves during the three years prior to the Baseline Interview.

Adjustment or the Adaptive Expectations Models were true.[1]

More direct evidence on the effect of experimental duration is available from the Seattle/Denver Income Maintenance Experiments. Those experiments offered a variety of income-conditioned payments similar in form to the Unconstrained payments tested in the Demand Experiment. In addition, unlike the Demand Experiment, the Seattle/Denver Income Maintenance Experiments included both three- and five-year offers. If the three-year duration of the Demand Experiment in fact limited the changes in housing undertaken in response to the Percent of Rent price rebates, then one would expect to find lower responses to the income transfers by Seattle and Denver households with three-year offers as compared to those with five-year offers. In fact, analysis by Ohls and Thomas (1979) indicates almost no difference between the two groups.

Ohls and Thomas estimate, among other things, the effect of the experimental income transfers on rental expenditures three years after enrollment, by regressing monthly rental expenditures on variables for race/ethnicity, household type, average (three-year) experimental payment, and average (three-year) income from other sources. As shown in Table 6-4, estimates for households with five-year offers were almost identical to estimates for the entire sample of households (including both households with three-year offers and those with five-year offers). Likewise, direct estimates of the difference in response for the two groups (reported only for Denver) are small and insignificant.[2,3]

These results suggest that the three-year duration of the Demand Experiment did not in itself materially affect household responses to the rent rebates offered by the Percent of Rent plans. Accordingly, the failure to find consistent patterns of increased housing change over time seems less likely to reflect the influence of limited duration and more likely to indicate that the adaptive expectations or partial adjustment models do not apply to changes in rental housing.

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[1] Some additional evidence that duration did not matter is presented in Appendix VII, which compares the effect on mobility of experimentally induced changes in desired expenditures and pre-experimental deviation between actual and desired expenditures.

[2] The significant, though small difference in elasticities reported in Table C-8 of Ohls and Thomas is due to a misplaced decimal point in transcription (the actual estimated effect is one-tenth of that reported in Table C-8 for rental expenditures).

[3] Ohls and Thomas' estimates of income elasticities among households that moved are similar to those reported here--0.420 in Denver and 0.331 in Seattle (Ohls and Thomas, Table II-6, p. 35).

Table 6-4

COMPARISON OF OHLS AND THOMAS' ESTIMATED EFFECTS
OF EXPERIMENTAL INCOME TRANSFERS ON RENTAL EXPENDITURES
FOR THREE- AND FIVE-YEAR GUARANTEES
(SEATTLE/DENVER)

	ESTIMATED COEFFICIENT FOR EXPERIMENTAL PAYMENTS			
	DENVER COEFFICIENT	SAMPLE SIZE	SEATTLE COEFFICIENT	SAMPLE SIZE
All renter households	.007** (.001)	(824)	.008** (.002)	(401)
Renter households with five-year guarantees	.007** (.002)	(486)	.009** (.002)	(231)
All renter households, with interaction for five-year offers	.006** (.002)	(824)	N/A	
[Difference in coefficient for five-year guar-antees]	.0008 (.0015)		N/A	

DATA SOURCES: Ohls and Thomas, 1979, Tables F-1, F-2, F-44.
NOTE: Standard errors in parentheses.
** t-statistic significant at the 0.01 level.

In conclusion, the most important dynamic factor in response may be the difference in response between movers and nonmovers discussed in Chapters 2 and 4. There is no evidence of other important dynamic patterns. It must be admitted, however, that the various dynamic models considered in this section cannot be conclusively rejected with the available data.

6.2 SELECTION BIAS IN PRICE ELASTICITY ESTIMATES

The sample of households offered enrollment in Percent of Rent plans was carefully designed to be a random sample of the low-income population in each site. The equilibrium demand functions were estimated on a different sample of households--households that accepted the enrollment offer, were verified to be within the income eligibility limit, remained in the experiment, and moved sometime between enrollment and two years after enrollment. Each of these selection criteria may have introduced bias in the estimated coefficients, so that they may differ from the population coefficients, as follows:

> Acceptance bias. Households offered higher payments may have been more likely to accept the enrollment offer than households offered lower payments. Since, for each rebate level, payment increases with housing expenditures, households that accepted the Percent of Rent offers may have tended to spend more for housing than Controls. In this case, cross-sectional comparison of Percent of Rent and Control households might overestimate the effect of the rebate.
>
> Attrition bias. Likewise, households may be more likely to remain in the program if they received higher payments. Again, Percent of Rent households that tend to spend more on housing regardless of the experiment may be more likely to remain in the experiment.
>
> Mobility bias. In theory, households move to change their housing and hence should be, other things equal, more likely to move the larger their desired changes. Households may move in order to spend less or to spend more on housing. The rent rebates offered to Percent of Rent households would be expected to encourage moving by households that would have moved to increase their spending. Thus the sample of Percent of Rent movers may not be comparable to the sample of Control movers.[1]

[1] One other possible bias is not considered here. If the price elasticity is itself stochastic, then households that moved during the first two years might tend to include more "high response" households. Estimates based on these households would overestimate the responses of later movers. As discussed in Section 6.1, there is no consistent evidence of declining response over time.

The remainder of this section evaluates the actual extent of such selection bias. A more complete discussion of the models involved is presented in Appendix XI.

The selection bias problem may be formally characterized in terms of the stochastic error term in the estimated demand function. Specify, for example, the log-linear expenditure function is

$$\ln(R_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(1-a) + \varepsilon_t \tag{13}$$

where

R_t = housing expenditures at time t

Y_t = household income at time t, and

a = the percentage rent rebate.

Under Equation (13), if households had not had the Percent of Rent rebates, the value of $\ln(1-a)$ would have been zero (a=0), and their rental expenditures would have been determined by

$$\ln(R_t^N) = \beta_0 + \beta_1 \ln(Y_t) + \varepsilon_t \tag{14}$$

where R_t^N is the normal level of expenditures that would have occurred in the absence of the experiment.

The sample selection biases described above all in effect suggest that at various periods, Percent of Rent households with higher levels of $\ln(R_t^N)$--that is, with higher values of ε_t--were more likely to accept enrollment, stay in the experiment, or move than households with lower levels of $\ln(R_t^N)$. Furthermore, this effect is likely to be larger at higher rebate levels. Thus even if households were randomly assigned so that ε_t was, for the entire assigned population, independent of $\ln(1-a)$, among selected households ε_t and $\ln(1-a)$ may be correlated. In this case, the Ordinary Least Squares estimate of β_2 will be biased.

The expenditure functions estimated in this report are based on cross-sectional observations at the end of two years (t=2). Thus the concern for estimation is sample selection that directly or indirectly affects ε_2. The problem is that observations at two years after enrollment cannot distinguish between genuine experimental effects and the artifacts of sample selection. Some indirect way must be found to identify sample selection.

The basic method used in this report for testing for selection bias is serial correlation. To the extent that the stochastic term, ε_t, reflects underlying differences in tastes or other slowly changing factors, it is reasonable to assume that the value of ε_t for any individual household will only change gradually over time. Thus ε_t and ε_{t+1} or ε_{t-1} are expected to be related. More exactly, the usual assumption is that ε_t and ε_{t-1} have a bivariate normal distribution with means μ_t, μ_{t-1} variances, σ_t^2 and σ_{t-1}^2, and correlation coefficient, ρ. But this means that ε_2 and ε_0 (the values of ε at two years and at enrollment, respectively) are linked by the relationships

$$(15) \quad \begin{cases} \varepsilon_2 = \mu_2 + \rho\dfrac{\sigma_2}{\sigma_0}(\varepsilon_0 - \mu_0) + \eta_2 \\ \\ \varepsilon_0 = \mu_0 + \rho\dfrac{\sigma_0}{\sigma_2}(\varepsilon_2 - \mu_2) + \gamma_0 \end{cases}$$

where ρ is the correlation between ε_2 and ε_0, and η_2 and γ_0 are stochastic terms distributed independently of ε_0 and ε_2, respectively, with mean zero.

The estimated two-year serial correlation, based on estimating Equation (15) at enrollment and two years for Control households that move, are shown in Table 6-5.

Table 6-5

TWO-YEAR SERIAL CORRELATIONS
FOR CONTROL MOVERS

	PITTSBURGH	PHOENIX
Expenditures	0.478	0.461
Housing Services	0.415	0.383
Sample Size	(82)	(98)

SAMPLE: Control movers active at two years after enrollment excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Periodic Interviews.

Now assume that there is some selection, S, of households between t_0 and t_2. Observations are available at t_0 for both selected and nonselected households and at t_2 for selected households. Given the serial correlation of Equation (15) if the selection S does affect the distribution of ε_2 for the selected sample, so that

(16) $$\varepsilon_2^S = \mu_2 + \alpha_0 + \alpha_1 \ln(1-a) + \lambda_2,$$

where ε_2^S is ε_2 for the selected sample and $E(\lambda_2) = 0$, then ε_0^S will also be related to (1-a), using Equation (15), by

(17) $$\varepsilon_0^S = \mu_0 + \rho\frac{\sigma_0}{\sigma_2}(\varepsilon_2^S - \mu_2) + \gamma_0$$

or,

(18) $$\varepsilon_0^S = \mu_0 + \rho\frac{\sigma_0}{\sigma_2}(\alpha_0 + \alpha_1 \ln(1-a) + \lambda_2) + \gamma_0 .$$

If ε_0 has some prior relation to ln(1-a) given by

(19) $$\mu_0 = \theta_0 + \theta_1 \ln(1-a) + \lambda_0,$$

where $E(\lambda_0) = 0$, the effect of the subsequent selection, S, can be identified by

(20) $$\begin{aligned}\varepsilon_0 &= \theta_0 + \theta_1 \ln(1-a) + (\rho\frac{\sigma_0}{\sigma_2}\alpha_0)\delta + (\rho\frac{\sigma_0}{\sigma_2}\alpha_1)\delta\ln(1-a) + \xi_0 \\ &= \theta_0 + \theta_1 \ln(1-a) + \tilde{\alpha}_0\delta + \tilde{\alpha}_1\delta\ln(1-a) + \xi_0\end{aligned}$$

where

$$\delta = \begin{cases} 1 \text{ if the household is subsequently selected,} \\ 0 \text{ if the household is not subsequently selected,} \end{cases}$$

$$\tilde{\alpha}_0 = \rho\frac{\sigma_0}{\sigma_2}\alpha_0,$$

$$\tilde{\alpha}_1 = \rho\frac{\sigma_0}{\sigma_2}\alpha_1, \text{ and}$$

$$E(\xi_0) = 0.$$

Equation (2) can be used to test for the effects of selection by testing the hypothesis that the coefficients of δ and $\delta\ln(1-a)$ are zero. If they are significantly different from zero, the bias introduced into ε_2^S by the selection can be inferred by dividing the estimated coefficient of $\delta\ln(1-a)$ by the term $(\rho\ \sigma_0/\sigma_2)$.

It should be clear that the exact correction implied by finding evidence of a prior selection depends on when the selection took place. The model above suggested the selection processes: one occurring before enrollment (t=0) which introduced the prior relationship between ε_0 and ln(1-a) shown in Equation (19); the other occurring at two years after enrollment (t=2) which introduced an additional relationship for ε_0 of the selected sample as shown in Equation (16). The prior selection will shift the expected value of ε_2 (via serial correlation) by the amount $(\rho\ \sigma_0/\sigma_2)\ (\theta_0 + \theta_1 \ln(1-a))$.[1] The correction for ε_2 is obtained by multiplying θ_0 or θ_1 by $(\rho\ \sigma_0/\sigma_2)$. The subsequent selection induces a relationship with ε_0 of $(\rho\ \sigma_2/\sigma_0)$ $(\alpha_0 + \alpha_1 \ln(1-a))$. The correction for ε_2 is obtained by dividing $\tilde{\alpha}_0$ or $\tilde{\alpha}_1$ (the effects on ε_0 as shown in Equation (20)) by $(\rho\ \sigma_2/\sigma_0)$. Yet a third possibility is that a selection process occurs between ε_0 and ε_2. If so, it may affect both errors (ε_0 and ε_2) equally. In this case, the correction for ε_2 is simply equal to the effect on ε_0.

The details of alternative models are discussed further in Appendix XI. The important point to be made here is that the exact correction depends critically on prior specification of when the selection occurred. This can be more complicated than it seems, as the time of the selection depends on the time period on which the selection decision was based rather than the moment at which the decision was actually made. (For example, if households acceptance of the enrollment offer reflects their assessment of their future

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[1]This is simply the usual components of variance case in which serial correlation can be used to control for sampling error or selection effects in the initial assignment to experimental plans. As is well known, this provides more exact estimates of experimental effects. This technique was not used in the main body of the report because of the interest in estimating both price and income elasticities. Controlling for initial position would clearly be appropriate in estimating the effects of the Percent of Rent rebates. It would just as clearly give spuriously tight confidence intervals for income elasticities.

To take the extreme case, say that the three-year average income data collected by the experiment is used for all estimates (that is, the same income variable is used for estimating the pre-experimental demand function and initial error term and in estimating the final cross section). In this case the estimated initial error, $\hat{\varepsilon}_0$, is by construction orthogonal to ln(Y). Thus, its inclusion cannot possible affect the estimated income elasticity. It would therefore be misleading to use it in the two-year cross-sectional estimates to reduce the standard error and thus the estimated error of estimate for the income elasticity. See Appendix VI for estimated price elasticities taking account of serial correlation.

expenditures, the selection would not be on ε_0 (the error at enrollment) but on later values of ε.) Despite these complications, the most plausible model appears to be that selections subsequent to enrollment occurred on average one year after enrollment and will thus affect both ε_0 and ε_2 equally.

Actual estimation of selection effects was done using both the entire Baseline sample (the sample of households that completed the Baseline Interview, administered before households were told about the experiment) and the sample of enrolled households. While several models of selection indicate no significant selection effects, the most plausible model of selection effects suggests that expenditure and housing services elasticities could be biased by the amounts shown in Table 6-6.

Table 6-6

POSSIBLE BIAS IN PRICE ELASTICITIES

	PITTSBURGH	PHOENIX
Expenditures	+0.059	-0.092
Housing services	+0.008	-0.052

SOURCE: Appendix XI.

The only statistically significant bias found was for Phoenix expenditures. Note also that while the estimated direction of bias is consistent with theory in Phoenix (that is, the bias increases the absolute size of the estimated price elasticity), there is an opposite effect in Pittsburgh. This suggests that the estimates may reflect sampling error more than systematic selection. In any case, while correcting elasticity estimates for bias would increase the absolute value of the estimated elasticity in Pittsburgh and reduce it in Phoenix, the two-site average is essentially unchanged. Thus it appears that sample selection processes if they occurred were not severe enough to materially alter the conclusions of Chapters 4 or 5.

6.3 PROGRAM UNDERSTANDING

Program understanding by participant households is a difficult issue to deal with. If households receiving a rent rebate did not properly understand the relationship between their rent payment and the rebate, then they would not have responded in the theoretically expected way. If this problem were widespread, then the interpretation of the estimated price elasticity is questionable.

Households enrolled in the Percent of Rent plans were contacted up to five times during the experiment with both specific and general information about how a rent rebate worked, on both an individual and a group basis. The first relevant contact was the Enrollment Interview in which the percentage rent rebate was described in detail (in English or Spanish, as appropriate), the household's particular percentage rebate identified and explained with an example, and any questions clarified.[1] This interview was followed up by a booklet (in English or Spanish) explaining the Demand Experiment procedures and the concept of a rent rebate payment. In addition, there was a Housing Information Program which, in the first session held in the first weeks of participation, also gave a general description of the rent rebate offer (attendance, however, was voluntary).[2] Finally, detailed letters including examples were sent to each household at 4 and again at 12 months into the program.[3]

Two questions were included on each Periodic Interview to assess households' program understanding: (1) "What do you think would happen to your housing allowance payments if your landlord increased your rent by $10 a month... would your payments go up, go down, or stay the same?" and (2) (if the respondent answered go up or down), "By how much would you expect your monthly allowance to change?"[4] As might be expected, a larger percentage of the population got the first question correct than the second (see Table

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[1] The interview also collected information for final determination of program eligibility and allowance amount.

[2] Only about one-quarter of all Experimental households attended this session (29 percent in Pittsburgh, 25 percent in Phoenix).

[3] Further, households were free to query site offices at any time with questions about the program.

[4] First Periodic Questions 13.2 and 13.2A, Second Periodic Questions 4.2 and 4.2A, and Third Periodic Questions 5.2 and 5.2A.

6-7).[1] The mean percentage rebate given by respondents that answered the first question correctly appears to be independent of the actual percentage rebate, however. This is because of the large proportion of households responding "$5" or "$10" to the second question, irrespective of treatment group. Indeed, most of the correct responses for the whole sample can be attributed to responses of "$5" for the 50 percent treatment group. Thus it appears that the answers to the second question are not valid and cannot be used for further investigation.[2]

Program understanding has therefore been defined on the basis of the first question. The following definition of understanding was used: a household understood the program if it gave the correct response on any Periodic Interview (74 percent did so in Pittsburgh, 76 percent in Phoenix).[3] A log-linear demand function was estimated for all movers and also separately for those defined as understanding and those not understanding (that is, never understood the general direction on any Periodic Interview). Variance ratio tests for overall homogeneity in the relationships could not reject the hypothesis of no difference between the groups. An additional test allowed the price elasticity alone to differ between the groups. Analysis of covariance could not reject the hypothesis of no difference.

In conclusion, it appears that though many households do not appear to have understood the program (as understanding is defined here), their response to the allowance payment can be analyzed _as if_ they understood. It appears more likely that households did not understand the question than that they did not understand the program.

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[1]A correct response to the first question would be "go up." A correct response to the second would be the actual dollar change, depending on their treatment group, subsequent to a correct answer on the first.

[2]It is true, however, that the proportion of households responding "$10" tended to increase with the percentage rebate level, so that the mean dollar estimate increased as well.

[3]A more restrictive definition, understanding on _all_ Periodic Interviews, resulted in a much smaller sample (25 percent understood in Pittsburgh, and 29 percent in Phoenix).

Table 6-7

PARTICIPANT UNDERSTANDING OF THE RELATIONSHIP
BETWEEN RENT AND ALLOWANCE PAYMENT

TIME OF RESPONSE	UNDERSTOOD DIRECTION OF THE RELATIONSHIP		UNDERSTOOD BOTH THE DIRECTION AND THE AMOUNT	
	Pittsburgh	Phoenix	Pittsburgh	Phoenix
Six months after enrollment	56%	61%	14%	12%
One year after enrollment	56	54	19	18
Two years after enrollment	45	49	20	25
SAMPLE SIZE	(171)	(142)	(171)	(142)

SAMPLE: Percent of Rent households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: First, Second, and Third Periodic Interviews.

REFERENCES

Griliches, Zvi, "Distributed Lags: A Survey," Econometrica, vol. 35, no. 1, January 1967, pp. 16-49.

Intriligator, Michael D., Econometric Models, Techniques, and Applications, Englewood Cliffs, N.J., Prentice-Hall, 1978.

Johnston, J., Econometric Methods, 2nd edition, New York, McGraw-Hill, 1972.

MacMillan, Jean, Mobility in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., 1978 (revised June 1980).

Mayo, Stephen K., Housing Expenditures and Quality Part I: Housing Expenditures Under a Percent of Rent Housing Allowance, Cambridge, Mass., Abt Associates Inc., 1977.

Merrill, Sally R., Hedonic Indices as a Measure of Housing Quality, Cambridge, Mass., Abt Associates Inc., December 1977 (revised June 1980).

Ohls, James C. and Cynthia Thomas, The Effects of the Seattle and Denver Income Maintenance Experiments on Housing Consumption, Ownership, and Mobility, Denver, Colorado, Mathematica Policy Research, Inc., December 31, 1979.

APPENDIX I

DESIGN OF THE DEMAND EXPERIMENT

This appendix presents a brief overview of the Demand Experiment's purpose, data collection procedures, experimental design, and sample allocation.

I.1 PURPOSE OF THE DEMAND EXPERIMENT

The Demand Experiment is one of three experiments established by the U.S. Department of Housing and Urban Development (HUD) as part of the Experimental Housing Allowance Program.[1] The purpose of these experiments is to test and refine the concept of housing allowances.

Under a housing allowance program, money is given directly to individual low-income households to assist them in obtaining adequate housing. The allowance may be linked to housing either by making the amount of the allowance depend on the amount of rent paid or by requiring that households meet certain housing requirements in order to receive the allowance payment. The initiative in using the allowance and the burden of meeting housing requirements are therefore placed upon households rather than upon developers, landlords, or the government.

The housing allowance experiments are intended to assess the desirability, feasibility, and appropriate structure of a housing allowance program. Housing allowances could be less expensive than some other kinds of housing programs. Allowances permit fuller utilization of existing sound housing because they are not tied to new construction. Housing allowances may also be more equitable. The amount of the allowance can be adjusted to changes in income without forcing the household to change units. Households may also, if they desire, use their own resources (either by paying higher rent or by searching carefully) to obtain better housing than is required to qualify for the allowance. As long as program requirements are met, housing allowances offer households considerable choice in selecting housing most appropriate to their needs--for example, where they live (opportunity to locate near schools, near work, near friends

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[1]The other two experiments are the Housing Allowance Supply Experiment and the Administrative Agency Experiment.

or relatives, or to break out of racial and socioeconomic segregation) or the type of unit they live in (single-family or multifamily). Finally, housing allowances may be less costly to administer. Program requirements need not involve every detail of participant housing. The burden of obtaining housing that meets essential requirements is shifted from program administrators to participants.

These potential advantages have not gone unquestioned. Critics of the housing allowance concept have suggested that low-income households may lack the expertise necessary to make effective use of allowances; that the increased supply of housing needed for special groups such as the elderly will not be provided without direct intervention; and that an increase in the demand for housing without direct support for the construction of new units could lead to a substantial inflation of housing costs.[1]

If housing allowances prove desirable, they could be implemented through a wide range of possible allowance formulas, housing requirements, non-financial support (such as counseling), and administrative practices. The choice of program structure could substantially affect both the program's costs and impact.

The Demand Experiment addresses issues of feasibility, desirability, and appropriate structure by measuring how individual households (as opposed to the housing market or administrative agencies) react to various allowance formulas and housing standards requirements. The analysis and reports are designed to answer six policy questions:

1. <u>Participation</u>

   Who participates in a housing allowance program? How does the form of the allowance affect the extent of participation for various households?

2. <u>Housing Improvements</u>

   Do households that receive housing allowances improve the quality of their housing? At what cost? How do households

[1] The issue of inflation is being addressed directly as part of the Housing Allowance Supply Experiment.

that receive a housing allowance seek to improve their housing--by moving, by rehabilitation? With what success?

3. Locational Choice

For participants who move, how does their locational choice compare with existing residential patterns? Are there non-financial barriers to the effective use of a housing allowance?

4. Administrative Issues

What administrative issues and costs are involved in the implementation of a housing allowance program?

5. Form of Allowance

How do the different forms of housing allowance compare in terms of participation, housing quality achieved, locational choice, costs (including administrative costs), and equity?

6. Comparison with Other Programs

How do housing allowances compare with other housing programs and with income maintenance in terms of participation, housing quality achieved, locational choice, costs (including administrative costs), and equity?

The Demand Experiment tests alternative housing allowance programs to provide information on these policy issues. While the experiment is focused on household behavior, it also offers data on program administration to supplement information gained through the Administrative Agency Experiment. Finally, the Demand Experiment gathers direct information on participants and housing conditions for a sample of households in conventional HUD-assisted housing programs at the two experimental sites for comparison with allowance recipients.

I.2 DATA COLLECTION

The Demand Experiment was conducted at two sites--Allegheny County, Pennsylvania (Pittsburgh), and Maricopa County, Arizona (Phoenix). HUD selected these two sites from among 31 Standard Metropolitan Statistical Areas (SMSAs) on the basis of their growth rates, rental vacancy rates, degree of racial concentration and housing costs. Pittsburgh and Phoenix were chosen to provide contrasts between an older, more slowly growing Eastern metropolitan area and a newer, relatively rapidly growing Western metropolitan area. In addition, Pittsburgh has a substantial black minority and Phoenix a substantial Spanish American minority population.

Most of the information on participating households was collected from:

Baseline Interviews, conducted by an independent survey operation before households were offered enrollment;

Initial Household Report Forms and monthly Household Report Forms, completed by participating households during and after enrollment, which provided operating and analytic data on household size and income and on housing expenditures.

Supplements to the Household Report Forms, completed annually by participating households after enrollment, which provide data on assets, income from assets, actual taxes paid, income from self-employment, and extraordinary medical expenses;

Payments and status data on each household maintained by the site offices;

Housing Evaluation Forms, completed by site office evaluators at least once each year for every dwelling unit occupied by participants, which provide information on housing quality;

Periodic Interviews, conducted approximately six, twelve, and twenty-four months after enrollment by an independent survey operation; and

Exit Interviews, conducted by an independent survey operation for a sample of households that declined the enrollment offer or dropped out of the program.

Surveys and housing evaluations were also administered to a sample of participants in other housing programs: Public Housing, Section 23/8 Leased Housing, and Section 236 Interest Subsidy Housing.

Since households were enrolled throughout the first ten months of operations, the operational phase of the experiment extended over nearly four years in total. Analysis will be based on data collected from households during their first two years after enrollment in the experiment. The experimental programs were continued for a third year in order to avoid confusion between participants' reactions to the experimental offers and their adjustment to the phaseout of the experiment. During their last year in the experiment eligible and interested households were aided in entering other housing programs.

I.3 ALLOWANCE PLANS USED IN THE DEMAND EXPERIMENT

The Demand Experiment tested a number of combinations of payment formulas and housing requirements and several variations within each of these combinations. These variations allow some possible program designs to be tested directly. More importantly, they allow estimation of key responses such as participation rates and changes in participant housing in terms of basic program parameters such as the level of allowances; the level and type of housing requirements; the minimum fraction of its own income that a household can be expected to contribute toward housing; and the way in which allowances vary with household income and rent. These response estimates can be used to address the policy questions for a larger set of candidate program plans, beyond the plans directly tested.[1]

Payment Formulas

Two payment formulas were used in the Demand Experiment--Housing Gap and Percent of Rent.

Under the Housing Gap formula, payments to households constitute the difference between a basic payment level, C, and some reasonable fraction of family income. The payment formula is:

$$P = C - bY$$

where P is the payment amount, C is the basic payment level, "b" is the rate at which the allowance is reduced as income increases, and Y is

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[1]The basic design and analysis approach, as approved by the HUD Office of Policy Development and Research, is presented in Abt Associates Inc., Experimental Design and Analysis Plan of the Demand Experiment, Cambridge, Mass., August 1973, and in Abt Associates Inc., Summary Evaluation Design, Cambridge, Mass., June 1973. Details of the operating rules of the Demand Experiment are contained in Abt Associates Inc., Site Operating Procedures Handbook, Cambridge, Mass., April 1973.

the net family income.[1] The basic payment level, C, varies with household size, and is proportional to C*, the estimated cost of modest existing standard housing at each site.[2] Thus, payment under the Housing Gap formula can be interpreted as making up the difference between the cost of decent housing and the amount of its own income that a household should be expected to pay for housing.[3]

Under the Percent of Rent formula, the payment is a percentage of the household's rent. The payment formula is:

$$P = aR$$

where R is rent and "a" is the fraction of rent paid by the allowance. In the Demand Experiment the value of "a" remained constant once a household had been enrolled.[4]

Housing Requirements

The Percent of Rent payment formula is tied directly to rent: a household's allowance payment is proportional to the total rent. Under the Housing Gap formula, however, specific housing requirements are needed to tie the allowance to housing. Two types of housing requirement were used: Minimum Standards and Minimum Rent.

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[1] In addition, whatever the payment calculated by the formula, the actual payment cannot exceed the rent paid.

[2] The housing cost parameter, C*, was established from estimates given by a panel of qualified housing experts in Pittsburgh and Phoenix. For more detailed discussion regarding the derivation of C*, refer to Abt Associates Inc., Working Paper on Early Findings, Cambridge, Mass., January 1975, Appendix II.

[3] As long as their housing met certain requirements (discussed below), Housing Gap households could spend more or less than C* for housing, as they desired, and hence contribute more or less than "b" of their own income. This is in contrast to other housing programs, such as Section 8 (Existing).

[4] Five values of "a" were used in the Demand Experiment. Once a family had been assigned its "a" value, the value generally stayed constant in order to aid experimental analysis. In a national Percent of Rent program, "a" would probably vary with income and/or rent. Even in the experiment, if a family's income rose beyond a certain point, the value of "a" dropped rapidly to zero. Similarly, the payment under Percent of Rent could not exceed C* (the maximum payment under the modal Housing Gap plan), which effectively limited the rents subsidized to less than C*/a.

Under the Minimum Standards requirement, participants received the allowance payment only if they occupied dwellings that met certain physical and occupancy standards. Participants occupying units that did not meet these standards either had to move or arrange to improve their current units to meet the standards. Participants already living in housing that met standards could use the allowance to pay for better housing or to reduce their rent burden (the fraction of income spent on rent) in their present units.

If housing quality is broadly defined to include all residential services, and if rent levels are highly correlated with the level of services, then a straightforward housing requirement (one that is relatively inexpensive to administer) would be that recipients spend some minimum amount on rent. Minimum Rent was considered as an alternative to Minimum Standards in the Demand Experiment, in order to observe differences in response and cost and to assess the relative merits of the two types of requirements. Although the design of the experiment used a fixed minimum rent for each household size, a direct cash assistance program could employ more flexible structures. For example, some features of the Percent of Rent formula could be combined with the Minimum Rent requirement. Instead of receiving a zero allowance if their rent is less than the Minimum Rent, households might be paid a fraction of their allowance depending on the fraction of Minimum Rent paid.

Allowance Plans Tested

The three combinations of payment formulas and housing requirements used in the Demand Experiment were Housing Gap Minimum Standards, Housing Gap Minimum Rent, and Percent of Rent. A total of 17 allowance plans were tested.

The twelve Housing Gap allowance plans are shown in Table I-1. The first nine plans include three variations in the basic payment level, C (1.2C*, C*, and 0.8C*) and three variations in housing requirements (Minimum Standards, Minimum Rent Low (0.7C*), and Minimum Rent High (0.9C*)). The value of "b"--the rate at which the allowance is reduced as income increases--is 0.25 for each of these plans. The next two plans have the same level of C (C*) and use the Minimum Standards Housing Requirement, but use different values of "b". In the tenth plan the value of "b" is 0.15, and in the eleventh plan, 0.35. Finally, the twelfth plan is unconstrained, that is, it has no housing requirement. This unconstrained plan allows a direct comparison with a general income-transfer program.

Eligible households that did not meet the housing requirement were still able to enroll. They received full payments whenever they met the requirements during the three years of the experiment. Even before meeting the housing requirements, such households received a cooperation payment of $10 per month as long as they completed all reporting and interview requirements.

Within the Housing Gap design, the average effects of changes in the allowance level or housing requirements can be estimated for all the major responses. In addition, interactions between the allowance level and the housing requirement can be assessed. Responses to variations in the allowance/income schedule (changes in "b") can be estimated for the basic combination of the Minimum Standards housing requirement and payments level of C*.

The Percent of Rent allowance plans consist of five variations in "a" (the proportion of rent paid to the household), as shown in Table I-1.[1] A demand function for housing is estimated primarily from the Percent of Rent observations. Demand functions describe the way in which the amount people will spend on housing is related to their income, the relative price of housing and other goods, and various demographic characteristics. Such functions may be used to simulate response to a variety of possible rent subsidy programs not directly tested within the Demand Experiment. Together with estimates of supply response, they may also be used to simulate the change in market prices and housing expenditures over time due to shifts in housing demand or costs.

[1]Designation of multiple plans for the same "a" value reflects an early assignment convention and does not indicate that the households in these plans were treated differently for either payment purposes or analysis.

Table I-1
ALLOWANCE PLANS TESTED

HOUSING GAP: ($P = C - bY$, where C is a multiple of C^*)

b VALUE	C LEVEL	HOUSING REQUIREMENTS			
		Minimum Standards	Minimum Rent Low = $0.7C^*$	Minimum Rent High = $0.9C^*$	No Requirement
b = 0.15	C^*	Plan 10			
b = 0.25	$1.2C^*$	Plan 1	Plan 4	Plan 7	
	C^*	Plan 2	Plan 5	Plan 8	Plan 12
	$0.8C^*$	Plan 3	Plan 6	Plan 9	
b = 0.35	C^*	Plan 11			

Symbols b = Rate at which the allowance decreases as the income increases.
C^* = Basic payment level (varied by family size and also by site).

PERCENT OF RENT ($P = aR$)

a = 0.6	a = 0.5	a = 0.4	a = 0.3	a = 0.2
Plan 13	Plans 14 - 16	Plans 17 - 19	Plans 20 - 22	Plan 23

CONTROLS:

With Housing Information	Without Housing Information
Plan 24	Plan 25

Control Groups

In addition to the various allowance plans, control groups were necessary in order to establish a reference level for responses, since a number of uncontrolled factors could also induce changes in family behavior during the course of the experiment. Control households received a cooperation payment of $10 per month. They reported the same information as families that received allowance payments, including household composition and income; they permitted housing evaluations; and they completed the Baseline Interview and the three Periodic Interviews. (Control families were paid an additional $25 fee for each Periodic Interview.)

Two control groups were used in the Demand Experiment. Members of one group (Plan 24) were offered a Housing Information Program when they joined the experiment and were paid $10 for each of five sessions attended. (This program was also offered to households enrolled in the experimental allowance plans but they were not paid for their attendance.) The other control group (Plan 25) was not offered the Housing Information Program.

All the households in the various allowance plans had to meet a basic income eligibility requirement. This limit was approximately the income level at which the household would receive no payment under the Housing Gap formula:

$$\text{Income Eligibility Limit} = \frac{C^*}{0.25}$$

In addition, households in plans with lower payment levels (Plans 3, 6, 9 and 11) had to have incomes low enough at enrollment to receive payment under these plans. Finally, only households with incomes in the lower third of the eligible population were eligible for enrollment in Plan 13, and only those in the upper two-thirds were eligible for Plan 23.

I.4 FINAL SAMPLE

Final analysis of the impact of the housing allowance will be based on the first two years of experimental data. Thus, the key sample size for this report and the other reports in this series is the number of households in the experiment at the end of the first two years. The two-year sample size is shown in Table I-2, and comprises households that were still active, in the sense that they were continuing to fulfill reporting requirements. The sample size for a particular analysis may be smaller. For example, analysis of the housing expenditures of movers uses only those households that moved during the first two years after enrollment.

Table I-2
SAMPLE SIZE AFTER TWO YEARS

HOUSING GAP: ($P = C - bY$, where C is a multiple of C*)

b VALUE	C LEVEL	HOUSING REQUIREMENTS: Minimum Standards	Minimum Rent Low = 0.7C*	Minimum Rent High = 0.9C*	No Requirement
b = 0.15	C*	Plan 10 PIT = 45 PHX = 36			
b = 0.25	1.2C*	Plan 1 PIT = 33 PHX = 30	Plan 4 PIT = 34 PHX = 24	Plan 7 PIT = 30 PHX = 30	
	C*	Plan 2 PIT = 42 PHX = 35	Plan 5 PIT = 50 PHX = 39	Plan 8 PIT = 44 PHX = 44	Plan 12 PIT = 63 PHX = 40
	0.8C*	Plan 3 PIT = 43 PHX = 39	Plan 6 PIT = 44 PHX = 35	Plan 9 PIT = 43 PHX = 35	
b = 0.35	C*	Plan 11 PIT = 41 PHX = 34			

Total Housing Gap: 512 households in Pittsburgh, 421 households in Phoenix.

Symbols: b = Rate at which the allowance decreases as the income increases.
C* = Basic payment level (varied by family size and also by site).

PERCENT OF RENT ($P = aR$):

a = 0.6	a = 0.5	a = 0.4	a = 0.3	a = 0.2
Plan 13 PIT = 28 PHX = 21	Plans 14 - 16 PIT = 109 PHX = 81	Plans 17 - 19 PIT = 113 PHX = 66	Plans 20 - 22 PIT = 92 PHX = 84	Plan 23 PIT = 65 PHX = 46

Total Percent of Rent: 407 households in Pittsburgh, 298 households in Phoenix

CONTROLS:

With Housing Information	Without Housing Information
Plan 24 PIT = 159 PHX = 137	Plan 25 PIT = 162 PHX = 145

Total Controls: 321 households in Pittsburgh, 282 households in Phoenix.

NOTE This sample includes households that were active, although not necessarily receiving payments, after two years of enrollment; households whose enrollment income was above the eligibility limits or that moved into subsidized housing or their own homes are excluded. While data on the excluded households may be useful for special analyses, particular analyses may also require the use of a still more restricted sample than the one shown here

APPENDIX II

DESCRIPTION OF THE SAMPLES USED FOR ANALYSIS

This appendix discusses the households selected for analysis in this report and explores some of the factors affecting the exclusion of households from a particular sample. In addition, since the final analytic sample is smaller than the original sample at enrollment, the comparability of the final and original samples is examined.

Table II-1 shows the samples used in this report.[1] The sample of enrolled households is included to demonstrate attrition during the course of the experiment. The sample of households active at two years is used for most of the analysis in this report. The samples of households that moved or did not move over the two-year experimental period are examined separately as well. The Percent of Rent sample is presented broken down by treatment group in Table II-2.

Table II-3 sets out demographic characteristics for the eligible enrolled and active populations. (See Appendix III for definitions of the characteristics.)

Comparison of the pre-experimental (baseline) characteristics of Experimental and Control households at enrollment and at two years after enrollment shows that the sample characteristics remain basically the same throughout the course of the experiment.[2] One exception was the Percent of Rent group receiving a 60 percent rent rebate; only households in the lower third of the eligible income range could participate in this group. In any event,

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[1] All samples exclude households enrolled with incomes above the eligibility limit. In general, households were not allowed to enroll in the experiment if their verified income exceeded the eligibility limit for their treatment group. Verification of income took up to two months, depending on the speed with which income sources (e.g., employers, welfare agencies, and pension funds) replied to requests for information. Towards the end of the enrollment period, it was more efficient to enroll some households prior to the completion of verification and exclude them from the sample if they were later verified to be overincome, since this allowed the enrollment period to be closed (and hence the experimental operations to begin) two months earlier.

[2] The sample sizes in Table II-3 are slightly smaller than those in Tables II-1 and II-2 due to missing values on some demographic variables.

Table II-1

OVERVIEW OF SAMPLES USED FOR ANALYSIS IN THIS REPORT

SAMPLE	TREATMENT TYPE: PERCENT OF RENT	TREATMENT TYPE: UNCONSTRAINED	TREATMENT TYPE: CONTROL	TOTAL
PITTSBURGH				
Enrolled households	510	75	434	1,019
Households active at two years[a]	407	63	321	791
Households that moved between enrollment and two years[a]	153	25	112	290
Households that did not move between enrollment and two years[a]	254	38	209	501
PHOENIX				
Enrolled households	490	70	525	1,085
Households active at two years[a]	298	40	282	620
Households that moved between enrollment and two years[a]	182	23	148	353
Households that did not move between enrollment and two years[a]	116	17	134	267

DATA SOURCES: Payments file and Periodic Interviews.

NOTE: Samples exclude households with enrollment incomes over the eligibility limits.

a. Excludes households living in their own homes or in subsidized housing.

Table II-2

PERCENT OF RENT SAMPLE AT TWO YEARS USED FOR ANALYSIS IN THIS REPORT

PERCENTAGE REBATE	NUMBER OF HOUSEHOLDS ACTIVE AT TWO YEARS	
	Pittsburgh	Phoenix
60%	28	21
50%	109	81
40%	113	66
30%	92	84
20%	65	46

SAMPLE: Percent of Rent households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCE: Payments file.

Table II-3

SELECTED HOUSEHOLD CHARACTERISTICS AT BASELINE FOR THE ELIGIBLE, ENROLLED, AND TWO-YEAR ACTIVE SAMPLE

SAMPLE	MEAN RENT	MEAN MONTHLY INCOME	MEAN HOUSEHOLD SIZE	PERCENTAGE ELDERLY	PERCENTAGE MINORITY	PERCENTAGE FEMALE-HEADED	SAMPLE SIZE
			PITTSBURGH				
Eligible Households	$107	$335	2.8	37%	20%	54%	(2,948)
Enrolled Households							
Percent of Rent	111	377	3.0	28	25	49	(480)
Percentage rebate:							
20%	108	427	3.2	27	33	56	(86)
30%	112	364	3.1	25	24	43	(115)
40%	114	416	3.1	25	27	46	(133)
50%	110	341	2 8	32	20	50	(113)
60%	107	254	2.7	36	12	67	(33)
Control	114	389	3.2	23	20	50	(403)
Households Active at Two Years[a]							
Percent of Rent	112	384	3.0	28	21	50	(382)
Percentage rebate							
20%	109	426	3 0	30	30	60	(60)
30%	110	360	2.9	26	21	47	(89)
40%	118	449	3.3	22	21	43	(104)
50%	111	345	2.8	31	19	49	(102)
60%	107	260	2.8	33	11	63	(27)
Control	115	399	3.3	21	19	51	(297)
			PHOENIX				
Eligible Households	$128	$417	3.2	22%	34%	34%	(2,956)
Enrolled Households							
Percent of Rent	134	442	3.2	20	31	37	(454)
Percentage rebate.							
20%	138	450	2.8	31	25	35	(80)
30%	135	455	3 5	19	31	29	(125)
40%	133	438	3.1	17	27	39	(106)
50%	138	469	3 4	16	33	34	(115)
60%	101	266	3.2	21	45	79	(28)
Control	131	434	3 4	18	31	36	(474)
Households Active at Two Years[a]							
Percent of Rent	130	429	3.3	23	36	43	(274)
Percentage rebate:							
20%	128	424	2.6	42	30	44	(43)
30%	128	436	3.8	25	39	39	(75)
40%	130	455	3.2	17	33	43	(58)
50%	138	442	3.4	19	34	36	(80)
60%	106	266	3.6	11	61	89	(18)
Control	124	420	3.4	22	36	44	(257)

DATA SOURCES Household Events List, Initial and monthly Household Report Forms, and payments file
NOTE Samples exclude households with enrollment incomes over the eligibility limits
a. Excludes households living in their own homes or in subsidized housing.

the relevant characteristics of this group appear to remain constant over the course of the experiment.

Not all households offered enrollment in the experimental housing allowance program accepted the offer. Overall acceptance by eligible households offered enrollment in Pittsburgh was 75 percent for Percent of Rent households and 60 percent for Control households.[1] In Phoenix, 83 percent of the Percent of Rent and 75 percent of the Control households accepted. Acceptance rates appear unrelated to the Percent of Rent discount level (see Table II-4).

Of all the households accepting the enrollment offer, 98 percent of the Percent of Rent households in both sites actually enrolled in the program. The figures for the Control households are somewhat lower, 85 percent in Pittsburgh and 93 percent in Phoenix.[2]

Finally, of the enrolled households, 74 percent of the Pittsburgh Control households and 80 percent of the Pittsburgh Experimental households remained active in the program for the full two years. In Phoenix, a smaller percentage remained: 54 percent of the Control and 61 percent of the Percent of Rent households. Table II-5 shows that there may have been an experimental effect on attrition, as attrition rates tended to decrease as the subsidy level increased.[3]

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[1]The basic eligibility criterion for admission into the Demand Experiment was an income threshold which varied by household size. Nevertheless, for administrative reasons, there were some households offered admission to the program who were above the income limit at the time of the Baseline Interview. This was especially true for the Control group. Some of the "overincome" households later fell below the income limit during the course of the experiment.

[2]Most of the households that accepted the enrollment offer but that were not actually enrolled were deemed ineligible because their verified incomes were too high (see Hoaglin and Joseph, 1978).

[3]Possible bias due to acceptance and attrition is dealt with in Section 6.2 and Appendix XI.

Table II-4

ACCEPTANCE RATES OF PERCENT OF RENT AND
CONTROL HOUSEHOLDS OFFERED ENROLLMENT

SAMPLE	PITTSBURGH		PHOENIX	
	NUMBER OF HOUSEHOLDS OFFERED ENROLLMENT	PERCENTAGE ACCEPTING	NUMBER OF HOUSEHOLDS OFFERED ENROLLMENT	PERCENTAGE ACCEPTING
Control	678	60%	662	75%
Percent of Rent	521	75	603	83
Percentage rebate:				
20%	152	70	115	77
30%	152	76	167	81
40%	172	78	141	89
50%	167	75	130	86
60%	54	72	50	82

SAMPLE: Percent of Rent and Control households that received an enrollment offer excluding those with enrollment incomes above the eligibility limits.

DATA SOURCE: Household Events List.

Table II-5

RATES OF CONTINUED ENROLLMENT FOR PERCENT OF RENT AND CONTROL HOUSEHOLDS FOR THE FULL TWO YEARS

SAMPLE	PITTSBURGH		PHOENIX	
	NUMBER OF HOUSEHOLDS ENROLLED	PERCENTAGE ACTIVE AT TWO YEARS	NUMBER OF HOUSEHOLDS ENROLLED	PERCENTAGE ACTIVE AT TWO YEARS
Control	434	74%	525	54%
Percent of Rent	510	80	490	61
Percentage Rebate				
20%	92	71	84	55
30%	118	78	140	60
40%	145	78	118	56
50%	121	90	116	70
60%	34	82	32	66

SAMPLE: Percent of Rent and Control households that enrolled, excluding those with enrollment incomes over the eligibility limits.

DATA SOURCES: Household Events List, Initial and monthly Household Report Forms, and payments file.

REFERENCES

Hoaglin, David C. and Catherine A. Joseph, Income Reporting and Verification in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., April 1978 (revised June 1980).

APPENDIX III

DATA SOURCES AND MAJOR VARIABLES USED IN THE ANALYSIS

III.1 DATA SOURCES

Table III-1 indicates the data sources used in the derivation of each of the variables used for the analysis in this report. If a household's record is missing from any of the data sources required for the derivation of a variable, that particular variable is assigned a missing value code and the household is removed from the sample for analyses involving that variable. Other reasons for missing value codes include nonresponses; "don't know" responses; out of range responses; and data that are inconsistent between data sources. The major data collection instruments used are discussed below.

Initial Household Report Form

Initial Household Report Forms were completed for all enrolled households as part of the enrollment interview. Enrollment interviews were conducted between April 1973 and February 1974. Detailed information was collected on each households' composition, housing expenditures (rent, utilities, furnishings, and so forth), and asset holdings (savings bonds, stocks, and so forth), as of the time of the interview. Income data were collected for each of the previous 12 months for each type of income (e.g., wages, Social Security, welfare) for each household member 18 years of age or over. Household expenses (e.g., alimony, child care, medical) were also collected for the 12 most current months. Data from the Initial Household Report Form were used operationally to determine whether initial household composition and income eligibility requirements had been met. Analytically, these data have been used to describe the household's demographic characteristics and income just prior to participation in the program.

Monthly Household Report Forms

After households were enrolled, they were required to complete monthly Household Report Forms which collected detailed information on the household's composition, housing expenditures, and income for the previous month. The information was similar to that collected on the Initial Household Report Form and

Table III-1

DATA SOURCES USED TO DERIVE KEY VARIABLES

VARIABLES	DATA SOURCES: Enrollment	DATA SOURCES: Two Years
Income Net income for analysis Net income for eligibility	Initial Household Report Form	24-month history from Household Report Form
Demographics Race/ethnicity Education of head of household	Baseline Interview	---
Age of head of household Sex of head of household Household size Household composition	Initial Household Report Form	24-month history from Household Report Form
Rent	Initial Household Report Form; Baseline Interview	Household Report Form; Third Periodic Interview
Rent Burden	Initial Household Report Form; Baseline Interview	Household Report Form; payments file; Third Periodic Interview
Satisfaction Variables	Baseline Interview	Third Periodic Interview
Housing Quality Housing standards	Housing Evaluation Form for enrollment	Housing Evaluation Form
Housing adequacy	Housing Evaluation Form for enrollment	Housing Evaluation Form
Hedonic index	Housing Evaluation Form; Census data; Baseline Interview; other site data	Housing Evaluation Form; Census data, Third Periodic Interview, other site data
Occupancy	Initial Household Report Form, Housing Evaluation Form	Household Report Form; Housing Evaluation Form
Move Status	---	Initial Household Report Form: First, Second, and Third Periodic Interview
Current Payment Status	Initial Household Report Form; payments file	24-month history from Household Report Form, payments file

was used to determine the household's monthly payment. Analytically, these data are used to describe the household's housing expenditures, demographic characteristics, and income during the course of the experiment. In addition, annual supplements collected information on assets and taxes.

Payments Data

After each monthly payment cycle, the household's current payment status, reasons for the status (if other than Full Payments status), payment period number, payment amount, and the intermediate variables used to calculate the payment were extracted from the operational payments system and entered into an analytic payments file.

Baseline Interview

Baseline Interviews[1] were administered to all households before offers to enroll in the program occurred, and were completed between March 1973 and January 1974. Data were collected in the following general categories: housing expenditures and consumption; location and housing search; neighborhood and housing preferences and satisfaction; maintenance and upgrading; household composition; household assets, income, and expenses; and participation in other government programs. The interviews provided measures of the household's position prior to the experiment.

Periodic Interviews

Periodic Interviews were administered to all enrolled households at approximately six months, one year and two years after enrollment. Data were collected on a number of subjects included in the Baseline Interview. Subject areas included housing expenditures and consumption; location and housing search; preferences and satisfaction; maintenance and upgrading; and participation in other government programs. In addition, the Periodic Interviews included questions relating to participant expectations at the time of enrollment and impressions of various

[1] This interview, as well as the Exit Interview for Non-Participants, and the First, Second, and Third Periodic Interviews, were designed by Abt Associates Inc. and administered in the field by the National Opinion Research Center; some Baseline Interviews were conducted by Westat, Inc.

aspects of the program, such as the Housing Information Program, the housing and reporting requirements, and the amount and variability of the allowance payment.

Housing Evaluation Form

Housing evaluations were conducted for all dwelling units occupied by households that accepted the enrollment offer. Units were evaluated at enrollment and whenever a participant moved or upgraded their current unit to meet either Minimum Standards or Minimum Rent housing requirements. In addition, all units were re-evaluated at least once a year. Households with a Minimum Standards requirement also could request evaluations of new units before deciding to move to see if these units met the requirement. The Housing Evaluation Form, used to collect these data on housing quality, provides information on basic housing services, safety hazards, structure and surface condition, and other indicators of housing condition.

Census Data

Census variables for Allegheny and Maricopa counties were extracted from the 1970 Census of Population and Housing Fourth Count Summary Tapes. The variables that were selected included descriptors of the tract and its housing stock and socio-economic characteristics of the population. Household-level Census tract assignments were made using standard geocoding programs at the time of enrollment and each of the Periodic Interviews. When the location by tract was determined, the Census variables for that tract were posted to the household file.

III.2 KEY VARIABLES

Key variables used in this report include income and demographic variables, rent, satisfaction, housing standards, occupancy measures, an hedonic index measuring housing services, move status, and current payment status. Definitions of the variables used in this report are discussed below. Table III-1 summarizes the data sources for these variables.

Income

A major variable used in the analysis in this report is "Net Income for Analysis," a measure of household disposable income. Net Income for Analysis is an estimate of the annual income received by all household members age 18 or over; it is the sum of earned and other income net of taxes and alimony paid. A complete list of all income components included in the definition of net income and its relation to two other income measures (the income definition used to determine eligibility for the experimental program and that used by the census) are given in Table III-2.[1]

Net Income for Eligibility defines an annual net disposable income for eligibility and payment purposes which is easily and accurately measured and which is defined as equitably as possible for demographically different households that receive income from a variety of sources (see Table III-3 for eligibility limits). Net income for eligibility was derived by adding the annual incomes of all household members who were at least 18 years of age, and subtracting taxes, work-related expenses, alimony paid, and major medical expenses. Table III-2 compares this definition with the census definition and the analytic definition of income.

Demographic Variables

Race/ethnicity. The following categories are used in this report for each site:

PITTSBURGH	PHOENIX[2]
White	White
Black	Black
	Spanish American

Classifications are based on interviewer observations of the head of household, except for the Spanish American designation, which is based on surname according to Census conventions.

Age of head of household. The age of head of household is defined according to Census conventions.

Sex of head of household. The Census convention is used. To establish the Census designated head of household, the sex and relationship of each household member to the respondent who is designated head is checked. Unless the household has a single female head, it is classified as having a male head of household.

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[1] Households with annual income less than $1000 were excluded from the analysis. Elasticity estimates were not affected by this exclusion.

[2] In some analyses both black and Spanish American households in Phoenix were classified as minority households.

Table III-2

COMPONENTS INCLUDED IN THE DEFINITION OF NET INCOME FOR ANALYSIS AND COMPARISON WITH CENSUS AND PROGRAM ELIGIBILITY DEFINITIONS

COMPONENTS	NET INCOME FOR ELIGIBILITY	NET INCOME FOR ANALYSIS	CENSUS (GROSS INCOME)
I GROSS INCOME			
A. Earned Income			
1 Wages and Salaries	X	X	X
2. Net Business Income	X	X	X
B. Income-Conditioned Transfers			
1. Aid for Dependent Children	X	X	X
2. General Assistance	X	X	X
3 Other Welfare	X	X	X
4. Food Stamps Subsidy	-	X*	-
C. Other Transfers			
1. Supplemental Security Income (Old Age Assistance, Aid to the Blind, Aid to the Disabled)	X	X	X
2. Social Security	X	X	X
3 Unemployment Compensation	X	X	X
4. Workmen's Compensation	X	X	X
5. Government Pensions	X	X	X
6. Private Pensions	X	X	X
7. Veterans Pensions	X	X	X
D. Other Income			
1. Education Grants	X	X	X
2. Regular Cash Payments	X	X	X
3 Other Regular Income	X	X	X
4 Alimony Received	X	X	X
5. Asset Income	X*	X*	X*
6. Income from Roomers and Boarders	-	-	-
II. GROSS EXPENSES			
A. Taxes			
1. Federal Tax Withheld	X*	X*	-
2. State Tax Withheld	X*	X*	-
3. FICA Tax Withheld	X*	X*	-
B. Work-Conditioned Expenses			
1. Child Care Expenses	X	-	-
2. Care of Sick at Home	X	-	-
3. Work Related Expenses	X*	-	-
C. Other Expenses			
1. Alimony Paid Out	X	X	-
2. Major Medical Expenses	X	-	-

*The amounts of these income and expense items are derived using data reported by the household. All other amounts are included in the income variables exactly as reported by the household.

Table III-3

INCOME ELIGIBILITY LIMITS AT ENROLLMENT
FOR PERCENT OF RENT AND CONTROL HOUSEHOLDS

	HOUSEHOLD SIZE				
DESIGN POINT[a]	1	2	3,4	5,6	7+
PITTSBURGH					
Treatment Groups 12, 14-23	$5,050	$5,800	$6,750	$7,700	$9,150
Treatment Group 13	3,002	3,600	4,537	5,060	5,257
Treatment Groups 24, 25[b]	12,500	12,500	12,500	12,500	12,500
PHOENIX					
Treatment Groups 12, 14-23	$6,000	$7,450	$8,650	$10,600	$12,750
Treatment Group 13	2,700	4,100	4,500	4,700	5,400
Treatment Groups 24, 25[b]	15,500	15,500	15,500	15,500	15,500

NOTE: Indicated amounts are $500 greater than formal eligibility limits. A $500 margin of error is allowed. Only households with incomes more than $500 above the formal limits are considered to be overincome.

a. Refer to the summary experimental design in Appendix I for identification of these groups.

b. These amounts were used as criteria in the actual enrollment process. Note, however, that households in these treatment groups are considered to be overincome for this income eligibility status at enrollment if their income is greater than the Income Eligibility Limits for Treatment Groups 12 and 14-23

Household size. The definition of household size includes all persons living with the household except roomers and boarders.

Household composition. This variable identifies the structure of the household based on the relationships of household members to the head. Two classifications are developed from the data.

Basic Classification:

One-person household
Single head with children; no relatives
Single head with children and relatives
Single head with no children; relatives present
Married couple; no children, no relatives
Married couple with children; no relatives
Married couple with children and relatives
Married couple with no children, but with relatives

Abbreviated Classification (eight basic categories collapsed into three):

Single-person
Single adult with children or others present
Married couple with or without others present

Rent

Analysis of participant expenditures on housing takes two basically different approaches:

How much do households spend on rent?

How much does it cost to rent a dwelling unit with particular characteristics?

These differences in approach require variations in the analytical definitions of rent. For example, reduction in rent for contributions from roomers and boarders is appropriate for the first approach but not the second.

Analytical adjusted contract rent is basically defined as the monthly payment for an unfurnished dwelling unit including basic utilities. The formula is

Adjusted Contract Rent = Contract rent + utilities - furnishings + work in lieu of rent adjustment.

The components included are discussed below:

Contract rent. Contract rent is adjusted to a monthly amount to provide a common rental period.

Utilities adjustment. If the costs of utilities are not included in the household's contract rent, utilities adjustments are added to contract rent. Adjustments are made via site-specific tables for electricity, gas, heat, water, garbage, and trash. The amount of the adjustments depends on the numbers of rooms reported in the Housing Evaluation Form. No adjustment is made for any other utilities or services, such as parking. Allowance is made for increased utility costs over the two-year experimental period.

Furnishings adjustment.[1] For furnished units, a deduction is made for the rent equivalent of furnishings.

Work in lieu of rent adjustment. If the contract rent paid by the household is reduced because a household member works for the landlord, the amount of the reduction is added to contract rent. The adjustment has not been added to income, although it should in theory be added.

The analytical adjusted contract rent used in this report for the analysis of housing expenditures refers to shelter costs borne by the household, so contributions from roomers and boarders are subtracted.[2]

Rent Burden

Rent burden was calculated as the ratio of analytic rent to net income for analysis, adjusted for allowance payments. Rent burden is thus defined as Net Rent/Net Income:

$$\text{Rent Burden} = \frac{\text{Contract Rent-Allowance Payment}^{3}}{\text{Net Income for Analysis (monthly)}}$$

Rent burden statistics are highly sensitive to the definition of income used. Statistics calculated from different sources using different definitions of income may have to be recalculated or adjusted before comparisons may be made. The Housing Allowance Demand Experiment data appear to be unique in both attempting to use an analytic definition of net disposable income and in having the data to do so. In general, the source of variation in rent burden statistics result primarily from differences in income definitions. See Budding (forthcoming) for further discussion of this problem.

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[1] For more specific definitions of these adjustments, refer to Abt Associates Inc., Working Paper on Early Findings, January 1975, Appendix IV.

[2] Households with rents less than $40 per month were excluded from the sample. This exclusion was based on a judgment that gross rent figures below this cutoff may be erroneous. Elasticity estimates were not affected by this exclusion.

[3] For Control households, the $10 cooperation payment was deducted from the contract rent amount.

Satisfaction Variables

Both housing unit and neighborhood satisfaction are measured on a four-point scale:

Very satisfied
Somewhat satisfied
Somewhat dissatisfied
Very dissatisfied.

Program Housing and Occupancy Standards

This section describes the housing and occupancy measures used in the analysis. These measures are based on the Minimum Standards housing requirements used in one part of the experiment. They were developed from elements of the American Public Health Association/Public Health Service, Recommended Housing Ordinance (1971).[1] Table III-4 lists the Minimum Standards housing requirements as they apply to the dwelling unit itself. The requirements are grouped into 15 components made up of related items.

Two physical standards and one occupancy standard are used in this report. The "low standard" applies to basic systems in and the exterior of the unit while the "program standard" includes the interior and other features. The standards that must be met to meet this low level of standard are complete plumbing, complete kitchen facilities, presence of the core rooms, adequate heating equipment, roof structure, and exterior walls (numbers 1, 2, 3, 6, 13, and 14 in Table III-4).

Occupancy requirements are separate from the physical requirements listed in Table III-4. However, the requirements for light/ventilation, ceiling height, and electrical service are applied to bedrooms in determining the number of adequate bedrooms for the program occupancy requirement. The occupancy requirement sets a maximum of two persons for every adequate bedroom, regardless of age. A studio or efficiency apartment is counted as a bedroom for occupancy standards. An adequate bedroom is a room that can be completely closed off from other rooms and that meets the following program housing standards: ceiling height, light/ventilation, and electrical service. In addition, the room must meet the housing standards for the condition of room structure, room surface, floor structure, and floor

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[1] See Abt Associates Inc. (1975) for more detail on the development of the Minimum Standards.

Table III-4

COMPONENTS OF MINIMUM STANDARDS
(Program Definition)

1 COMPLETE PLUMBING

Private toilet facilities, a shower or tub with hot and cold running water, and a washbasin with hot and cold running water will be present and in working condition

2. COMPLETE KITCHEN FACILITIES

A cooking stove or range, refrigerator, and kitchen sink with hot and cold running water will be present and in working condition.

3 LIVING ROOM, BATHROOM, KITCHEN PRESENCE

A living room, bathroom, and kitchen will be present. (This represents the dwelling unit "core," which corresponds to an efficiency unit.)

4. LIGHT FIXTURES

A ceiling or wall-type fixture will be present and working in the bathroom and kitchen.

5. ELECTRICAL

At least one electric outlet will be present and operable in both the living room and kitchen A working wall switch, pull-chain light switch, or additional electrical outlet will be present in the living room.[a]

6 HEATING EQUIPMENT

Units with no heating equipment, with unvented room heaters which burn gas, oil, or kerosene, or which are heated mainly with portable electric room heaters will be unacceptable

7. ADEQUATE EXITS

There will be at least two exits from the dwelling unit leading to safe and open space at ground level (for multifamily building only) Effective November, 1973 (retroactive to program inception) this requirement was modified to permit override on case-by-case basis where it appears that fire safety is met despite lack of a second exit.

8. ROOM STRUCTURE

Ceiling structure or wall structure for all rooms must not be in condition requiring replacement (such as severe buckling or leaning)

9. ROOM SURFACE

Ceiling surface or wall surface for all rooms must not be in condition requiring replacement such as surface material that is loose, containing large holes, or severely damaged)

10 CEILING HEIGHT

Living room, bathroom, and kitchen ceilings must be 7 feet (or higher) in at least one-half of the room area.[a]

11. FLOOR STRUCTURE

Floor structure for all rooms must not be in condition requiring replacement (such as large holes or missing parts)

12. FLOOR SURFACE

Floor surface for all rooms must not be in condition requiring replacement (such as large holes or missing parts).

13 ROOF STRUCTURE

The roof structure must be firm.

14. EXTERIOR WALLS

The exterior wall structure or exterior wall surface must not need replacement (For structure this would include such conditions as severe leaning, buckling, or sagging, and for surface conditions such as excessive cracks or holes.)

15 LIGHT/VENTILATION

The unit will have a 10 percent ratio of window area to floor area and at least one openable window in the living room, bathroom, and kitchen or the equivalent in the case of properly vented kitchens and/or bathrooms.[a]

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a. This housing standard is applied to bedrooms in determining the number of adequate bedrooms for the program occupancy standard.

surface. If the dwelling unit contains four or more adequate bedrooms, it is judged to meet occupancy standards; this reflects the actual program operating rule, which set this ceiling to occupancy standards at the requirement for an eight-member household. (Roomers and boarders are added to household size when determining whether a household meets occupancy standards, because all the rooms in the dwelling unit are taken into account.)

Housing Adequacy Measure

The housing adequacy measure classifies units into one of three categories: clearly inadequate, at least minimally adequate, or ambiguous. The measure is closely related to the Minimum Standards measure in that the adequacy measure includes all but one (bathroom window adequacy) of the Minimum Standards indicators plus only two additional indicators (presence of rats and window condition). See Chapter 5 and Budding (1978) for a more detailed description.

Hedonic Index of Housing Services

The hedonic index is a summary measure of housing services. This index estimates the market value of a unit in terms of the attributes of the unit itself, the neighborhood and the quality of public and private services available. See Chapter 5 and Merrill (1977) for a more detailed description.

Move Status

Determination of a move is always based on the comparison of addresses rather than on the household's response to interview questions regarding moving. A household is classified as having moved during the experiment if the address on the Initial Household Report Form is different from any of the addresses reported by the household during the two-year experimental period.

Current Payment Status

Status of the household is defined as one of the following:

Active full payments

Active minimum payments

Inactive, reactivated for later cycles (for example, households that moved out of county and then moved back into the county)

Inactive, never reactivated in later cycles

Terminated.

Possible reasons for minimum payments status are:

Household owns home
Household lives in subsidized housing
Rent receipt not returned
Failure to meet housing requirements (housing Gap Minimum Rent and Minimum Standards groups only).

Possible reasons for inactive or terminated status are:

Move out of county
Ineligible household composition
Residing in institution
Cannot locate
Periodic Interview refused
Housing Evaluation refused
Missing Evaluation refused
Missing Household Report Forms
New household members refused to comply with requirements.

Additional possible reasons for termination are:

Household deceased
Ineligible household split
Fraud
Received ineligible relocation benefits
Termination other (conflict of interest)
Reverification refused
Quit (voluntary termination).

REFERENCES

Abt Associates Inc., Working Paper on Early Findings, Cambridge, Mass., January 1975.

Budding, David, W., Housing Deprivation Among Enrollees in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., November 1978 (revised June 1980).

Merrill, Sally R., Hedonic Indices as a Measure of Housing Quality, Cambridge, Mass., Abt Associates Inc., December 1977 (revised June 1980).

APPENDIX IV

HOUSING PROGRAM EFFICIENCY[1]

One criterion for evaluating a housing program is the extent to which payments are translated into increased housing expenditures. In these terms, program "efficiency" may be narrowly defined as the ratio of the change in total rental expenditures to the payment amount, or

$$E = \frac{R_1 - R_0}{S} \quad , \tag{1}$$

where

E = subsidy efficiency

S = the amount of the allowance payment

R_1 = total rental expenditures (after subsidy), and

R_0 = total rental expenditures (before subsidy).

Thus, if none of the subsidy is used to increase rental expenditures its efficiency will be zero; if the entire subsidy is added to pre-existing rental expenditures, its efficiency will equal one.[2]

Under a Percent of Rent housing allowance, the payment is equal to a fraction, "a," of rent, so that

$$E = \frac{R_1 - R_0}{aR_1} \quad . \tag{2}$$

Efficiency can be computed based on the log-linear housing demand function,

$$\begin{cases} \ln(R) = \ln(\alpha) + \beta_1 \ln(Y) + (1+\beta_2)\ln(p_H), \text{ also written} \\ R = \alpha Y^{\beta_1} p_H^{(1+\beta_2)} \end{cases} \tag{3}$$

where

R = total rental expenditures

Y = disposable income

p_H = price of housing, and

$\alpha,\ \beta_1,\ \beta_2$ = demand function parameters.

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[1] This appendix is drawn from Mayo (1977).

[2] Efficiency is not constrained to the zero-one range.

Equilibrium rental expenditures after the percentage price subsidy are related to equilibrium rental expenditures before the subsidy by

$$(4) \qquad R_1 = R_0(1-a)^{\beta_2}.$$

Substituing Equation (4) into Equation (2) gives[1]

$$(5) \qquad E = \frac{(1-a)^{\beta_2}-1}{a(1-a)^{\beta_2}} = \frac{1}{a}\,[1-(1-a)^{-\beta_2}].$$

Thus, the efficiency of a Percent of Rent payment is determined by two parameters--the percentage rebate, "a," and the price elasticity, β_2. Table IV-1 presents values of subsidy efficiency for several hypothetical combinations of percentage rebate and price elasticity.

Table IV-1

SUBSIDY EFFICIENCY OF PERCENT OF RENT SUBSIDIES
FOR DIFFERENT SUBSIDY RATES AND PRICE ELASTICITIES

	PRICE ELASTICITY OF DEMAND (β_2)			
SUBSIDY RATE (a)	-0.25	-0.50	-0.75	-1.00
0.2	0.27	0.53	0.77	1.00
0.4	0.30	0.56	0.80	1.00
0.6	0.34	0.61	0.83	1.00

The table indicates, for example, that at 40 percent rent rebate and a price elasticity of -0.50, the efficiency is 0.56. In other words, 56 percent of the payment goes toward increasing total rental expenditures. The table illustrates that the efficiency of the subsidy is an increasing function of the absolute value of the price elasticity, β_2. As the price elasticity approaches -1.0, the entire subsidy will be used to increase rental

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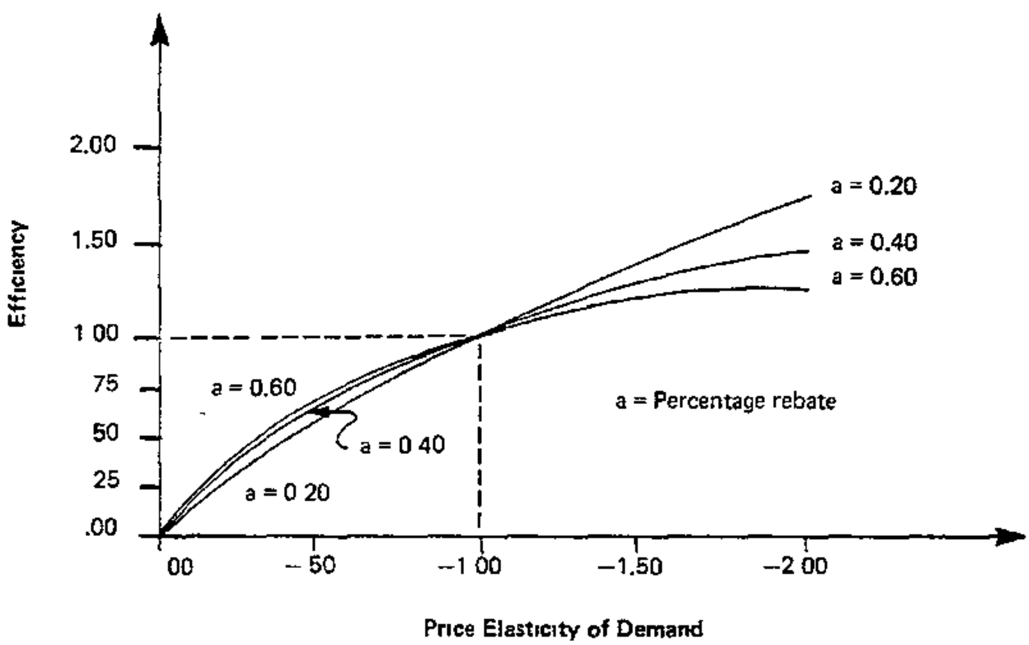
[1] $E = \frac{R_1-R_0}{aR_1} = \frac{R_0(1-a)^{\beta_2}-R_0}{aR_0(1-a)^{\beta_2}} = \frac{(1-a)^{\beta_2}-1}{a(1-a)^{\beta_2}}.$

expenditures and subsidy efficiency approaches 1.0 regardless of the subsidy rate.[1]

If the price elasticity is greater than one in absolute value, not only will the subsidy be entirely spent on housing, but the household will shift some of its before-subsidy income from other goods to housing. In such cases, the calculated subsidy efficiency will be greater than 1.0. As the price elasticity increases in absolute value, the calculated subsidy efficiency approaches an upper limit of 1/a.[2] Figure IV-1 illustrates the relationship among subsidy efficiency, subsidy rates, and price elasticity.

Figure IV-1
EFFICIENCY AS A FUNCTION OF PERCENT OF RENT REBATE RATES AND PRICE ELASTICITY



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[1] For the price elasticities less than one in absolute value, efficiency also increases as the subsidy rate increases.

[2] From Equation (5),

$$E = \frac{1}{a}\,[1-(1-a)^{-\beta_2}].$$

Since (1-a) is less than one, in the limit the bracketed term approaches one or,

$$\lim_{\beta_2 \to -\infty} E = \frac{1}{a}$$

The relative impact on rental expenditures of unrestricted income transfers and price subsidies of equivalent magnitude may be compared based on the analysis above. A straightforward comparison is possible because unrestricted income transfers operate through income elasticities of demand and price subsidies operate through price elasticities of demand.

A price subsidy should always produce a greater increase in housing expenditures than an equal income subsidy. With an equal income subsidy, the household can purchase the same amounts of housing and other goods as it purchases under the price subsidy. However, under the income subsidy it still faces the original, higher price for housing and so may be expected to buy less housing than under the price subsidy, which offers the incentive to lower prices.

The extent of the difference in housing expenditures under the two types of subsidy depends on the income and price elasticities and the original rent-income ratio. The price subsidy, S_p, needed to achieve a given level of housing expenditures, R_1, is

$$S_p = aR_1 = a(1-a)^{\beta_2}R_0, \tag{6}$$

from Equation (4). The rent achieved under an income subsidy, S_y, is

$$R_1 = \alpha P^{(1+\beta_2)}(y + S_y)^{\beta_1}$$

$$= R_0[1 + \frac{S_y}{y}]^{\beta_1}.$$

Thus the income subsidy necessary to achieve $R_1 = (1-a)^{\beta_2}R_0$, is given by

$$(1-a)^{\beta_2}R_0 = R_0[1 + \frac{S_y}{y}]^{\beta_1}. \tag{7}$$

Thus,

$$S_y = y[(1-a)^{\beta_2/\beta_1}-1]. \tag{8}$$

Combining Equations (6) and (8), the ratio of the subsidy needed under a price subsidy to that needed under an income subsidy is

$$\frac{S_p}{S_y} = \frac{a(1-a)^{\beta_2}R_0}{y[1-a)^{\beta_2/\beta_1}-1]} \quad , \text{ or} \tag{9}$$

$$(10) \qquad \frac{S_p}{S_y} = a\left(\frac{R_0}{y}\right)\left[(1-a)^{-\beta_2(1-\frac{1}{\beta_1})} - (1-a)^{-\beta_2}\right]^{-1}$$

where $-\beta_2$ is positive. Since the change in rent is the same in both cases, S_p/S_y is also the ratio of the subsidy efficiency under an income subsidy to that under a price subsidy. The relative efficiency of price subsidies is generally larger (for a given initial rent-income ratio) as the price elasticity is larger in absolute value, and is larger as the income elasticity is smaller.

REFERENCES

Mayo, Stephen K., Housing Expenditures and Quality, Part I: Housing Expenditures Under a Percent of Rent Housing Allowance, Cambridge, Mass., Abt Associates Inc., January 1977.

APPENDIX V

THE ECONOMICS OF THE FOOD STAMP HOUSING SUBSIDY

The maximum possible Food Stamp subsidy (S) is equal to:

$$(1) \qquad S = \begin{cases} A - \sigma Y & \text{for } R \leq .3Y \\ A - \sigma[Y-(R-.3Y)] = A-\sigma(1.3Y-R) & \text{for } R > .3Y \end{cases}$$

where

A = the value of food that can be bought with the full Food Stamp allotment, where $A = p_F F_s$ (F_s = the maximum anount of food that can be bought with the subsidy when the price of food is p_F),

σ = the contribution rate ($\sigma \simeq 0.3$),

Y = net household income after deductions, and

R = housing expenditures (rent); where $R = p_H H$ (p_H = the price of housing, and H = the amount of housing).

The subsidy moves the initial budget constraint ($Y = p_F F + p_H H + p_Z Z$, where F is actual food consumption, p_Z is the price of other goods, and Z represents other goods). Four cases can be distinguished.

<u>Case (a)</u> $p_F F > A$, $R \leq 0.3Y$

In this case the household purchases more food than is covered by its Food Stamp allotment. The budget constraint becomes

$$(2) \qquad Y = p_F F - S + p_H H + p_Z Z.$$

Substituting for the subsidy, S, Equation (2) becomes

$$(3) \qquad (1-\sigma)\ Y = p_F F + p_H H + p_Z Z - A.$$

In this case the relative prices of food, housing, and other goods are all unchanged. The program simply acts to increase income by the amount of the Food Stamp subsidy ($A-\sigma Y$).

Case (b) $p_F F > A$, $R > 0.3Y$

Here again, the household purchases more food than is covered by its Food Stamp allotment. Now, however, it is spending enough on housing to bring the shelter deduction into effect. Using Equation (2) and again substituting in for the subsidy, S, the budget constraint becomes

$$(4) \qquad (1-1.3\sigma)\ Y = p_F F + (1-\sigma)p_H H + p_Z Z - A.$$

The effect here is to increase income by $(A - \sigma(1.3)Y)$ and reduce the price of housing from p_H to $(1-\sigma)p_H$.

Case (c) $p_F F \leq A$, $R < 0.3Y$

If a household purchases less food than the amount possible with a full allotment, it is allowed to purchase a fraction of its full allotment (one-quarter, one-half, or three-quarters). It is assumed here that the household can purchase the actual fraction desired ($p_F F/A$) by averaging its fractional purchases over several months. The budget constraint becomes

$$(5) \qquad Y + (A - \sigma Y)\frac{p_F F}{A} = p_F F + p_H H + p_Z Z$$

or

$$(6) \qquad Y = \frac{\sigma Y}{A}\ p_F F + p_H H + p_Z Z$$

In this case, the price of food is reduced from p_F to $(\frac{\sigma Y}{A}\ p_F)$. (This must decrease the price of food, since the subsidy $[A - \sigma Y] > 0$ for recipients.)

Case (d) $p_F F \leq A$, $R \geq 0.3Y$

In this case, the budget constraint becomes

$$(7) \qquad Y + [A - \sigma(1.3Y-R)]\ \frac{p_F F}{A} = p_F F + p_H H + p_Z Z$$

or,

$$(8) \qquad Y = p_F F\ (\frac{\sigma(1.3)Y}{A}) - p_F F\ p_H H\ \frac{\sigma}{A} + p_H H + p_Z Z.$$

This function is nonlinear in food and housing. Prices (net cost per additional unit) are no longer constant. The implications of this are discussed further below.

Three of the four cases are illustrated in Figure V-1.[1] For cases (a) and (b), the impact of the Food Stamp program on housing expenditures can be analyzed using the housing demand function alone. As long as the household spends more than its coupon allotment for food, the effect of the program is simply to raise its income and/or reduce the price of housing. Since housing is a normal good, the amount of housing consumed will increase as income increases. There will also be an increase in housing consumption due to the decrease in the relative price of housing for households spending more than 30 percent of their net income on rent [case (b)].

Figure V-2 illustrates income and price effects for several different situations using indifference curves to represent a household's equilibrium position.[2] Figure V-2a illustrates an increase in housing consumption due solely to the income effect. Figure V-2b illustrates a situation in which housing consumption increases due to both income and price effects. Note that the income effect alone may cause households to increase their rent-to-net income ratio to above 30 percent, making it eligible for a price subsidy. (The household could also have been spending more than 30 percent initially.)

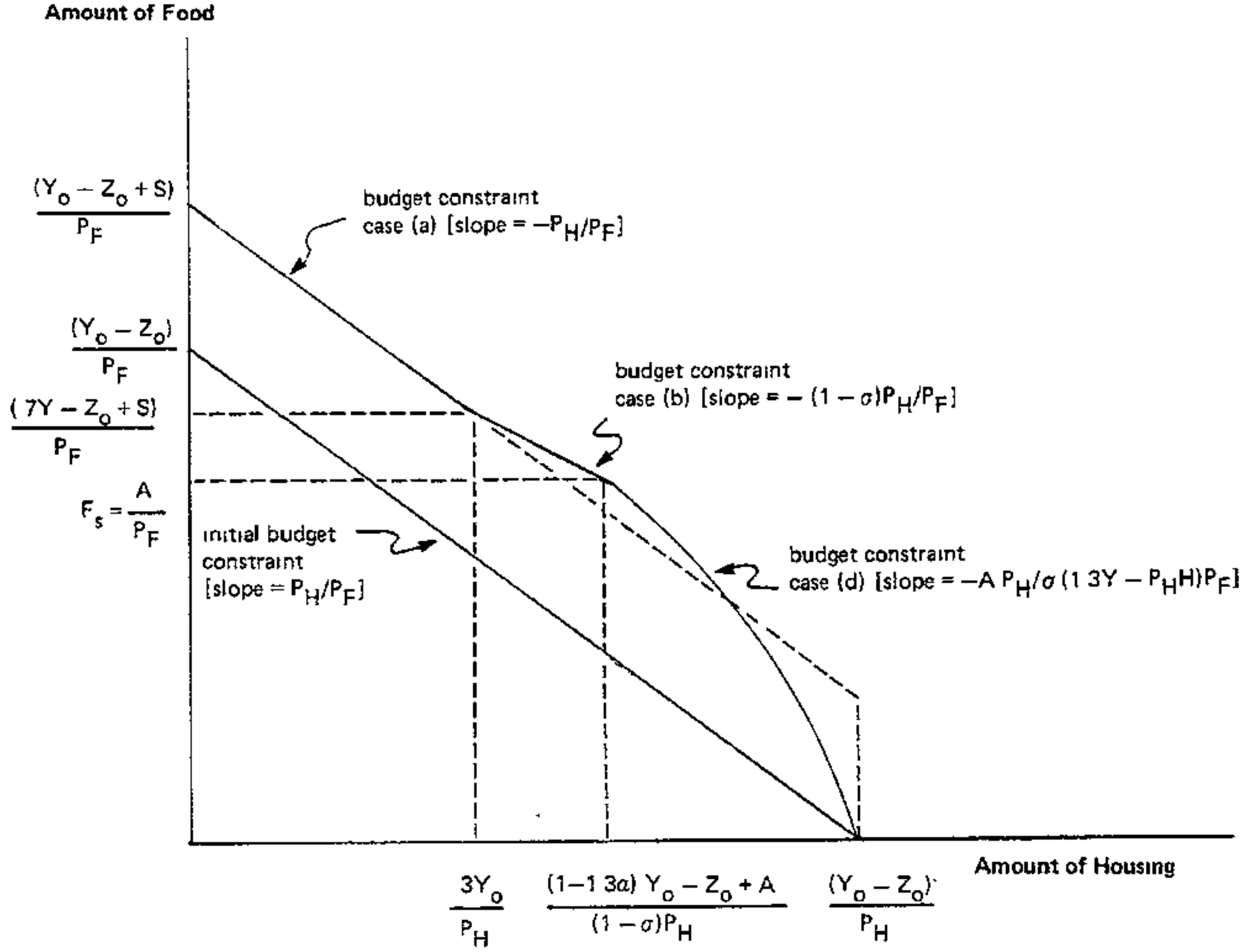
In the remaining two cases, in which households spend less than their allotment on food, the Food Stamp program leads to changes in the price of food as well as changes in income and, in case (d), the price of housing. Thus, these cases cannot be analyzed solely in terms of the housing demand function estimated in this report. However, as mentioned in Chapter 2, cases (a) and (b) probably account for the bulk of Food Stamp recipients.

---

[1]Figure V-1 assumes that expenditures on all other goods is fixed at $Z_0(p_Z = 1)$. Initial income is Y_0. Figure V-1 also assumes that there is <u>some</u> range of housing for which the household is paying more than 30 percent of its net income for rent. (If this were not true, analysis could be restricted to cases (a) and (c).) Since in the low-income population enrolled as Demand Experiment Control households more than half of the households were paying more than 30 percent (the median was 32 percent), and since 74 percent of Food Stamp households took the shelter deduction, the situation depicted seems reasonable.

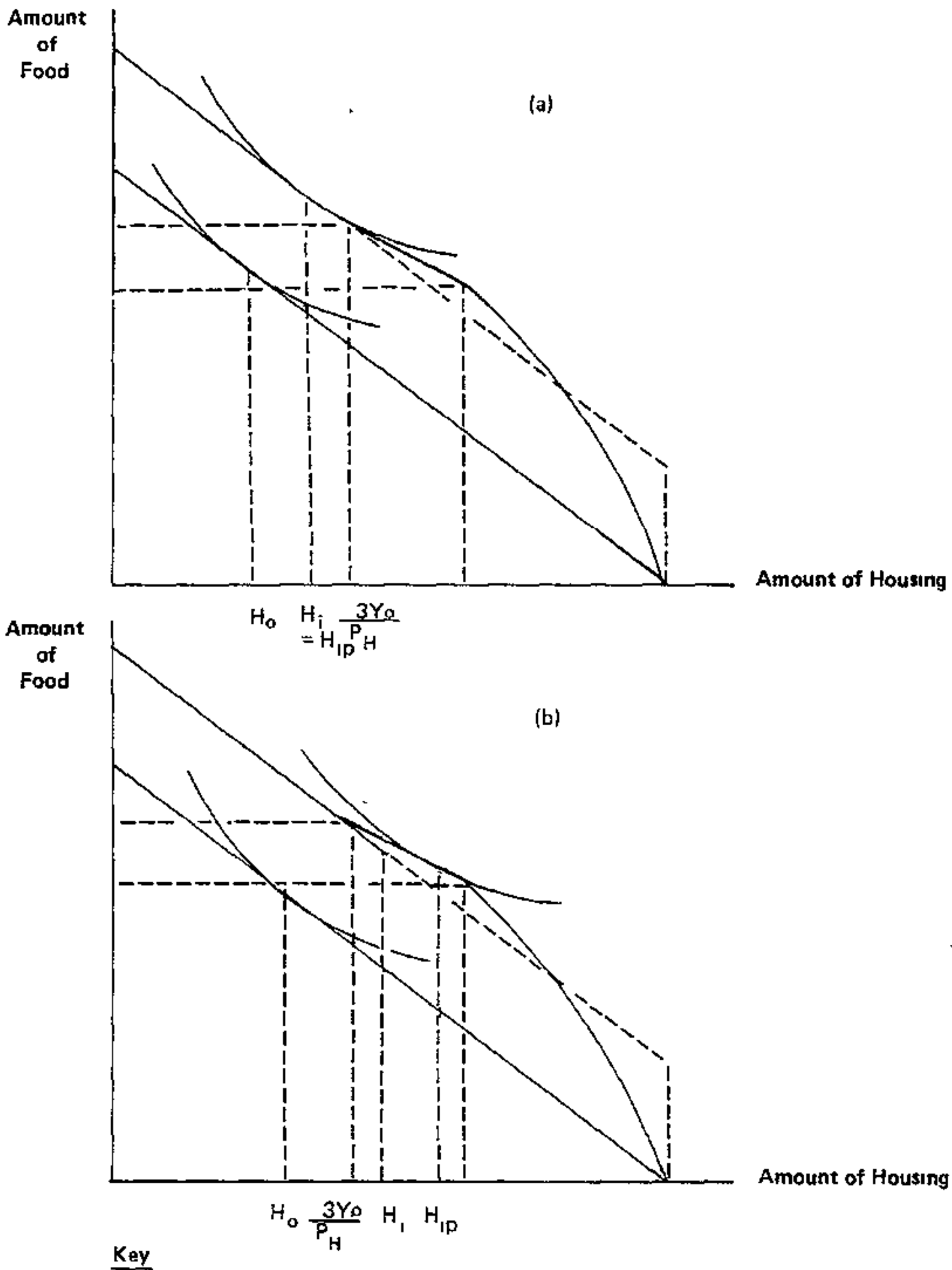
[2]Each indifference curve represents the combinations of housing and food which make the household equally well off. A household would prefer to be on a higher indifference curve since this would enable them to consume more of at least one good. Consumption will increase to the point where the budget is completely spent.

Figure V-1
FOOD STAMP BUDGET CONSTRAINTS



Notes
- Y_o = income
- Z_o = consumption of nonhousing goods
- S = value of the Food Stamp subsidy to the household
- A = the value of food that can be bought with the full coupon allotment
- F_s = the maximum amount of food that can be bought with the subsidy
- P_F = the price of food
- H = the amount of housing
- P_H = the price of housing
- σ = the benefit reduction rate

Figure V-2
INCOME AND PRICE EFFECTS OF FOOD STAMPS ON HOUSING



Key

H_o: initial consumption of housing

H_i: consumption of housing due to income effect of food stamp subsidy

H_{ip} consumption of housing due to income and price effect of food stamp subsidy

Note: See Figure V-1 for additional diagramatic detail.

Tabulations from the 1976 Survey of Income and Education, shown in Table V-1, indicate that 94 percent of Food Stamp recipients purchase their full Food Stamp allotment. Of these, 65 percent say they spend more on food than is covered by their Food Stamp allotment. Thus, at least 61 percent of Food Stamp recipients (0.94 x 0.65) clearly fall into case (a) or (b). Furthermore, most of these recipients report expenditures well above their allotment.[1]

Cases (a) and (b) apply as well to households that would purchase no less than full allotment if the budget line did not curve down for food purchases of less than the allotment (see Figure V-1). There is no ready way to tell what proportion of the full allotment households that report spending all of their allotment fall into this category.

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[1] MacDonald (1977) estimates that roughly two-thirds of all recipient households are effectively unconstrained by the program.

Table V-1

COMPARISON OF FOOD PURCHASES AND FOOD STAMP ALLOTMENT

	PURCHASE FULL ALLOTMENT	PURCHASE LESS THAN FULL ALLOTMENT
Number	4,869,687	307,782
Percentage of total recipients	94%	6%
Spend more on food than is covered by Food Stamps	3,151,900	187,531
Percentage of total recipients	61%	4%
Spend more by		
less than $5 per month	71,992	5,579
$5 to $15	696,049	34,306
$16 to $25	727,733	29,407
more than $26	1,627,581	117,814
don't know	28,544	426

SOURCE: Unpublished data from 1976 Survey of Income and Education, unedited data tabulated by U.S. Bureau of the Census, Table 1 (weighted to represent the U.S. population).

APPENDIX VI

AN ALTERNATIVE ESTIMATION OF EXPERIMENTAL EFFECTS

Chapter 4 described estimation of demand functions with the effect of Percent of Rent rebates specified as a linear function of ln(1-a). This appendix uses a less form-constrained method to evaluate the impact of rent rebates on expenditures.

VI.1 DEVELOPMENT OF THE METHODOLOGY

Experimental effects are measured under the assumption that the actual housing expenditures of Percent of Rent households at two years after enrollment, R, can be decomposed into two parts--the normal housing expenditures that would have been made in the absence of the rebates and an additional amount which is induced by the rebates. Thus

$$R = R_N + R_X \tag{1}$$

where

R = actual expenditures two years after enrollment

R_N = normal expenditures two years after enrollment, and

R_X = the experimental effect on expenditures.

The experimental effect can be measured either as the difference between actual and normal expenditures or as their ratio

$$\frac{R}{R_N} = \frac{R_N + R_X}{R_N} = 1 + \frac{R_X}{R_N} . \tag{2}$$

For consistency with the log-linear demand functions estimated in Chapter 4, and for convenience, throughout this appendix the experimental effect is measured in terms of the ratio of actual to normal expenditures.

Experimental effects are estimated under the assumption that the ratio of actual to normal housing expenditures is functionally related to experimental variables and a random error, specifically

(3) $$\frac{R}{R_N} = \exp(X\beta + e),$$

or

(4) $$\ln(R/R_N) = \ln(R) - \ln(R_N) = X\beta + e,$$

where

X = a vector of experimental variables

β = a vector of experimental effects, and

e = a random error term distributed $N(0,\sigma_e^2)$.

The coefficients β of Equation (4) may be interpreted as the percentage change in rent associated with a unit change in the relevant variable, X.[1] Since $\ln(R_N)$ is not observable, it is estimated using Control households (which have not been affected by rent rebates).

The log-linear specification for housing expenditures is chosen for convenience:

(5) $$r_N^i = \ln(R_N^i) = \alpha + \beta \ln(Y^i) + e^i$$

where Y^i is income.

Given the specification of Equation (5) and the fact that observations on each household "i" are available for two time periods, t=0 (enrollment) and t=1 (two years), a critical issue in estimating the parameters of the equation concerns the particular assumptions about the nature of the stochastic error term, e_t^i. If the residuals over the two time periods, e_0^i and e_1^i, are correlated, then the Ordinary Least Squares (OLS) estimation of this equation would be inefficient. An asymptotically more efficient estimation technique, Seemingly Unrelated Regression (SUR), developed by Zellner (1962), is used here. Taking account of initial position through e_0^i improves prediction.

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[1]Note that

$$\frac{\partial[\ln(R/R_N)]}{\partial X_i} = \frac{\partial(R/R_N)}{\partial X_i} \cdot \frac{1}{R/R_N} = \beta_i.$$

Thus, β_i measures the proportional change in (R/R_N) in response to a unit change in X_i.

The SUR procedure consists of estimating Equation (5) for the two time periods separately using OLS; then computing $\hat{\rho}$, the correlation between the estimated residuals, $\hat{e}_0^i$ and $\hat{e}_1^i$, which is a consistent estimate of the true serial correlation coefficient, ρ. The estimate $\hat{\rho}$ is then used to transform the independent and dependent variables in Equation (5) in order to provide Generalized Least Squares (GLS) estimates of the parameters.

As Chapter 2 demonstrated, there are large differences between changes in housing expenditures of households that moved and those that stayed in their enrollment units. Thus, the prediction of normal housing expenditures incorporates moving behavior. Since it is possible that the rent rebates induced residential mobility, the estimation of normal rent does not depend on whether a household had actually moved after enrollment. Rather, the estimation is based on the normal probability of moving, estimated from the sample of Control households. Figure VI-1 describes the disposition of Percent of Rent households noting that a Percent of Rent household may have been induced to move. The normal expenditure of any household, i, is then

$$r_N^i = (1-p_C^i)\ r_N^{NM} + p_C^i\ r_N^{MV} \tag{6}$$

where

p_C^i = the normal probability of moving (absent the experiment)

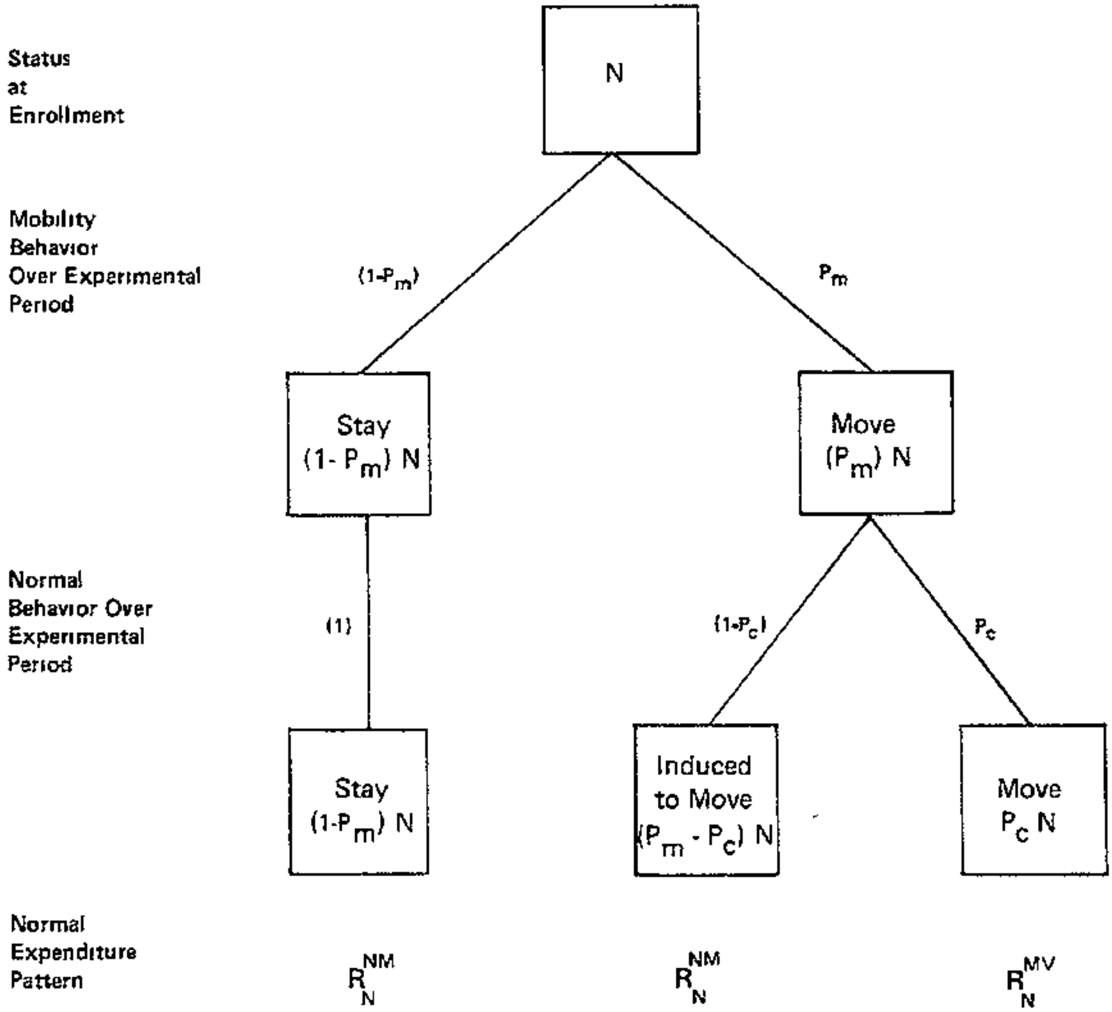
r_N^{NM} = the normal log expenditure of household i, if it were not to move, and

r_N^{MV} = the normal log expenditure of household i, if it were to move.

Chapter 2 indicated that the response of movers and nonmovers differed in important ways. Mover and nonmover households can be examined separately. If all Percent of Rent households that did not move would not have moved in the absence of the experiment,[1] the normal expenditure for nonmovers is simply

[1] It is possible, in theory, that Percent of Rent rebates could induce some households that would have moved to less expensive units to retain their original units.

Figure VI — 1
DISPOSITION OF EXPERIMENTAL HOUSEHOLDS BY MOBILITY STATUS



Notes

Pm Proportion of Experimental households that moved

Pc Proportion of Control households that moved (normal mobility)

N Total number of households

R_N^{NM} Normal expenditure of Control households that did not move

R_N^{MV} Normal expenditure of Control households that moved

(7) $$r_N^1 \text{ (nonmover)} = r_N^{NM} .$$

Normal expenditure for movers is more complex due to induced mobility (see Figure VI-1), since some movers would normally have been nonmovers:

(8) $$r_N^1 \text{ (mover)} = \frac{\left(p_m^1 - p_c^1\right)}{p_m^1} r_N^{NM} + \frac{p_c^1}{p_m^1} r_N^{MV}$$

where p_m^1 is the probability that a Percent of Rent household will move ($(p_m^1 - p_c^1)$ is thus the increase in the probability of moving).[1]

VI.2 EMPIRICAL ESTIMATION OF EXPERIMENTAL EFFECTS

As the previous section described, normal expenditure equations are estimated using Control households.[2] The probability of moving equations are obtained from MacMillan (1978). Table VI-1 presents the estimated experimental effect. The estimates of increase in rent above normal conform to expectations, showing an increase with the percentage rebate, both overall and for movers (assuming either no or some induced mobility). For nonmovers there is no experimental effect at all--apparently the rent rebate did not induce any additional housing expenditure by nonmovers.

The difference between actual and predicted ln(rent) can be regressed on the experimental variable ln(1-a) to approximate the log-linear response function estimated in Chapter 4. As in Chapter 4, the coefficient of the variable ln(1-a) is interpreted as a price elasticity.[3] Table VI-2 presents the

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[1] (p_c^1/p_m^1) is the fraction of movers that would normally have moved; $((p_m^1-p_c^1)/p_m^1)$ is the fraction that would normally have stayed. Results are also presented below under the assumption $p_m^1 = p_c^1$ (all mobility is normal, none is induced).

[2] These prediction equations for normal rent are, for movers,

(i) $$\ln(R_t) = \alpha_1 - \rho\alpha_0 + \beta\left[\ln(Y_t) - \rho\ln(Y_{t-1})\right] + \rho\ln(R_{t-1})$$

and, for nonmovers,

(ii) $$\ln(R_t) = \gamma + \delta\ln(R_{t-1})$$

The coefficients estimated from Control households are presented in Appendix Table X-45. In these equations R_{t-1} and R_t are rental expenditures at enrollment and two years after enrollment, respectively. Similarly Y_{t-1} and Y_t are household's current income at enrollment and two years after enrollment.

[3] See Footnote 1 on second page of this appendix.

Table VI-1

EXPERIMENTAL IMPACT OF RENT REBATES
(Median Percentage Increase in Rent Above Normal)

HOUSEHOLD GROUP	DISCOUNT RATE 20%	30%	40%	50%	60%	SAMPLE SIZE
			PITTSBURGH			
Overall	-1.0 (3.0)	2.3 (2.7)	4.6 (2.4)	4.6 (2.5)	11.2* (5.0)	(382)
Movers						
No induced mobility assumed	-3.3 (7.7)	3.9 (5.8)	8.3 (5.2)	8.2 (6.0)	17.8 (11.6)	(144)
Induced mobility assumed	-2.9 (7.7)	4.4 (5.8)	8.7 (5.2)	9.1 (6.0)	19.9 (11.9)	(144)
Nonmovers	0.3 (1.9)	-0.9 (1.8)	1.9 (1.7)	2.4 (1.6)	2.1 (3.2)	(248)
			PHOENIX			
Overall	7.6* (4.0)	6.2* (3.0)	5.8 (3.4)	9.6** (3.1)	16.2** (6.4)	(275)
Movers						
No induced mobility assumed	10.5 (5.7)	15.5** (4.7)	16.1** (5.2)	13.9** (4.1)	17.9** (7.6)	(165)
Induced mobility assumed	11.5* (5.6)	16.2** (4.6)	17.0** (5.2)	14.8** (4.1)	20.1** (7.6)	(165)
Nonmovers	1.0 (3.3)	2.1 (2.3)	-0.4 (2.7)	-0.6 (2.9)	2.1 (6.5)	(115)

SAMPLE: Percent of Rent households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Standard errors in parentheses.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

Table VI-2

PRICE ELASTICITY ESTIMATES
FROM NORMAL EXPENDITURES

HOUSEHOLD GROUP	PITTSBURGH	PHOENIX
Movers		
No induced mobility assumed	-0.134** (0.049)	-0.230** (0.035)
Induced mobility assumed	-0.146** (0.049)	-0.245** (0.035)
SAMPLE SIZE	(144)	(165)

SAMPLE: Percent of Rent movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Standard error in parentheses.

** t-statistic significant at the 0.01 level.

resulting price elasticity estimates for mover households. The estimates are similar to (and not significantly differently from) those presented in Chapter 4.[1]

[1]These were -0.211 in Pittsburgh and -0.219 in Phoenix.

REFERENCES

MacMillan, Jean, Mobility in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., June 1978 (revised June 1980).

Zellner, Arnold, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias," Journal of the American Statistical Association, vol. 57, 1962, pp. 348-367.

APPENDIX VII

A DISEQUILIBRIUM MODEL OF MOBILITY

This appendix focuses on the implications of household disequilibrium in housing consumption for adjustments in housing consumption via residential mobility. Three factors prompted this analysis--a concern about the problem of selecting movers, the possibility of shedding some light on the effects of experimental duration, and an interest in testing some further implications of the consumer demand theory presented in Chapter 3. The analysis is admittedly preliminary and as such is only suggestive of further analysis tasks. It presumes basic knowledge of the microeconomics of household behavior and is of interest to those concerned with applied microeconomics.

The existence and persistence of household disequilibrium requires explicit recognition of the reasons for disequilibrium and the sources of friction in the market for housing. Section VII.1 presents a simple model of adjustment (residential mobility) when there are no transactions (moving) costs. Section VII.2 presents empirical results of estimating such a model with significant transactions costs, using the empirical demand functions estimated in this report.

VII.1 THEORETICAL DEVELOPMENT OF A MOBILITY MODEL[1]

Consider the conventional residential location models which derive the equilibrium pattern of location and consumption of housing services in a metropolitan area (see Alonso, 1964 or Muth, 1969). The results derived from such models are "equilibrium" in the sense that under unchanged conditions, households have no incentive to adjust their location or housing consumption.

In the absence of transaction costs a household would be expected to adjust its housing consumption in response to changes in variables affecting the equilibrium consumption of housing. Thus, changes in the relative price of housing, a household's income, or composition would be expected to result in changes in housing consumption, and usually in moving.

[1]The model and discussion presented in this section draws on Quigley and Weinberg (1977).

Such adjustments are implausible in the real world because the costs of moving are substantial. These costs include not only the cost of searching for and moving to a new residence but also loss of any long-term tenancy discount that might exist at the old residence. The existence of substantial transactions costs (including both monetary and more general psychic costs), immediately suggests that, having chosen an equilibrium position, households will drift out of equilibrium as small changes render their choice of housing nonoptimal for their particular household characteristics. Such drifts will result in utility losses.

In principle, the utility gain foregone by a household in not moving to its equilibrium may be measured by using the concept of the compensating income variation--the maximum amount of money households could spend on moving costs given the prevailing prices and income and still be as well off after the move as they were beforehand.[1] If the "income compensation" is larger than the actual costs associated with moving, the household should, in theory, prefer to move.

Household behavior can be formalized using the same model of utility maximization introduced in Chapter 3, and the income compensation of any disequilibrium can be computed using the parameter estimates obtained from the demand functions discussed in Chapter 4. A household in any period is assumed to maximize its utility, $U(H,Z)$, where H represents housing services and Z represents other goods, subject to a budget constraint. This maximization implies an equilibrium demand function for housing

$$H^* = H(p_H, Y) \tag{1}$$

where

p_H = the relative price of housing, and

Y = household income.

In the absence of transactions costs, the income compensation is simply the additional income, IC, that if subtracted from a household's own income, would make such a household as well off with its current nonoptimal housing (consuming H_0 without moving) as it would be if it were to consume the optimal

[1] A similar concept is the equivalent income variation--the amount of money required to supplement the quantity of other goods which would make the household as well off as its current location as it would be if it were to consume its preferred quantity of housing services.

amount H_1^* after a move. The value of IC is obtained by solving Equation (2):

$$U(H_0, Y_1 - R_0) = U(H_1^*, Y_1 - R_1^* - IC) \tag{2}$$

where

R_1^* = rental expenditures for the desired amount of housing services H_1^*.

The derivation of IC is illustrated in Figure VII-1.[1] The household is assumed to be in equilibrium in period t_0 with income Y_0 and utility U_0. For illustration, in period t_1 the household's income increases from Y_0 to Y_1. If no adjustment is made, the household utility will now be U_1. If the optimal position (H_1^*) is chosen, however, the maximum moving costs allowing the household to have utility U_1 is the value of IC for which the associated utility function $[U(Y_1-IC; p_H)]$ has a maximum equal to U_1.

The household will move if moving costs for that household (M) are less than IC--in other words, if the net gain from moving is positive. For a particular household, moving will not be perfectly correlated with the sign (plus or minus) of difference (IC - M), however. Uncertainty about the future, imperfect information and the distribution of tastes across households will destroy any exact relationship. It should still be true, though, that the probability of moving is positively related to the benefits to be gained and inversely related to the costs.

For a well-defined utility function, the exact (Hicksian) measure of the compensating income of any disequilibrium can be derived directly (from Equation (2)). Take, for example, the Stone-Geary form already discussed in Chapter 3.

$$U(H,Z) = (H-\theta_1)^b (Z-\theta_2)^{1-b} \tag{3}$$

The compensating variation, IC, that would make the household as well off consuming its initial housing, H_0, paying rent, R_0, as it would be if it were to consume its optimal housing, H*, at rent R*, given exogenous income Y_0, is obtained from solving Equation (4):

$$(H_0-\theta_1)^b (Y_0-R_0-\theta_2)^{1-b} = (H^*-\theta_1)^b (Y_0-IC-R^*-\theta_2)^{1-b}. \tag{4}$$

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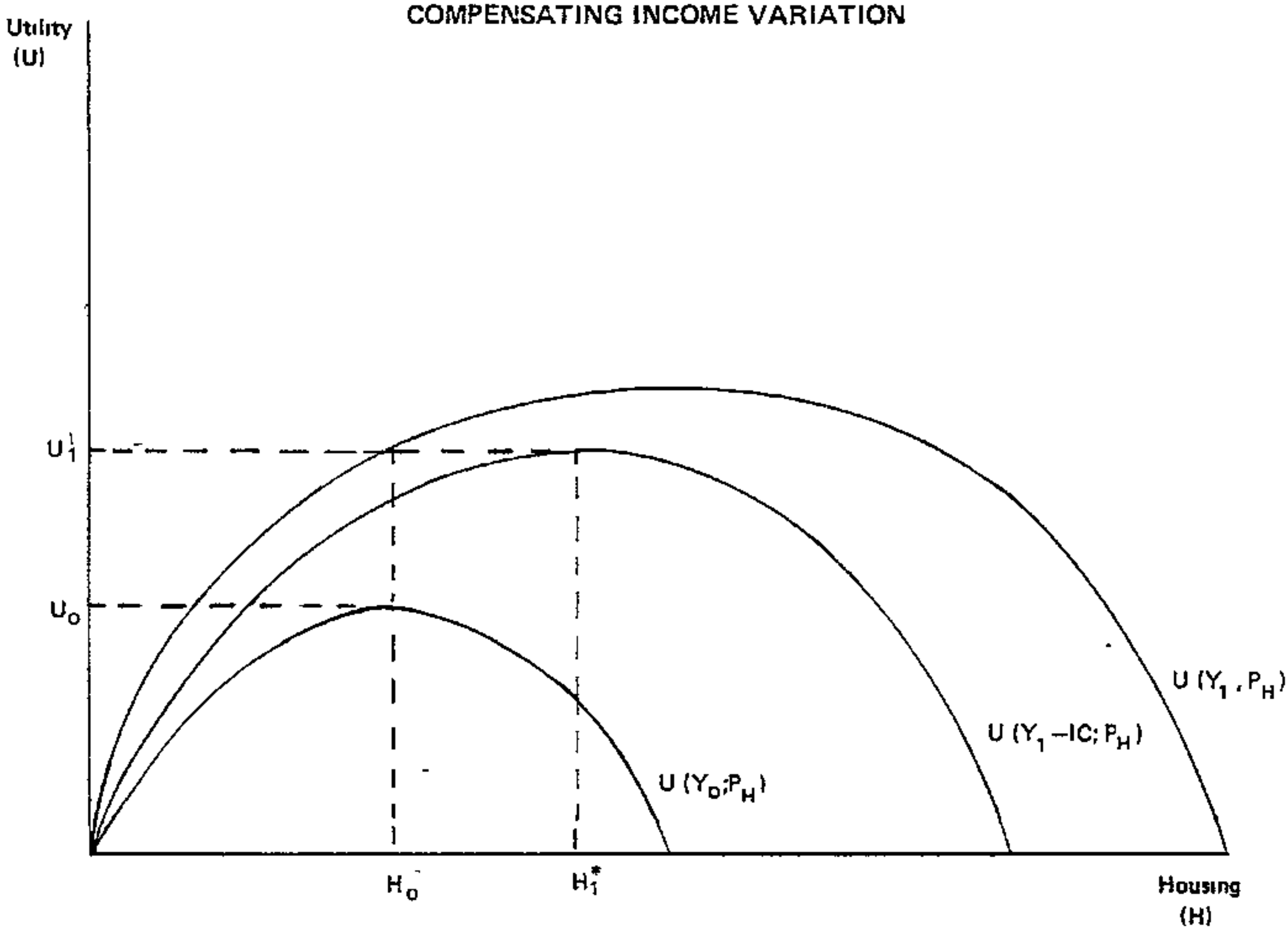
[1] Each utility curve reaches a maximum because for any given income and prices, there is a combination of housing and nonhousing goods that maximize utility within the feasible budget set.

Figure VII-1
COMPENSATING INCOME VARIATION



H_o initial housing consumption

H_1^* the optimal (maximum utility) level of housing consumption under prices, P_H, and income, $(Y_1 - IC)$

Y_o initial income level

Y_1 current income level

P_H the price of housing

IC compensating income variation needed to make the household as well off after the move as before (i e , achieve utility level U_1)

Rearranging terms and expressing everything in terms of rental expenditures gives

$$\text{(5)} \qquad IC_{SG} = Y_0 - \left[\frac{R^*-p_H\theta_1}{R_0-p_H\theta_1}\right]^{b/(1-b)} \cdot \left[Y_0-R_0^*-\theta_2\right] - R^*-\theta_2 .$$

Alternatively, if the household demand function (but not the utility function) is known, say $p_H = D(H)$, the Marshallian compensation, a close approximation to the exact Hicksian compensation, can be computed.[1] It is simply the difference in consumer surplus between enjoying the equilibrium level of housing services, H^* (and spending R^* on rent), and the initial position of consuming H_0 housing services (and spending R_0 on rent at the prevailing prices).[2] This difference in consumer surplus is defined as

$$\text{(6)} \qquad IC = \left[\left(\int_0^{H^*} D(H)\,dH\right) - R^*\right] - \left[\left(\int_0^{H_0} D(H)\,dH\right) - R_0\right]$$

$$= \int_{H_0}^{H^*} (D(H)\,dH) + (R_0-R^*).$$

For example, if the demand curve for housing services is log-linear as in Equation (7):

$$\text{(7)} \qquad \ln(H) = \ln(K) + a\ \ln(Y) + b\ \ln(p_H),$$

substitution into Equation (6) yields

$$\text{(8)} \qquad IC_{LL} = \left[\int_{H_0}^{H^*} \left(\frac{H}{kY^a}\right)^{1/b} dH\right] - R^* + R_0 .$$

[1] Willig (1976) demonstrated that in many practical situations the Marshallian and Hicksian measures of income compensation are numerically very close. The distinction is that the Hicksian measure uses a compensated demand curve while the Marshallian measure uses an uncompensated one. For the data used in this section, the approximation error is under 2 percent.

[2] Consumer surplus results from the fact that individual demand curves are downward sloping. Because there is typically one price at which the household buys all its demand, it is in fact spending less on each inframarginal unit that it would be willing to. Consumer surplus measures this difference for each unit.

In terms of rent, this can be written as[1]

$$\text{(9)} \qquad IC_{LL} = \left(\frac{b}{b+1}\right)\left[R^* - R_0^{(b+1)/b} \cdot R^{*-(1/b)}\right] - R^* + R_0.$$

Any pre-experimental housing disequilibrium would be expected to alter the effects of rent rebates, which change the effective relative price of housing faced by recipients. Ignoring moving costs for the sake of exposition, in the case of initial underconsumption, actual housing H_0 is less than the desired amount H_0^* (see Figure VII-2a). Similarly, in the case of initial overconsumption, H_0 is larger than H_0^* (see Figure VII-2b). The household's utility gain of moving is $(U_0^* - U_0)$. With the introduction of the price discount, the utility level of consuming H_0 increases to U_e and the utility of consuming the desired level of housing (H_e^*) becomes U_e^*.[2] The utility gain from moving $(U_e^* - U_e)$, may be decomposed into three parts:

$$\text{(10)} \qquad (U_e^* - U_e) = (U_e^* - U_0^*) + (U_0^* - U_0) - (U_e - U_0).$$

---

[1]The results of the integration of Equation (8) are

$$\text{(i)} \qquad IC_{LL} = \left(\frac{1}{kY^a}\right)^{1/b}\left(\frac{b}{b+1}\right)\left[H^{*(b+1)/b} - H_0^{(b+1)/b}\right] - R^* + R_0.$$

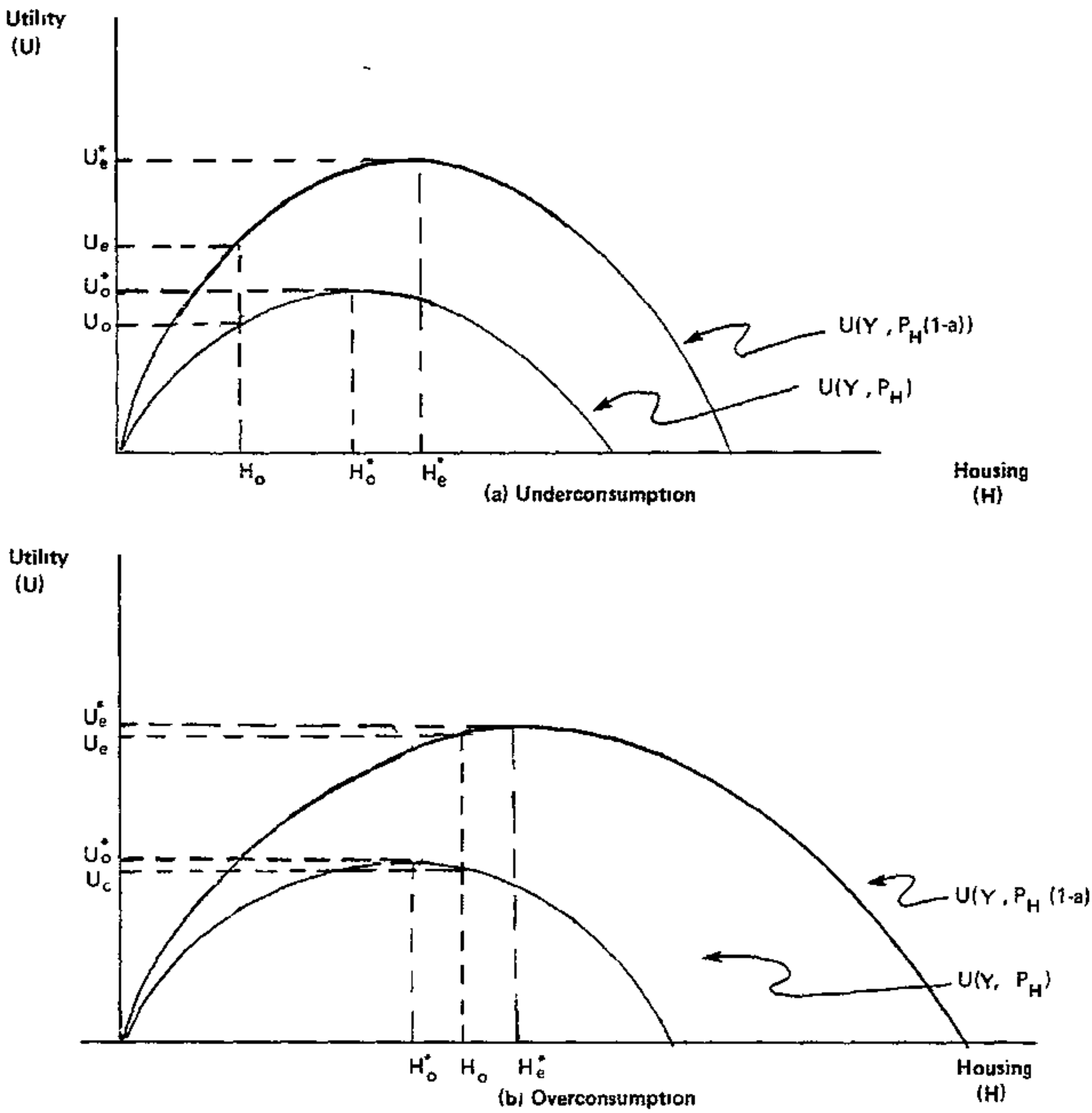
Multiplying by $\left(\frac{p_H}{p_H}\right)^{(b+1)/b}$ gives

$$\text{(ii)} \qquad IC_{LL} = \left(\frac{1}{kY^a p_H^{b+1}}\right)^{1/b}\left(\frac{b}{b+1}\right)\left[\left(p_H H^*\right)^{(b+1)/b} - \left(p_H H_0\right)^{(b+1)/b}\right] - R^* + R_0$$

(iii) Recalling that $R^* = kY^a p_H^{b+1}$, Equation (ii) can be written as Equation (9).

[2]Note that those overconsuming relative to their initial equilibrium could already be consuming H_e^* and have no incentive to adjust their housing $(U_e^* = U_e)$. H_e^* will always be greater than H_0^* because housing is a normal good.

Figure VII-2
INITIAL AND INDUCED DISEQUILIBRIUM FOR PERCENT OF RENT HOUSEHOLDS (NO MOVING COSTS)



H_o actual pre-experimental housing consumption
H_o^* optimal pre-experimental housing consumption
H_e^* optimal housing consumption given the percentage rebate, a
Y_1 current income level
P_H the price of housing
a the rebate level

The term $(U_e^* - U_0^*)$ represents the experimentally induced change in equilibrium utility levels; the term $(U_0^* - U_0)$ represents the pre-experimental disequilibrium; and the term $(U_e - U_0)$ represents the household's actual utility gain at its initial position. This decomposition of the utility gain into its components may be relevant because of the limited duration of the experiment. The household might respond differently to an experimentally induced disequilibrium than to a nonexperimental disequilibrium. The compensatory income variations of these separate components of utility gain can be computed, allowing hypotheses about their separate effects to be tested.[1]

VII.2 EMPIRICAL ANALYSIS OF MOBILITY

Theoretical development of the benefit measures was presented in the previous section. Specification of the cost measures is less complicated. Costs of moving should include not only the out-of-pocket costs but also any losses that must be borne by the household.[2]

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[1]For the log-linear demand function, these variations are, from Equation (7),

(a)
$$IC_{LL}^{a} = \int_{H_0}^{H_0^*}\left[D(H)\,dH\right] - R_0^* + R_0 = \left(\frac{b}{b+1}\right)\left[R_0^{*\,(b+1)/b} - R_0\, R_1^{*\,-(1/b)}\right] - R_0^* + R_0 \; .$$

(b)
$$IC_{LL}^{b} = \int_{H_0^*}^{H_e^*}\left[D(H)\,dH\right] - (1-a)R_e^* - R_0^* = \left(\frac{b}{b+1}\right)\left[R_e^{*\,(b+1)/b}\, R_0^{*\,-b(1/b)} - R_0^*\right] - (1-a)R_e^* + R_0^*$$

(c)
$$IC_{LL}^{c} = \int_{H_0}^{H_0}\left[D(H)\,dH\right] - (1-a)\,R_0 + R_0 = aR_0.$$

Similarly, Equation (5) can be used to derive the income compensations for the Stone-Geary utility function.

[2]Not all moving costs can be measured, however. Such costs include psychic costs due to such factors as neighborhood social attachment.

Out-of-pocket costs of moving possessions is the cost most closely associated with moving. Since the household makes its decision prior to actually experiencing the costs, it is the expected moving costs that matter. Actual moving costs for movers were taken from the Second and Third Periodic Interviews (given at one year and two years after enrollment, respectively). Household demographic characteristics for movers were used as independent variables in a regression equation to predict prospective moving costs.[1]

The second type of moving costs used here is search costs. Once again this is a prospective measure. Reported time spent finding the household enrollment dwelling (on the Baseline Interview) was regressed on the same household characteristics as was out-of-pocket moving costs and the resultant equation used to predict expected search time.[2]

Finally, a variable used to approximate the loss of monthly rent discount attributable to long-term occupancy (a maximum of about $15 in Pittsburgh and $22 in Phoenix) was obtained from an hedonic regression of rental expenditures on housing components and household characteristics (see Merrill, 1977).

The estimates of out-of-pocket costs and search time are admittedly ad hoc. The estimating regressions had very low R^2 and small theoretical rationale.[3] Nor do these costs, even if predicted accurately, pretend to capture all or

[1]The mean out-of-pocket moving costs reported by movers answering the question on the Second Periodic Interview was $54.06 in Pittsburgh and $12.59 in Phoenix. The costs are low in Phoenix because 85 percent moved their belongings using their own or a borrowed vehicle or no vehicle at all (the corresponding figure in Pittsburgh was 35 percent). In order to get a monthly cost, the expected moving cost should be amortized over the household's expected tenure in the new unit. Inclusion of expected moving costs as predicted from the regression equation as a separate term will allow the sample itself to determine simultaneously the amortization rate and its effect on mobility.

[2]The mean search time reported on the Baseline Interview was 95 days in Pittsburgh and 33 days in Phoenix. When included in the mobility equation, this measure's coefficient could implicitly measure the (amortized) price of search time.

[3]In addition while search time data was taken from the Baseline Interview, data on out-of-pocket moving costs was collected from Periodic Interviews of households that moved during the experiment. Thus to the extent that movers tend to be households with lower than average costs, this method will underestimate the potential out-of-pocket moving costs of a randomly selected household.

even most of the costs of search and moving. They are only intended to provide a beginning indication of the role of moving costs.

Practical reasons prohibited the use of the Stone-Geary income compensation as a measure of benefits.[1] Rather than approximating the Stone-Geary form with a Cobb-Douglas form,[2] the Marshallian income compensations derived for the log-linear case are used instead.

As suggested in Section VII.1, two specifications of benefit measures were used: Model I--a measure partitioning the household's disequilibrium into an initial disequilibrium (that is, pre-experimental disequilibrium) and an experimentally induced disequilibrium (the latter is zero for Control households); and Model II--an overall measure. Households may discount the experimental disequilibrium, so the initial and induced equilibrium may have different impacts on mobility. The hypothesis of equal impacts will be tested.[3]

The median, mean, standard deviation, and range for each of the measures of costs and benefits are presented in Tables VII-1 and VII-2, respectively.[4] The most surprising element of the tables is the remarkably small magnitude of the potential benefits from moving compared to the potential costs. While out-of-pocket costs and search time spent are one-time expenditures that can be amortized over the expected tenure at the new unit, the tenure discount is a monthly cost. Especially notable is the negligible disequilibrium

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[1] In the formula [Equation (5)], the difference between rent and $p_H\theta_1$ is raised to a fractional power. When a household's equilibrium or actual rent is less than $p_H\theta_1$, this number is imaginary and the compensating income variation is undefined.

[2] The Cobb-Douglas form constrains $\theta_1 = \theta_2 = 0$. This implies a unitary income elasticity, which, as shown in Chapter 4, is inappropriate for housing.

[3] The initial position (1973) is characterized in terms of 1975 dollars by inflating initial rent by 15 percent in Pittsburgh and 10 percent in Phoenix in order to permit direct comparison with equilibrium expenditure estimates in 1975 dollars. These numbers are based on the findings of Merrill (1977). The results were not sensitive to changes in the inflation rate. Equilibrium rent is predicted using a serial correlation model of expenditure (see Appendix VI).

[4] The maximum is misleading--only 2 of 701 households in Pittsburgh and 6 of 563 in Phoenix had income equivalents worth more than $300. Each of these households was spending less than half of its equilibrium housing expenditure.

Table VII-1

CHARACTERISTICS OF COST MEASURES
USED IN ANALYSIS OF MOBILITY

MEASURE	MEDIAN	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
		PITTSBURGH			
Expected out-of-pocket moving cost	58.70	61.05	15.82	0.0	137.98
Expected search time (days)	60.76	59.97	16.37	0.0	105.33
Current tenure discount	5.12	6.25	5.59	0.0	15.04
SAMPLE SIZE			(701)		
		PHOENIX			
Expected out-of-pocket moving cost	16.84	16.38	4.97	0.0	38.72
Expected search time (day)	36.14	36.32	17.87	0.0	87.63
Current tenure discount	4.02	7.05	7.54	0.0	22.72
SAMPLE SIZE			(563)		

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Baseline amd Periodic Interviews.

Table VII-2

CHARACTERISTICS OF BENEFIT MEASURES
USED IN ANALYSIS OF MOBILITY

PITTSBURGH

MEASURE[a]	MEDIAN	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
Initial Disequilibrium					
Percent of Rent households	16.12	28 96	36.85	0.00	276.96
Percentage rebate					
20%	15.36	24 94	28.18	0.02	140 83
30%	15 76	30 24	40.02	0.01	233.64
40%	16.97	33.25	46.17	0.02	276.96
50%	15.06	26.49	29.32	0.06	172.32
60%	17.16	26.56	27 15	0 00	93 44
Control households	17 82	34.38	47.49	0.00	421.10
Induced Disequilibrium					
Percent of Rent households	4.33	3 60	11.27	-50 76	31.98
Percentage rebate					
20%	2.48	1.96	5.04	-13.17	10.74
30%	3.75	2.40	8 70	-31.09	19 29
40%	4.30	2 71	12 74	-50.76	30 30
50%	8.13	3.80	12.92	-31.60	28.56
60%	5 25	6.12	14.24	-24.59	31.98
Control households	0 00	0.00	0.00	0.00	0.00
Overall Disequilibrium					
Percent of Rent households	22.33	32.56	36.52	0 69	307.26
Percentage rebate					
20%	20.45	26 90	27 44	0.69	151.57
30%	18.04	32.65	39 84	1 54	249.94
40%	23.43	35.96	45.74	2.61	307.26
50%	22.45	32.29	28.86	3.52	198.92
60%	24 02	32 67	28.65	5.19	116.45
Control households	17.82	34.38	47.49	0.00	421.10

Sample Size	
Percent of Rent households	(398)
Percentage rebate:	
20%	(63)
30%	(88)
40%	(111)
50%	(108)
60%	(28)
Control households	(303)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, payments file, Third Periodic Interview.

a. Income equivalent of listed measure

Table VII-2 (continued)

CHARACTERISTICS OF BENEFIT MEASURES
USED IN ANALYSIS OF MOBILITY

PHOENIX

MEASURE[a]	MEDIAN	MEAN	STANDARD DEVIATION	MINIMUM	MAXIMUM
Initial Disequilibrium					
Percent of Rent households	17 92	33.48	63 46	0.00	802 99
Percentage rebate					
20%	17.60	34 68	50.30	0 21	317.19
30%	16.96	27.82	37.26	0.00	197 55
40%	17.14	29.49	52.62	0.00	399.63
50%	20 62	29.70	31.48	0.00	167 14
60%	20.87	79 55	179 47	0.02	802 99
Control households	19.11	37.81	57.60	0 02	565.46
Induced Disequilibrium					
Percent of Rent households	6.16	6.18	11.35	-27.03	65 67
Percentage rebate:					
20%	3.43	1 99	4.95	-9 90	8.77
30%	6 21	4 64	7 39	-25.93	16.99
40%	9.78	8.10	9.65	-18.12	35.62
50%	8 72	6.05	13.68	-27 03	39.23
60%	12.74	16.05	20.20	-20.02	65.67
Control households	0.00	0.00	0.00	0.00	0.00
Overall Disequilibrium					
Percent of Rent households	25 23	39.67	67.93	1.18	868 66
Percentage rebate					
20%	22.42	36.66	51.03	1.71	325.95
30%	21.42	32.46	37.74	1.18	212.56
40%	23 73	37.60	56.70	2 90	435.25
50%	29 31	35.75	32.10	4.24	206.37
60%	29.72	95.60	194.30	6.22	868 66
Control households	19.11	37.81	57.60	0.02	565 46

Sample Size	
Percent of Rent	(291)
Percentage rebate	
20%	(45)
30%	(83)
40%	(63)
50%	(79)
60%	(21)
Control households	(272)

SAMPLE Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES Initial and monthly Household Report Forms, payments file, Third Periodic Interview.

a. Income equivalent of listed measure.

induced by the rent rebates.[1] Apparently, households would be about as well off adjusting to their initial equilibrium (H_0^*) and accepting the percentage of rent associated with that unit as they would be if they adjusted all the way to their experimental position (H_e^*). In addition, unmeasured costs of moving (such as psychic costs) are likely to inhibit moving as well.

The modest size of the benefits to be gained from moving thus suggests that households are unlikely to respond in a significant way, though one would still expect a positive relationship between moving and the income equivalents. Table VII-3 presents the results of estimating this benefit/cost model of mobility using logit analysis. The overvall explanatory power of this model is lower than a model based solely on sociological-demographic determinants (see MacMillan, 1978). The cost measures perform well at both sites--significant variables have the expected (negative) sign. The most important cost variable is the tenure discount. Increasing this tenure discount by $1 a month will decrease the probability of moving by about 2.6 percentage points in Pittsburgh and 2.1 percentage points in Phoenix.[2]

The benefit measures add significantly to the explanatory power of the equation only in Pittsburgh. All the coefficients have the expected (positive) sign at both sites. The magnitude of these effects are small, with the effect of an experimentally induced disequilibrium larger than that of an already existing one. An increase of $10 in the induced disequilibrium will have an effect on mobility of 3.7 percentage points in Pittsburgh (1.2 in Phoenix) but the pre-existing disequilibrium has an effect of increasing the probablility of moving by only 1.0 point in Pittsburgh (and 0.1 point in Phoenix). Given the small average size of the induced disequilibrium, neither effect is very important.

Given the mean value of the induced disequilibrium for Percent of Rent households shown in Table VII-3, the estimated mean effect of the Percent of Rent offers is very small indeed--about 1 percentage point in each site and significant only in Pittsburgh. MacMillan (1978) using a direct logit

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[1] The induced equilibrium does tend to be larger for households with larger discounts (higher "a" level). Of course, for a given household in equilibrium, a larger discount would lead to a larger disequilibrium.

[2] These values are partial derivatives evaluated at the mean of the sample.

Table VII-3

DISEQUILIBRIUM LOGIT MODEL OF TWO-YEAR MOBILITY

INDEPENDENT VARIABLES	PITTSBURGH MODEL I	PITTSBURGH MODEL II	PHOENIX MODEL I	PHOENIX MODEL II
Constant	0.2821 (0 62)	0.2844 (0 63)	1.0983 (3 12)**	1.1123 (3 06)**
Cost Measures				
Expected out-of-pocket moving costs	-0.0091 (1.80)†	-0.0089 (1.77)†	0.0140 (0 85)	0.0140 (0 83)
Expected search time	0.0030 (0.57)	0 0029 (0.56)	-0.0133 (2.77)**	-0.0135 (2.81)**
Current tenure discount	-0.1146 (8.11)**	-0.1125 (8.02)**	-0.0859 (7.67)**	-0.0856 (7.50)**
Benefit Measures[a]				
Initial disequilibrium	0.0041 (2.14)*		0.00044 (0.29)	
Experimentally induced disequilibrium	0.0162 (1.77)†		0.0051 (0.56)	
Overall disequilibrium		0.0043 (2.25)*		0.00053 (0.36)
Chi-square of benefit measures[b] (significance)	6.48[c] (0.05)	4.88[d] (0.05)	0 32[c] (Not significant)	0.12[d] (Not significant)
Proportion moving	0.359		0 563	
Coefficient of determination (σ^2)	0.072	0.070	0 092	0.092
Sample size	(701)		(563)	

SAMPLE. Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing

DATA SOURCES Initial and monthly Household Report Forms.

NOTE: Asymptotic t-statistic in parentheses below coefficient.

a. See text for measurement method.

b. When only one benefit measure is added, the chi-square statistic gives the same significance level as the asymptotic t-statistic.

c. With two degrees of freedom.

d. With one degree of freedom.

† t-statistic significant at the 0.10 level

* t-statistic significant at the 0 05 level.

** t-statistic significant at the 0 01 level.

estimate of mobility differences between Percent of Rent and Control households, with a variety of demographic covariates found significant effects of 5 percentage points in Pittsburgh and 11 percentage points in Phoenix (though her analysis also indicated that attrition bias might account for 2 to 3 percentage points of the effect in each site). These estimates are small, but much larger than the 1 percentage point effect estimated here.[1]

One obvious possibility is that the continuous disequilibrium variables do not fully capture the difference between Percent of Rent and Control households. Comparisons of actual and predicted rates for these groups are presented in Table VII-4, using the estimates from Table VII-3. The predicted values are close to the actual values and fluctuate around them for the different rebate levels, with no apparent pattern (and certainly are not significantly different from the actual values). Nevertheless, there is a slight underprediction of Percent of Rent mobility and overprediction of Control mobility in each site. The net effect is an underprediction of the actual difference between the two groups of 3.3 percentage points in Pittsburgh and 7.6 percentage points in Phoenix (using Model II), which is enough to account for most of the difference from MacMillan's findings.

VII.3 SUMMARY

In this appendix, a cost-benefit model of mobility was proposed and tested. The major finding is that cost measures, as disincentives, do better at explaining mobility than do benefit measures. This reiterates a finding of

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[1]Otherwise, MacMillan's results were consistent with the results of Table VII. She also found a negative effect for length of tenure (though it was significant only in Pittsburgh), even when prior mobility was also included in the logit. Like this model, MacMillan's model follows the basic conceptual scheme of mobility as determined by the benefits of housing change and the costs of search and moving. Her analysis does not involve any prior specification or measure of disequilibrium and is focused more on developing proxies for various costs, and barriers in the search process.

The final model estimated by MacMillan reflects major variables found to affect mobility in previous studies and extensive empirical testing of alternative forms and variable sets. Her overall coefficient of determination using a 17 variable model was about twice as high as the 5 variable model of Table VII-3--0.165 in Pittsburgh and 0.206 in Phoenix.

Table VII-4

PREDICTIVE POWER OF MOBILITY EQUATION

	OBSERVED PROPORTION MOVING	AVERAGE PREDICTED PROBABILITY OF MOVING		SAMPLE SIZE
		Model I	Model II	
	PITTSBURGH			
Percent of Rent households	0.377	0.362	0.358	(398)
Percentage rebate:				
20%	0.286	0.321	0.323	(63)
30%	0.398	0.364	0.364	(88)
40%	0.432	0.356	0.354	(111)
50%	0.352	0.387	0.377	(108)
60%	0.393	0.376	0.366	(28)
Control households	0.337	0.355	0.360	(303)
	PHOENIX			
Percent of Rent households	0.612	0.580	0.576	(291)
Percentage rebate:				
20%	0.578	0.570	0.570	(45)
30%	0.530	0.562	0.560	(83)
40%	0.587	0.582	0.577	(63)
50%	0.696	0.609	0.606	(79)
60%	0.762	0.557	0.546	(21)
Control households	0.511	0.545	0.548	(272)

NOTE: Percent of Rent and Control t-statistics show that all observed proportions could have could from a normal distribution with mean $\hat{p}$ (the average predicted probability) and variance $\hat{p}(1-\hat{p})/N$, where N = sample size.

a. Predicted using coefficients reported in Table VII-3.

Goodman (1976). In his more rudimentary model, Goodman quantified benefits using disequilibrium measures derived from average group characteristics. Nevertheless, the statistically significant coefficients for the benefit measures in Pittsburgh do indicate that households are at least partially motivated by economic considerations when they consider moving. Given the preliminary nature of the models, the results are encouraging for future work.

REFERENCES

Alonso, William, Location and Land Use, Cambridge, Mass., Harvard University Press, 1964.

Goodman, John L., Jr., "Housing Consumption Equilibrium and Local Residential Mobility," Environment and Housing, vol. 8, 1976.

MacMillan, Jean, Mobility in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., June 1978 (revised June 1980).

Merrill, Sally R., Hedonic Indices as a Measure of Housing Quality, Cambridge, Mass., Abt Associates Inc., December 1977 (revised June 1980).

Muth, Richard F., Cities and Housing, Chicago, Ill., University of Chicago Press, 1969.

Quigley, John M. and Daniel H. Weinberg, "Intra-Urban Residential Mobility: A Review and Synthesis," International Regional Science Review, vol. 2, no. 1, Fall 1977, pp. 41-66.

Willig, Robert D., "Consumers' Surplus Without Apology," American Economic Review, vol. 66, 1976.

APPENDIX VIII

THE EFFECT OF DEMOGRAPHIC VARIABLES ON THE HOUSING EXPENDITURES OF THE OVERALL SAMPLE

Demographic Variables as Covariates

Under the approach used in this report, demographic variables were included as dummy variables in the demand equation. The variables included were those indicating minority status and household composition.[1] Models that include just a minority variable, just household composition variables, and combinations of the two are presented in Tables VIII-1 and VIII-2.

At both sites the specification that allows a separate intercept for each of the six groups created by interacting minority status with household composition dominates all others (as indicated by the R^2 statistic adjusted for degrees of freedom). For this specification, in Pittsburgh nonminority households headed by only one adult and minority single-person households appear to have lower housing expenditures than the reference group of nonminority households headed by a couple. In Phoenix, all categories of minority households and nonminority single-person households have lower expenditures than the reference group.

Stratification

The covariate analysis showed that each of the six demographic groups should have a separate intercept. The specification discussed there assumes that all the groups have the same price and income elasticities. Stratification allows these to vary--separate equations were estimated for each group (see Tables VIII-3 and VIII-4). The hypothesis of homogeneity of elasticities when the intercepts are different was tested using a variance-ratio test. At both sites this test statistic was small and less than its critical value. Thus, the hypothesis that the intercepts are different but the elasticities are equal across the groups could not be rejected.[2]

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[1] Other covariates (age, sex, and education of the head of household and household size) were examined and rejected as insignificant.

[2] The value of the F-statistic was 1.30 in Pittsburgh and 1.01 in Phoenix, both insignificant at the 0.05 level.

Table VIII-1

LOG-LINEAR DEMAND FUNCTIONS USING DEMOGRAPHIC VARIABLES AS COVARIATES FOR THE OVERALL SAMPLE (PITTSBURGH)

INDEPENDENT VARIABLES	NO COVARIATES	MINORITY STATUS	HOUSEHOLD COMPOSITION	ADDITIVE EFFECTS	COMPLETE INTERACTION
Constant	2.865** (0.170)	2.895** (0.169)	3.027** (0.224)	3.039** (0 221)	3.030** (0.222)
Income elasticity	0.328** (0.028)	0.326** (0.028)	0.300** (0.036)	0 301* (0 035)	0.301** (0.035)
Price elasticity	-0.178** (0.038)	-0.175** (0.037)	-0.174** (0.038)	-0.171** (0.037)	-0.171** (0.037)
Minority household[a]	--	-0.095** (0.027)	--	-0.110** (0.028)	
Single-person household[a]	--	--	-0.053 (0.038)	-0.051 (0.038)	--
Single head of household with others[a]	--	--	0.032 (0.026)	0.050 (0.026)	--
Nonminority single-person household[a]	--	--	--	--	-0.030 (0.039)
Nonminority single head of household with others[a]	--	--	--	--	-0.058* (0.029)
Minority single-person household[a]	--	--	--	--	-0.228** (0.070)
Minority single head of household with others[a]	--	--	--	--	-0.056 (0 038)
Minority household headed by a couple[a]	--	--	--	--	-0.059 (0.049)
R^2	0.178	0.193	0.187	0.206	0.209
Adjusted R^2	0 176	0.189	0.182	0.200	0 202
SEE	0.28	0.28	0.28	0.28	0.28
Sample size[b]	(669)	(669)	(669)	(669)	(669)

SAMPLE Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing

DATA SOURCES Initial and monthly Household Report Forms, and payments file.

NOTE. Dependent variable: ln(Rent), Standard error in parentheses.

a. Denotes dummy variable.

b. Sample size differs from previous tables due to additional selection on demographic variables.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

SEE = Standard Error of Estimate.

Table VIII-2

LOG-LINEAR DEMAND FUNCTIONS USING DEMOGRAPHIC VARIABLES AS COVARIATES FOR THE OVERALL SAMPLE (PHOENIX)

INDEPENDENT VARIABLES	NO COVARIATES	MINORITY STATUS	HOUSEHOLD COMPOSITION	ADDITIVE EFFECTS	COMPLETE INTERACTION
Constant	2.265** (0.197)	2.466** (0.195)	2.210** (0.234)	2.603** (0.235)	2.530** (0 235)
Income elasticity	0.441** (0.033)	0.417** (0.032)	0 447** (0.038)	0.394** (0.037)	0.411** (0.038)
Price elasticity	-0 235** (0.050)	-0.248** (0.048)	-0 231** (0.050)	-0.245** (0 048)	-0.241** (0.048)
Minority household[a]	--	-0.166 (0.030)	--	-0.190** (0.031)	--
Single-person household[a]	--	--	-0.015 (0.045)	-0.086* (0.045)	--
Single head of household with others[a]	--	--	0.065* (0.034)	0.060† (0.033)	--
Nonminority single-person household[a]	--	--	--	--	-0.111* (0.048)
Nonminority single head of household with others[a]	--	--	--	--	-0.004 (0.041)
Minority single-person household[a]	--	--	--	--	-0.267** (0.091)
Minority single head of household with others[a]	--	--	--	--	-0.099* (0.048)
Minority household headed by a couple[a]	--	--	--	--	-0.268** (0.042)
R^2	0.278	0 319	0.285	0.335	0.345
Adjusted R^2	0.275	0.315	0.279	0.329	0.336
SEE	0.33	0 32	0.33	0.32	0.31
Sample size[b]	(521)	(521)	(521)	(521)	(521)

SAMPLE Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES Initial and monthly Household Report Forms, and payments file.

NOTE Dependent variable: ln(Rent), Standard error in parentheses.

a. Denotes dummy variable.

b. Sample size differs from previous tables due to additional selection on demographic variables.

† t-statistic significant at the 0.10 level.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

SEE = Standard Error of Estimate.

Table VIII-3

STRATIFIED LOG-LINEAR EXPENDITURE FUNCTIONS
FOR THE OVERALL SAMPLE
(PITTSBURGH)

INDEPENDENT VARIABLES	ALL HOUSEHOLDS					NONMINORITY HOUSEHOLDS					MINORITY HOUSEHOLDS				
	Constant	Income Elas-ticity	Price Elas-ticity	SEE	R^2	Constant	Income Elas-ticity	Price Elas-ticity	SEE	R^2	Constant	Income Elas-ticity	Price Elas-ticity	SEE	R^2
All households	2.865**	0.328**	-0 178**	0 28	0 178	2.893**	0.326**	-0 171**	0.28	0 179	2.805**	0 324**	-0 197*	0.28	0.179
	(0.170)	(0 028)	(0 038)		(N=669)	(0.189)	(0.031)	(0.041)		(N=536)	(0.381)	(0.083)	(0 088)		(N=133)
Single-person households	2 596**	0 370**	-0.161†	0.32	0 129	2.517**	0 388**	-0 164†	0 32	0 129	3 244**	0 219	-0 186	0.25	0.133
	(0 480)	(0.088)	(0 091)		(N=133)	(0.559)	(0 100)	(0.097)		(N=113)	(0 867)	(0 157)	(0 220)		(N=20)
Single heads of house-hold with others	4 009**	0 141*	-0.149*	0.28	0.0425	3.839**	0 175**	-0 153*	0 27	0.063	4 183**	0 103	-0 087	0.29	0.014
	(0 346)	(0 051)	(0.059)		(N=257)	(0 390)	(0.066)	(0 066)		(N=182)	(0.726)	(0.120)	(0.127)		(N=75)
Households headed by a couple	2.345**	0 408**	-0 221**	0.26	0.196	2.302**	0 417**	-0.199**	0 27	0 183	2 579**	0.356**	-0.357*	0.24	0.300
	(0.325)	(0 052)	(0.057)		(N=279)	(0.369)	(0.059)	(0 062)		(N=241)	(0.666)	(0.107)	(0 135)		(N=38)

INDEPENDENT VARIABLE	ELDERLY				
	Constant	Income Elas-ticity	Price Elas-ticity	SEE	R^2
All households	2.795**	0 327**	-0 223*	0.33	0.115
	(0.551)	(0.099)	(0.102)		(N=112)

SAMPLE Pittsburgh Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES Initial and monthly Household Report Forms, and payments file

NOTE. Standard error in parentheses

† t-statistic significant at the 0.10 level

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0 01 level

SEE = Standard Error of Estimate.

Table VIII-4

STRATIFIED LOG-LINEAR EXPENDITURE FUNCTIONS
FOR THE OVERALL SAMPLE
(PHOENIX)

	ALL HOUSEHOLDS					NONMINORITY HOUSEHOLDS					MINORITY HOUSEHOLDS				
INDEPENDENT VARIABLES	Constant	Income Elas- ticity	Price Elas- ticity	SEE	R^2	Constant	Income Elas- ticity	Price Elas- ticity	SEE	R^2	Constant	Income Elas- ticity	Price Elas- ticity	SEE	R^2
All households	2.265** (0.197)	0 441** (0.033)	-0.235* (0.050)	0.33	0.278 (N=521)	2.138** (0 228)	0 470** (0.038)	-0 263** (0 057)	0.30	0 341 (N=339)	2 836** (0 350)	0.327** (0.059)	-0 227* (0 088)	0.36	0 171 (N=182)
Single-person households	1.752** (0 407)	0 529** (0 072)	-0.162 (0 117)	0.30	0 371 (N=98)	2.430** (0.475)	0 412** (0 084)	-0.172 (0.122)	0.29	0 253 (N=83)	0 283 (0 858)	0 775** (0.154)	-0.304 (0 343)	0.30	0.678 (N=15)
Single heads of house- hold with others	2.461** (0.361)	0 417** (0 061)	-0.207 (0 076)	0.33	0.220 (N=184)	2.339** (0 473)	0.440** (0.078)	-0.290** (0.092)	0.29	0.270 (N=105)	3 223** (0.837)	0 278* (0.111)	-0 136 (0 126)	0.37	0.087 (N=79)
Households headed by a couple	2.340** (0 390)	0 424** (0 063)	-0 279** (0 079)	0.34	0 202 (N=239)	2.466** (0 419)	0 419** (0 067)	-0.286** (0 090)	0.30	0.247 (N=151)	2 720** (0.710)	0.334** (0 116)	-0.313* (0.127)	0 33	0 166 (N=88)

	ELDERLY					SPANISH AMERICAN					BLACK				
INDEPENDENT VARIABLE	Constant	Income Elas- ticity	Price Elas- ticity	SEE	R^2	Constant	Income Elas- ticity	Price Elas- ticity	SEE	R^2	Constant	Income Elas- ticity	Price Elas- ticity	SEE	R^2
All households	1.962** (0 553)	0 489** (0 100)	-0 163 (0.135)	0 31	0 247 (N=81)	2 702** (0.403)	0.352** (0.067)	-0.171† (0.097)	0.35	0 178 (N=138)	3.477** (0.774)	0.204 (0.136)	-0.459* (0 204)	0.39	0.18 (N=44)

SAMPLE Phoenix Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.
DATA SOURCES Initial and monthly Household Report Forms, and payments file.
NOTE Standard error in parentheses
† t-statistic significant at the 0 10 level
* t-statistic significant at the 0 05 level
** t-statistic significant at the 0.01 level
SEE = Standard Error of Estimate.

APPENDIX IX

COMPARISON OF ELASTICITY ESTIMATES FROM FIRST-YEAR DATA ANALYSIS AND THIS REPORT

Chapter 4 noted that the income and price elasticities estimated by Mayo in the report on the first-year of data (Mayo, 1977) were different than the results presented here. Some differences are to be expected, as the samples used were not identical--

- for the overall sample, Chapter 4 used the sample of households active at two years after enrollment excluding those that had rents less than $40 per month or incomes less than $1,000 per year, while Mayo used the sample of households active at one year after enrollment with no other exclusions;

- for the mover sample, Chapter 4 in addition selected households moving between enrollment and two years after enrollment, while Mayo used only those households moving during the first year after enrollment.

Tables IX-1 and IX-2 present the steps taken to reconcile the two estimates for the overall and the movers samples, respectively. The first line in each table represents the numbers reported in Chapter 4. Succeeding lines first add some low-rent households excluded from the analysis of Chapter 4, then change the income variable from the three-year average income used in Chapter 4 to the two-year average income used in Mayo (1977), then change the dependent variable to rent at one year (and, in Table IX-2, the sample to households that moved in the first year), and then shifts from the sample of households active at the end of two years to the sample active at the end of one year. The final line gives the estimates reported by Mayo.

Re-estimating Mayo's exact specification using the two-year data base still leaves some differences since the two-year data base includes some information on some households that was missing from the one-year data base. However, this difference is not major. Differences in estimates essentially reflect differences in the estimated response for movers and occur for two reasons:

1) Second-year movers in Pittsburgh had a higher response than did first-year movers, while the reverse was true in Phoenix (See Table 6-2), and

2) In Pittsburgh, households that dropped out of the sample during the second year had somewhat lower than average first-year responses.

Table IX-1

COMPARISON OF ELASTICITY ESTIMATES: FINDINGS FROM FIRST-YEAR DATA ANALYSIS VS. THIS REPORT (OVERALL SAMPLE)

			PITTSBURGH			PHOENIX		
SAMPLE	RENT VARIABLE	INCOME VARIABLE	INCOME ELASTICITY	PRICE ELASTICITY	SAMPLE SIZE	INCOME ELASTICITY	PRICE ELASTICITY	SAMPLE SIZE
(1) A2,R,Y	Two-Year	Three-Year Average	0.333 (0.028)	-0.178 (0.038)	(674)	0.435 (0.032)	-0.234 (0.049)	(532)
(2) A2,Y	Two-Year	Three-Year Average	0.360 (0.028)	-0.178 (0.039)	(684)	0.445 (0.032)	-0.246 (0.049)	(543)
(3) A2,Y	Two-Year	Two-Year Average	0.336 (0.029)	-0.176 (0.039)	(684)	0.423 (0.032)	-0.243 (0.050)	(543)
(4) A2,Y	One-Year	Two-Year Average	0.345 (0.028)	-0.135 (0.037)	(696)	0.418 (0.033)	-0.237 (0.053)	(532)
(5) A1,Y	One-Year	Two-Year Average	0.354 (0.026)	-0.126 (0.035)	(781)	0.422 (0.030)	-0.217 (0.047)	(675)
(6) A1	One-Year[a]	Two-Year Average	0.338 (0.026)	-0.109 (0.036)	(764)	0.400 (0.029)	-0.234 (0.048)	(657)

SAMPLES: A1 - Percent of Rent and Control households active at one year after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

A2 - Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

R - Sample also excludes households with rent less than $40 per month.

Y - Sample also excludes households with incomes less than $1,000 per year.

DATA SOURCES For samples 1-5, estimates are from Chapter 4 of this report; for sample 6, estimates are from Table 4-1 in Mayo (1977).

NOTES: First-year data analysis refers to Mayo, 1977 (sample 6), in which the major sample used was households active at one year after enrollment; this report focuses on those households active at two years after enrollment. See Appendix IX text for a discussion of further sample differences.

Standard errors in parentheses.

a. The analytic rent definition used in Mayo (1977) used original utility adjustments and included the reported contribution of roomers, this report did not. Neither of these differences affected the results.

Table IX-2

COMPARISON OF ELASTICITY ESTIMATES FINDINGS FROM FIRST-YEAR DATA ANALYSIS VS. THIS REPORT (MOVERS SAMPLE)

			PITTSBURGH			PHOENIX		
SAMPLE	RENT VARIABLE	INCOME VARIABLE	INCOME ELASTICITY	PRICE ELASTICITY	SAMPLE SIZE	INCOME ELASTICITY	PRICE ELASTICITY	SAMPLE SIZE
(1) A2,M2, R,Y	Two-Year	Three-Year Average	0.363 (0.052)	-0.211 (0.063)	(236)	0.364 (0.042)	-0.219 (0.059)	(292)
(2) A2,M2, Y	Two-Year	Three-Year Average	0.448 (0.055)	-0.212 (0.069)	(244)	0.380 (0.042)	-0.238 (0.060)	(299)
(3) A2,M2, Y	Two-Year	Two-Year Average	0.383 (0.056)	-0.199 (0.072)	(244)	0.343 (0.042)	-0.349 (0.075)	(299)
(4) A2,M1, Y	One-Year	Two-Year Average	0.412 (0.059)	-0.111 (0.080)	(177)	0.346 (0.051)	-0.314 (0.065)	(222)
(5) A1,M1, Y	One-Year	Two-Year Average	0.401 (0.056)	-0.059 (0.075)	(198)	0.355 (0.046)	-0.312 (0.066)	(317)
(6) A1,M1	One-Year[a]	Two-Year Average	0.365 (0.059)	-0.045 (0.077)	(189)	0.348 (0.044)	-0.354 (0.060)	(291)

SAMPLES A1 - Percent of Rent and Control households active at one year after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

A2 - Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing

R - Sample also excludes households with rent less than $40 per month.

Y - Sample also excludes households with incomes less than $1,000 per year.

M1 - Move between enrollment and one year after enrollment.

M2 - Move between enrollment and two years after enrollment

DATA SOURCES For samples 1-5, estimates are from Chapter 4 of this report; for sample 6, estimates are from Table 4-2 in Mayo (1977).

NOTES. First-year data analysis refers to Mayo, 1977 (sample 6), in which the major sample used was households active at one year after enrollment, this report focuses on those households active at two years after enrollment. See Appendix IX text for a discussion of further sample differences

Standard errors in parentheses.

a. The analytic rent definition used in Mayo (1977) used original utility adjustments and included the reported contribution of roomers; this report did not. Neither of these differences affected the results

REFERENCES

Mayo, Stephen K., Housing Expenditures and Quality, Part I: Housing Expenditures Under a Percent of Rent Housing Allowance, Cambridge, Mass., Abt Associates Inc., January 1977.

APPENDIX X

DETAILED TABLES

This appendix contains the following detailed tables from which some of the tables and findings in Chapters 2 through 6 have been extracted.

Table X-1	Changes in Rent From Enrollment to Two Years After Enrollment
Table X-2	Changes in Median Rent Burden From Enrollment to Two Years
Table X-3	Change in Mean Rent Burden From Enrollment to Two Years
Table X-4	Percentage Distribution of Rent Burden
Table X-5	Changes in Rent From Enrollment to Two Years After Enrollment for the Mover Sample
Table X-6	Changes in Rent From Enrollment to Two Years After Enrollment for the Nonmover Sample
Table X-7	Change in Rent Applying Selective Income Eligibility Limits to Control Households
Table X-8	Change in Rent Applying Selective Income Eligibility Limits to Control Households for Mover Sample
Table X-9	Change in Rent Applying Selective Income Eligibility Limits to Control Households for Nonmover Sample
Table X-10	Proportion of Allowance Payment Allocated to Increased Rental Expenditures
Table X-11	Enrollment Rent Burden by Income Class for Combined Sites
Table X-12	Overall Characteristics of Variables Used in Regression Analysis
Table X-13	Log-Linear Expenditure Functions
Table X-14	Linear Expenditure Functions
Table X-15	Log-Linear Demand Function Allowing Variable Price Elasticity
Table X-16	Log-Linear Expenditure Functions - Sites Pooled
Table X-17	Log-Linear Demand Functions for Movers Sample Stratified by Median Monthly Income
Table X-18	Log-Linear Demand Functions for Mover Sample Estimated Using Income Spline

Table X-19 Log-Linear Expenditure Functions Using Demographic Variables as Covariates for the Mover Sample

Table X-20 Mean Monthly Housing Expenditures at Enrollment and at Two Years After Enrollment for the Mover Sample by Race/Ethnicity

Table X-21 Stratified Log-Linear Expenditure Functions for the Movers Sample

Table X-22 Rent for Movers by Stratified Demographics Pooled Sites

Table X-23 Changes in Rates of Passing Lowest Housing Standards From Enrollment to Two Years for Control and Percent of Rent Households

Table X-24 Changes in Rates of Passing Program Housing Standards From Enrollment to Two Years for Control and Percent of Rent Households

Table X-25 Changes in Rates of Passing Program Occupancy Standards From Enrollment to Two Years for Control and Percent of Rent Households

Table X-26 Changes in Rates of Passing Lowest Housing Standards From Enrollment to Two Years for Control and Percent of Rent Households for the Movers Sample

Table X-27 Changes in Rates of Passing Lowest Housing Standards From Enrollment to Two Years for Control and Percent of Rent Households for the Nonmover Sample

Table X-28 Changes in Rates of Passing Program Housing Standards From Enrollment to Two Years for Control and Percent of Rent Households for the Mover Sample

Table X-29 Changes in Rates of Passing Program Housing Standards From Enrollment to Two Years for Control and Percent of Rent Households for the Nonmover Sample

Table X-30 Changes in Rates of Passing Program Occupancy Standards From Enrollment to Two Years for Control and Percent of Rent Households for the Mover Sample

Table X-31 Changes in Rates of Passing Program Occupancy Standards From Enrollment to Two Years for Control and Percent of Rent Households for the Nonmover Sample

Table X-32 Changes in Housing Adequacy From Enrollment to Two Years for Control and Percent of Rent Households

Table X-33 Changes in Housing Adequacy From Enrollment to Two Years for Control and Percent of Rent Movers

Table X-34 Changes in Housing Adequacy From Enrollment to Two Years for Control and Percent of Rent Nonmovers

Table X-35 Change in Hedonic Housing Services Index From Enrollment to Two Years for Control and Percent of Rent Households

Table X-36 Changes in Hedonic Housing Services Index From Enrollment to Two Years for Control and Percent of Rent Households for the Mover Sample

Table X-37 Changes in Hedonic Housing Services Index From Enrollment to Two Years for Control and Percent of Rent Households for the Nonmover Sample

Table X-38 Search Effort for Last Move

Table X-39 Demand for Rent Components

Table X-40 Stratified Log-Linear Housing Services Functions for the Overall Sample

Table X-41 Stratified Log-Linear Housing Services Functions for the Mover Sample

Table X-42 Mean Monthly Housing Services at Enrollment and at Two Years After Enrollment for the Mover Sample by Race/Ethnicity

Table X-43 Stratified Log-Linear Housing Expenditures, Housing Services, and Hedonic Residuals Elasticities for the Mover Sample

Table X-44 Log-Linear Expenditure Functions for Housing Services Using Full Sample and Submarket Hedonic Indices for Phoenix

Table X-45 Estimate of Log (Normal Rent) at Two Years After Enrollment

TABLE X-1

CHANGES IN RENT FROM ENROLLMENT TO TWO YEARS AFTER ENROLLMENT

TREATMENT GROUP	MEAN RENT: At Enroll-Ment	MEAN RENT: At Two Years	MEAN CHANGE IN RENT: AMOUNT	MEAN CHANGE IN RENT: PERCENTAGE: Mean of Ratio	MEAN CHANGE IN RENT: PERCENTAGE: Ratio of Means	SAMPLE SIZE
PITTSBURGH						
All Percent of Rent Households	$114	$139	$25	26%	22%	(385)
Percentage rebate:						
20%	109	126	17	17	16	(62)
30%	112	136	25	25	22	(82)
40%	122	148	26	27	21	(108)
50%	114	140	27	27	24	(105)
60%	109	142	33	39	30	(28)
Control households	115	133	18	18	16	(289)
Unconstrained households	107	128	21	22	20	(59)
PHOENIX						
All Percent of Rent households	132	162	30	26	23	(280)
Percentage rebate:						
20%	133	156	23	24	17	(44)
30%	125	152	27	24	22	(79)
40%	136	166	30	24	22	(59)
50%	141	172	31	24	22	(77)
60%	112	157	45	45	40	(21)
Control households	128	145	17	18	13	(252)
Unconstrained households	135	165	30	35	22	(37)

SAMPLE: Percent of Rent, Control, and Unconstrained households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

TABLE X-2

CHANGES IN MEDIAN RENT BURDEN
FROM ENROLLMENT TO TWO YEARS

TREATMENT GROUP	MEDIAN RENT BURDEN: At Enrollment[a]	MEDIAN RENT BURDEN: At Two Years[b]	MEDIAN CHANGE IN RENT BURDEN	SAMPLE SIZE
		PITTSBURGH		
All Percent of Rent households	0.32	0.21	-0.11	(388)
Percentage rebate:				
20%	0.29	0.22	-0.06	(62)
30%	0.33	0.25	-0.09	(83)
40%	0.31	0.20	-0.11	(109)
50%	0.33	0.17	-0.15	(106)
60%	0.40	0.18	-0.22	(28)
Control households	0.29	0.26	-0.04	(290)
Unconstrained households	0.35	0.20	-0.17	(59)
		PHOENIX		
All Percent of Rent households	0.32	0.24	-0.09	(282)
Percentage rebate:				
20%	0.37	0.31	-0.01	(45)
30%	0.31	0.26	-0.06	(79)
40%	0.31	0.22	-0.11	(59)
50%	0.33	0.20	-0.14	(78)
60%	0.39	0.19	-0.18	(21)
Control households	0.32	0.30	-0.02	(256)
Unconstrained households	0.33	0.13	-0.23	(38)

SAMPLE: Percent of Rent, Control, and Unconstrained households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

a. Rent burden at enrollment is defined as the ratio of enrollment rent to enrollment income.

b. Rent burden at two years is defined as the ratio of net two-year rent (gross rent minus allowance payment) to two-year income.

TABLE X-3

CHANGE IN MEAN RENT BURDEN
FROM ENROLLMENT TO TWO YEARS

TREATMENT GROUP	MEAN RENT BURDEN At Enrollment[a]	At Two Years[b]	MEAN CHANGE IN RENT BURDEN	SAMPLE SIZE
PITTSBURGH				
All Percent of Rent households	0.36	0.23	-0.14	(388)
Percentage rebate:				
20%	0.35	0.26	-0.09	(62)
30%	0.34	0.27	-0.08	(83)
40%	0.36	0.22	-0.14	(109)
50%	0.38	0.20	-0.18	(106)
60%	0.44	0.19	-0.26	(28)
Control households	0.33	0.29	-0.04	(290)
Unconstrained households	0.39	0.20	-0.19	(59)
PHOENIX				
All Percent of Rent households	0.37	0.27	-0.10	(282)
Percentage rebate:				
20%	0.37	0.34	-0.03	(45)
30%	0.35	0.30	-0.06	(79)
40%	0.35	0.25	-0.11	(59)
50%	0.38	0.24	-0.15	(78)
60%	0.41	0.22	-0.19	(21)
Control households	0.35	0.34	-0.01	(256)
Unconstrained households	0.38	0.09	-0.29	(38)

SAMPLE: Percent of Rent, Control, and Unconstrained households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms

a. Rent burden at enrollment is defined as the ratio of enrollment rent to enrollment income.

b. Rent burden at two years is defined as the ratio of net two-year rent (gross rent minus allowance payment) to two-year income.

TABLE X-4

PERCENTAGE DISTRIBUTION OF RENT BURDEN

RENT BURDEN RANGE	PITTSBURGH AT ENROLLMENT	PITTSBURGH AT TWO YEARS	PHOENIX AT ENROLLMENT	PHOENIX AT TWO YEARS
Control Households				
<10%	0%	0%	1%	0%
10-20	13	21	14	11
20-25	19	18	15	12
25-30	22	16	13	20
30-40	20	21	29	27
40-50	15	13	17	14
>50	11	12	11	16
Total[a]	100	101	100	100
Sample size	(290)	(301)	(254)	(256)
Percent of Rent Households				
<10%	0	7	0	5
10-20	11	44	13	32
20-25	13	19	14	20
25-30	20	13	14	12
30-40	25	12	28	16
40-50	15	3	12	9
>50	17	2	19	6
Total[a]	101	100	100	100
Sample size	(387)	(389)	(281)	(285)
Unconstrained Households				
<10%	0	9	0	20
10-20	8	37	14	17
20-25	12	16	8	20
25-30	14	18	19	13
30-40	32	14	32	20
40-50	14	4	8	3
>50	20	4	19	7
Total[a]	100	102	100	100
Sample size	(59)	(57)	(37)	(30)

SAMPLE: Percent of Rent, Unconstrained, and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

a. Total may not add to 100 percent due to rounding.

TABLE X-5

CHANGES IN RENT FROM ENROLLMENT TO TWO YEARS AFTER ENROLLMENT FOR THE MOVER SAMPLE

TREATMENT GROUP	MEAN RENT		MEAN CHANGE IN RENT			SAMPLE SIZE
	At Enroll-ment	At two years	AMOUNT	PERCENTAGE Mean of Ratio	PERCENTAGE Ratio of Means	
PITTSBURGH						
All Percent of Rent households	$114	$156	$41	45%	36%	(142)
Percentage rebate:						
20%	110	135	25	27	23	(17)
30%	107	150	43	44	40	(33)
40%	128	167	39	43	30	(46)
50%	111	157	45	49	41	(35)
60%	[98]	[154]	[56]	[74]	[57]	(11)
Control households	120	147	26	29	22	(94)
Unconstrained households	109	145	36	39	33	(22)
PHOENIX						
All Percent of Rent households	135	179	44	38	33	(169)
Percentage rebate:						
20%	122	158	36	37	30	(26)
30%	137	181	44	37	32	(40)
40%	142	191	50	40	35	(33)
50%	143	184	41	32	29	(54)
60%	114	170	56	57	49	(16)
Control households	132	160	28	30	21	(123)
Unconstrained households	128	175	48	55	38	(21)

SAMPLE: Percent of Rent, Control, and Unconstrained movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Brackets indicate entries based on 15 or fewer observations.

TABLE X-6

CHANGES IN RENT FROM ENROLLMENT TO TWO YEARS AFTER ENROLLMENT FOR THE NONMOVER SAMPLE

TREATMENT GROUP	MEAN RENT		MEAN CHANGE IN RENT			SAMPLE SIZE
				PERCENTAGE		
	At Enroll-ment	At two years	AMOUNT	Mean of Ratio	Ratio of Means	
			PITTSBURGH			
All Percent of Rent households	$114	$130	$16	15%	14%	(243)
Percentage rebate:						
20%	109	123	14	13	13	(45)
30%	115	128	12	12	10	(49)
40%	117	134	17	15	15	(62)
50%	115	132	17	17	15	(70)
60%	116	134	18	16	16	(17)
Control households	112	127	14	13	13	(195)
Unconstrained households	106	119	13	12	12	(37)
			PHOENIX			
All Percent of Rent Households	127	134	8	7	6	(111)
Percentage rebate:						
20%	148	154	6	5	4	(18)
30%	112	122	10	10	9	(39)
40%	129	135	5	5	4	(26)
50%	137	143	7	6	5	(23)
60%	[108]	[116]	[9]	[9]	[8]	(5)
Control Households	125	132	7	7	6	(129)
Unconstrained households	145	151	7	8	5	(16)

SAMPLE: Percent of Rent, Control, and Unconstrained nonmovers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Brackets indicate entries based on 15 or fewer observations.

TABLE X-7

CHANGE IN RENT APPLYING SELECTIVE
INCOME ELIGIBILITY LIMITS TO CONTROL HOUSEHOLDS

TREATMENT GROUP	MEAN RENT At Enroll-ment	MEAN RENT At Two Years	MEAN CHANGE IN RENT AMOUNT	MEAN CHANGE IN RENT PERCENTAGE Mean of Ratio	MEAN CHANGE IN RENT PERCENTAGE Ratio of Means	SAMPLE SIZE
			PITTSBURGH			
Percentage rebate = 20%	$105	$120	$16	16%	15%	(39)
Control households	119	139	20	19	17	(179)
Percentage rebate = 60%	108	136	28	32	26	(23)
Control households	107	123	16	18	15	(111)
			PHOENIX			
Percentage rebate = 20%	146	166	20	19	14	(30)
Control households	140	156	17	15	12	(166)
Percentage rebate = 60%	117	155	38	36	32	(17)
Control households	106	120	15	21	14	(88)

SAMPLE: Percent of Rent households in Treatment Groups 13 and 23 and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: See Appendix Table III-3 for the income eligibility limits applied to these households.

TABLE X-8

CHANGE IN RENT APPLYING SELECTIVE INCOME ELIGIBILITY LIMITS TO CONTROL HOUSEHOLDS FOR MOVER SAMPLE

TREATMENT GROUP	MEAN RENT: At Enroll-ment	MEAN RENT: At Two Years	MEAN CHANGE IN RENT: AMOUNT	MEAN CHANGE IN RENT: PERCENTAGE: Mean of Ratio	MEAN CHANGE IN RENT: PERCENTAGE: Ratio of Means	SAMPLE SIZE
			PITTSBURGH			
Percentage rebate = 20%	[$100]	[$133]	[$33]	[33%]	[33%]	(7)
Control households	125	155	29	32	23	(47)
Percentage rebate = 60%	[104]	[146]	[43]	[56]	[41]	(9)
Control households	114	138	24	29	21	(48)
			PHOENIX			
Percentage rebate = 20%	[140]	[177]	[37]	[34]	[26]	(15)
Control households	145	171	26	23	18	(77)
Percentage rebate = 60%	[119]	[167]	[48]	[45]	[40]	(13)
Control households	112	135	23	34	21	(49)

SAMPLE: Percent of Rent movers in Treatment Groups 13 and 23 and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Brackets indicate entries based on 15 or fewer observations. See Appendix Table III-3 for the income eligibility requirements applied to these households.

TABLE X-9

CHANGE IN RENT APPLYING SELECTIVE INCOME ELIGIBILITY LIMITS TO CONTROL HOUSEHOLDS FOR NONMOVER SAMPLE

TREATMENT GROUP	MEAN RENT		MEAN CHANGE IN RENT			SAMPLE SIZE
				PERCENTAGE		
	At Enrollment	At Two Years	AMOUNT	Mean of Ratio	Ratio of Means	
			PITTSBURGH			
Percentage rebate = 20%	$105	$117	$12	12%	11%	(32)
Control households	117	133	16	15	14	(132)
Percentage rebate = 60%	[110]	[129]	[18]	[17]	[16]	(14)
Control households	102	112	10	10	10	(63)
			PHOENIX			
Percentage rebate = 20%	[151]	[155]	[4]	[4]	[3]	(15)
Control households	135	144	9	8	7	(89)
Percentage rebate = 60%	[112]	[118]	[6]	[7]	[5]	(4)
Control households	98	101	4	5	4	(39)

SAMPLE: Percent of Rent nonmovers in Treatment Groups 13 and 23 and Control nonmovers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Brackets indicate entries used on 15 or fewer observations. See Appendix Table III-3 for the income eligibility requirements applied to these households.

TABLE X-10

PROPORTION OF ALLOWANCE PAYMENT
ALLOCATED TO INCREASED RENTAL EXPENDITURES

HOUSEHOLD GROUP	MEAN CHANGE IN RENT ABOVE NORMAL[a]	MEAN PAYMENT	PROPORTION USED FOR INCREASED EXPENDITURES[b]	SAMPLE SIZE
	PITTSBURGH			
All Households	$ 7	$49	14%	(391)
Nonmovers	2	46	4	(248)
Percentage rebate:				
20%	-1	23	-4	(46)
30%	-2	35	-6	(52)
40%	3	50	6	(62)
50%	3	58	5	(71)
60%	4	74	5	(17)
Movers	15	56	27	(143)
Percentage rebate-				
20%	-1	27	-4	(17)
30%	17	40	43	(33)
40%	15	59	25	(47)
50%	19	70	27	(35)
60%	[30]	[87]	[34]	(11)
	PHOENIX			
All Households	$14	$59	24%	(285)
Nonmovers	1	46	2	(114)
Percentage rebate:				
20%	-1	28	-4	(18)
30%	3	35	9	(40)
40%	-1	51	-2	(27)
50%	-1	69	-1	(24)
60%	[2]	[66]	[3]	(5)
Movers	16	68	24	(171)
Percentage rebate:				
20%	12	29	41	(27)
30%	18	53	34	(40)
40%	24	69	35	(33)
50%	15	88	17	(55)
60%	30	100	30	(16)

SAMPLE. Percent of Rent households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Brackets indicate entries based on 15 or fewer observations.

a. This is computed as the mean change for Experimental households minus the mean change for Control households.

b. This is computed as the mean change above normal divided by the mean payment. It is intended to represent a program average rather than a household average.

TABLE X-11

ENROLLMENT RENT BURDEN BY
INCOME CLASS FOR COMBINED SITES

MONTHLY INCOME	MEAN RENT	MEAN INCOME	MEAN RENT BURDEN [a]	SAMPLE SIZE
$83.3-150	$ 86	$129	0.69	(159)
151-250	101	203	0.50	(625)
251-350	115	301	0.38	(709)
351-450	126	398	0.32	(694)
451-550	137	498	0.28	(585)
551-650	149	595	0.25	(311)
651-750	162	694	0.23	(120)
751+	157	864	0.18	(77)
Total	123	385	0.37	(3348)

SAMPLE: Experimental and Control enrollees, excluding those with enrollment incomes over the eligibility limits.

DATA SOURCES: Initial Household Report Forms.

a. Mean rent burden is defined as the mean of rent at enrollment divided by income at enrollment.

TABLE X-12

OVERALL CHARACTERISTICS OF VARIABLES
USED IN REGRESSION ANALYSIS

	ALL HOUSEHOLDS						MOVERS					
	PITTSBURGH			PHOENIX			PITTSBURGH			PHOENIX		
Equations	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample	Mean	Standard Deviation	Sample
Log-linear Expenditures Equation												
Log (rent)	4.869	0 313	(674)	4.966	0.385	(532)	4.977	0.308	(236)	5 085	0 347	(292)
Log (average monthly income)	5 958	0.395	(674)	5.982	0 442	(532)	5.968	0.356	(236)	5.998	0.426	(292)
Log (current monthly income)	6 040	0 452	(674)	5.999	0.491	(532)	5 968	0 416	(236)	6 006	0.478	(292)
Log (1-a)	-0.292	0 294	(674)	-0.265	0.291	(532)	-0.311	0 294	(236)	-0.305	0.306	(292)
Linear Expenditures Equation												
Rent	136.72	44 43	(674)	153.89	56 02	(532)	152.08	48.76	(236)	171.13	56.62	(292)
Average monthly income/(1-a)	573 69	266 91	(674)	588.07	303.01	(532)	579.81	243.50	(236)	617.93	305.59	(292)
Current monthly income/(1-a)	638 84	334.19	(674)	612.90	362 26	(532)	652.54	312.48	(236)	640 70	377.73	(292)
1/(1-a)	1 400	0 435	(674)	1 362	0.429	(532)	1.426	0.435	(236)	1.423	0.459	(292)
Log-linear Housing Services Equation												
Log (hedonic index of housing services)	4.739	0.235	(635)	4.931	0.325	(486)	4.783	0.251	(214)	5.005	0 329	(257)
Log (average monthly income)	5.954	0.393	(635)	5.986	0.438	(486)	5.954	0.354	(214)	6 001	0.422	(257)
Log (1-a)	-0.291	0.293	(635)	-0 264	0 289	(486)	-0.313	0.292	(214)	-0 304	0.302	(257)

SAMPLE· Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES Initial and monthly Household Report Forms.

TABLE X-13

LOG-LINEAR EXPENDITURE FUNCTIONS

HOUSEHOLD GROUP	PITTSBURGH Constant	PITTSBURGH Income Elasticity	PITTSBURGH Price Elasticity	PITTSBURGH R^2	PITTSBURGH SEE	PITTSBURGH Sample Size	PHOENIX Constant	PHOENIX Income Elasticity	PHOENIX Price Elasticity	PHOENIX R^2	PHOENIX SEE	PHOENIX Sample Size
All Households												
Current income	3 065** (0 149)	0 291** (0 024)	-0.164** (0.037)	0.08	0 28	(674)	2.678** (0.179)	0.371** (0 030)	-0.239** (0 050)	0.25	0.33	(532)
Average income	2 835** (0.169)	0.333** (0 028)	-0.178** (0 038)	0.18	0.28	(674)	2.303** (0.195)	0.435** (0.032)	-0 234** (0.049)	0.27	0.33	(532)
Mover Households												
Current income	2.955** (0 271)	0.324** (0.044)	-0 195** (0.062)	0.20	0.28	(236)	3.065** (0.229)	0.325** (0 038)	-0 219** (0 059)	0.23	0.31	(292)
Average income	2.744** (0.317)	0 363** (0.052)	-0.211** (0 063)	0 18	0.28	(236)	2.834** (0.256)	0.364** (0 042)	-0 219** (0 059)	0 23	0.31	(292)

SAMPLE Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE Standard Error in parentheses. The model used here is

$$\ln(\text{Rent}) = \beta_0 + \beta_1 \ln(\text{Income}) + \beta_2 \ln(1-a),$$

where "a" is the percentage rebate

** t-statistic significant at the 0.01 level

SEE = Standard Error of Estimate.

TABLE X-14

LINEAR EXPENDITURE FUNCTIONS

HOUSEHOLD GROUP	ESTIMATED COEFFICIENTS: Constant	ESTIMATED COEFFICIENTS: Income Coefficient	ESTIMATED COEFFICIENTS: Price Coefficient	STONE-GEARY COEFFICIENTS[a]: β	STONE-GEARY COEFFICIENTS[a]: $P_H\theta_1$	STONE-GEARY COEFFICIENTS[a]: θ_2	R^2	STANDARD ERROR OF ESTIMATE	SAMPLE SIZE
PITTSBURGH									
All Households									
Current income	115.47**	0.0577**	-11.15**	0.0577	122.54	193.24	0.16	40.9	(674)
	(5.36)	(0.0053)	(4.10)						
Average income	113.98**	0.0714**	-13.00**	0.0714	122.74	182.07	0.14	41.2	(674)
	(5.43)	(0.0069)	(4.26)						
Mover Households									
Current income	120.79**	0.0804**	-14.86*	0.0804	131.35	184.83	0.22	43.3	(236)
	(9.83)	(0.0102)	(7.34)						
Average income	117.41**	0.1027**	-17.43**	0.1027	130.85	169.72	0.21	43.7	(236)
	(10.03)	(0.0136)	(7.63)						
PHOENIX									
All Households									
Current income	122.80**	0.0745**	-10.69**	0.0745	132.69	143.49	0.20	50.2	(532)
	(7.25)	(0.0069)	(5.80)						
Average income	120.11**	0.1021**	-19.28**	0.1021	133.77	188.83	0.24	49.0	(532)
	(7.09)	(0.0083)	(5.89)						
Mover Households									
Current income	138.60**	0.0733**	-10.14	0.0733	149.56	138.34	0.21	50.6	(292)
	(9.69)	(0.0090)	(7.42)						
Average income	133.25**	0.1018**	-17.57*	0.1018	148.35	172.59	0.24	49.7	(292)
	(9.55)	(0.0114)	(7.58)						

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file

NOTE: Standard Error in parentheses. The model used here is: Rent $= A\left(\frac{1}{1-a}\right) + B\left(\frac{\text{Income}}{1-a}\right) + C'$, where "a" is the percentage rebate.

a. Stone-Geary Utility Function $U = (H-\theta_1)^{\beta}(Z-\theta_2)^{1-\beta}$, where

$$\beta = B$$

$$P_H\theta_1 = C'/(1-B)$$

$$\theta_2 = -A/B$$

* t-statistic significant at the 0.05 level

** t-statistic significant at the 0.01 level

TABLE X-15

LOG-LINEAR DEMAND FUNCTION
ALLOWING VARIABLE PRICE ELASTICITY

INDEPENDENT VARIABLE	PITTSBURGH	PHOENIX
Constant	2.803** (0.322)	2.864** (0.261)
Ln(income)	0.354** (0.053)	0.358** (0.043)
Log(0.8) for households receiving 20% rent rebate	0.055 (0.334)	-0.242 (0.299)
Log(0.7) for households receiving 30% rent rebate	-0.117 (0.160)	-0.324* (0.157)
Log(0.6) for households receiving 40% rent rebate	-0.288** (0.099)	-0.310** (0.118)
Log(0.5) for households receiving 50% rent rebate	-0.174* (0.081)	-0.206** (0.073)
Log(0.4) for households receiving 60% rent rebate	-0.195* (0.010)	-0.196* (0.090)
R^2	0.191	0.230
Standard error of estimate	0.28	0.31
Sample size	(236)	(292)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

NOTE: Standard Error in parentheses. The R^2 for a specification that constrains the price elasticity to a single value over the entire range of price discounts (the one used in Chapter 4) was 0.183 in Pittsburgh and 0.225 in Phoenix. F-tests could not reject the assumption of a single price elasticity (F=0.566 in Pittsburgh, F=0.370 in Phoenix, both insignificant).

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

TABLE X-16

LOG-LINEAR EXPENDITURE FUNCTIONS -
SITES POOLED

HOUSEHOLD GROUP	Pooled Site Intercept: Constant	Pooled Site Intercept: Income Elasticity	Pooled Site Intercept: Price Elasticity	Pooled Site Intercept: R^2	Pooled Site Intercept: SEE	Pooled Site Intercept: Sample Size	Different Site Intercept: Constant	Different Site Intercept: Phoenix Dummy	Different Site Intercept: Income Elasticity	Different Site Intercept: Price Elasticity	Different Site Intercept: R^2	Different Site Intercept: SEE	Different Site Intercept: Sample Size
All Households													
Current income	2.907** (0.117)	0.324** (0.019)	-0.189** (0.031)	0.20	0.31	(1206)	2.817** (0.116)	0.117** (0.018)	0.330** (0.019)	-0.199** (0.030)	0.23	0.31	(1206)
Average income	2.544** (0.129)	0.387** (0.021)	-0.200** (0.030)	0.23	0.31	(1206)	2.517** (0.128)	0.094** (0.018)	0.385** (0.021)	-0.207** (0.030)	0.24	0.30	(1206)
Mover Households													
Current income	3.068** (0.177)	0.316** (0.029)	-0.205 (0.044)	0.20	0.30	(528)	2.942** (0.175)	0.128** (0.026)	0.325** (0.028)	-0.209** (0.043)	0.24	0.29	(528)
Average income	2.765** (0.200)	0.369** (0.033)	-0.215** (0.044)	0.21	0.30	(528)	2.738** (0.197)	0.098** (0.026)	0.364** (0.033)	-0.216** (0.043)	0.23	0.29	(528)

SAMPLE Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing

DATA SOURCES Initial and monthly Household Report Forms, and payments file

NOTE Standard Error in parentheses F-tests of overall homogeneity (pooled site intercept versus separate regressions as in Appendix Table IV-1) indicate rejection in all four cases for each site at the 0.01 level F-tests of homogeneity of the elasticities (allowing for different site intercepts) indicate rejection only for all households (at the 0.05 level).

	Overall Homogeneity: F-statistic	Overall Homogeneity: Degrees of Freedom	Different Elasticities: F-statistic	Different Elasticities: Degrees of Freedom
All-current income	16.111	(3,1200)	2.804	(2,1201)
All-average income	11.535	(3,1200)	3.161	(2,1201)
Movers-current income	8.203	(3,522)	0.035	(2,523)
Movers-average income	4.825	(3,522)	0.001	(2,523)

** t-statistic significant at the 0.01 level

SEE = Standard Error of Estimate.

TABLE X-17

LOG-LINEAR DEMAND FUNCTIONS FOR MOVERS SAMPLE
STRATIFIED BY MEDIAN MONTHLY INCOME

INDEPENDENT VARIABLE	PITTSBURGH LOWER HALF OF INCOME DISTRIBUTION	PITTSBURGH UPPER HALF OF INCOME DISTRIBUTION	PHOENIX LOWER HALF OF INCOME DISTRIBUTION	PHOENIX UPPER HALF OF INCOME DISTRIBUTION
Constant	2.343** (0.692)	2.322** (0.775)	2.877** (0.542)	2.512** (0.816)
Log(1-a)	-0.167* (0.082)	-0.268** (0.100)	-0.217** (0.081)	-0.222* (0.087)
Log(average income)	0.439** (0.121)	0.427** (0.123)	0.357** (0.096)	0.415** (0.129)
R^2	0.12	0.13	0.13	0.09
Standard error of estimate	0.27	0.29	0.31	0.31
Sample size	(118)	(118)	(136)	(156)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

NOTE: Standard error in parentheses.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

TABLE X-18

LOG-LINEAR DEMAND FUNCTIONS FOR
MOVER SAMPLE ESTIMATED USING INCOME SPLINE

INDEPENDENT VARIABLE	PITTSBURGH	PHOENIX
Constant	2.673** (0.599)	2.955** (0.443)
Log(1-a)	-0.211** (0.064)	-0.220** (0.059)
Log(average income)	0.376** (0.104)	0.342** (0.077)
Log(average income) minus log (median income)[a]	-0.024 (0.172)	0.053 (0.159)
R^2	0.18	0.23
Standard error of estimate	0.28	0.31
Sample size	(236)	(292)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

NOTE: Standard error in parentheses.

a. For households with average income > median income (the independent variable is zero otherwise).

** t-statistic significant at the 0.01 level.

Table X-19

LOG-LINEAR EXPENDITURE FUNCTIONS USING DEMOGRAPHIC VARIABLES
AS COVARIATES FOR THE MOVER SAMPLE
(PITTSBURGH)

INDEPENDENT VARIABLES	NO COVARIATES	MINORITY STATUS	HOUSEHOLD COMPOSITION	ADDITIVE EFFECT	COMPLETE INTERACTION
Constant	2.768** (0.322)	2.768** (0.323)	2.540** (0.401)	2.542** (0.402)	2.534** (0.405)
Income elasticity	0.359** (0.053)	0.359** (0.053)	0.391** (0.064)	0.391** (0.064)	0.393** (0.065)
Price elasticity	-0.213 (0.064)	-0.213** (0.064)	-0.219** (0.064)	-0.218** (0.064)	-0.220** (0.065)
Minority head of household	--	-0.005 (0.050)	--	--0.015 (0.050)	--
Single-person household	--	--	0.031 (0.067)	0.030 (0.067)	--
Single head of household with others present	--	--	0.075† (0.043)	0.076† (0.043)	--
Nonminority single-person household	--	--	--	--	0.014 (0.070)
Nonminority single head of household with others present	--	--	--	--	0.073 (0.047)
Minority single-person household	--	--	--	--	0.143 (0.171)
Minority single head of household with others present	-- --	-- --	-- --	-- --	0.055 (0.070)
Minority household headed by a couple	--	--	--	--	-0.044 (0.081)
R^2	0.178	0.178	0.189	0.189	0.192
Adjusted R^2	0.177	0.177	0.188	0.188	0.188
Standard error of estimate	0.28	0.28	0.28	0.28	0.28
Sample size	(234)	(234)	(234)	(234)	(234)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.
DATA SOURCES Initial and monthly Household Report Forms, and payments file.
NOTE: Standard error in parentheses. Dependent variable: ln(Rent)
† t-statistic significant at the 0.10 level.
** t-statistic significant at the 0.01 level.

TABLE X-19, continued

LOG-LINEAR EXPENDITURE FUNCTIONS USING DEMOGRAPHIC VARIABLES AS COVARIATES FOR THE MOVER SAMPLE (PHOENIX)

INDEPENDENT VARIALBES	NO COVARIATES	MINORITY STATUS	HOUSEHOLD COMPOSITION	ADDITIVE EFFECT	COMPLETE INTERACTION
Constant	2.796** (0.260)	2.993** (0.258)	2.700** (0.303)	2.968** (0.302)	2.915** (0.299)
Income elasticity	0 370** (0.043)	0.345** (0.042)	0.384** (0.048)	0.348** (0.048)	0.365** (0.048)
Price elasticity	-0.219** (0.060)	-0.237** (0.059)	-0.222** (0.061)	-0.236** (0.059)	-0.226** (0.058)
Minority head of nousehold	--	-0 153** (0.038)	--	-0.157** (0.039)	--
Single-person household	--	--	0.031 (0.067)	-0.016 (0.066)	--
Single head of household with others present	--	--	0.024 (0.042)	0.024 (0.041)	--
Nonminority single-person housenold	--	--	--	--	-0.080 (0.071)
Nonminority single head of household with others present	--	--	--	--	-0 064 (0.049)
Minority single-person housenold	--	--	--	--	-0.065 (0.139)
Minority single head of household with others present	--	--	--	--	-0.105† (0.058)
Minority household headed by a couple	--	--	--	--	-0.289** (0.054)
R^2	0.230	0.272	0.231	0.274	0.303
Adjusted R^2	0.225	0.264	0.220	0.261	0.285
Standard error of estimate	0.31	0.30	0.31	0.30	0.39
Sample size	(285)	(285)	(285)	(285)	(285)

SAMPLE. Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES. Initial and monthly Household Report Forms, and payments file.

NOTE. Standard error in parentheses. Dependent variable. ln(Rent)

† t-statistic significant at the 0.10 level.

** t-statistic significant at the 0.01 level.

TABLE X-20

MEAN MONTHLY HOUSING EXPENDITURES AT ENROLLMENT AND AT TWO YEARS AFTER ENROLLMENT FOR THE MOVER SAMPLE BY RACE/ETHNICITY

TREATMENT GROUP	MEAN HOUSING EXPENDITURES: At Enrollment	MEAN HOUSING EXPENDITURES: At Two Years	MEAN CHANGE IN HOUSING EXPENDITURES: AMOUNT	MEAN CHANGE IN HOUSING EXPENDITURES: PERCENTAGE: Mean of the Ratio	MEAN CHANGE IN HOUSING EXPENDITURES: PERCENTAGE: Ratio of the Means	SAMPLE SIZE
PITTSBURGH						
Nonminority households						
Percent of Rent households	$115	$156	$41	44%	36%	(121)
Control households	120	147	27	29	23	(81)
Unconstrained households	114	145	31	33	27	(16)
Minority (black) households						
Percent of Rent households	115	159	44	50	38	(22)
Control households	114	141	26	29	23	(18)
Unconstrained households	[90]	[142]	[52]	[57]	[58]	(5)
PHOENIX						
Nonminority households						
Percent of Rent households	$146	$192	$46	37%	32%	(106)
Control households	141	166	25	22	18	(81)
Unconstrained households	[138]	[175]	[37]	[42]	[30]	(12)

(continued)

SAMPLE: Percent of Rent Unconstrained and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

TABLE X-20 (continued)

MEAN MONTHLY HOUSING EXPENDITURES AT ENROLLMENT AND AT TWO YEARS AFTER ENROLLMENT FOR THE MOVER SAMPLE BY RACE/ETHNICITY

TREATMENT GROUP	MEAN HOUSING EXPENDITURES At Enrollment	MEAN HOUSING EXPENDITURES At Two Years	MEAN CHANGE IN HOUSING EXPENDITURES AMOUNT	MEAN CHANGE PERCENTAGE Mean of the Ratio	MEAN CHANGE PERCENTAGE Ratio of the Means	SAMPLE SIZE
		PHOENIX (continued)				
Minority households						
Percent of Rent households	$114	$156	$42	39%	37%	(61)
Control households	113	144	31	42	27	(43)
Unconstrained households	[114]	[176]	[62]	[72]	[54]	(9)
Black households						
Percent of Rent households	[108]	[154]	[46]	[43]	[43]	(15)
Control households	[114]	[125]	[11]	[26]	[10]	(15)
Unconstrained households	[127]	[224]	[97]	[76]	[76]	(1)
Spanish-American households						
Percent of Rent households	116	156	41	38	35	(46)
Control households	113	155	42	50[a]	37	(28)
Unconstrained households	[112]	[170]	[58]	[71]	[52]	(8)

SAMPLE: Percent of Rent Unconstrained and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

a. Eliminating one Control household with an abnormally large change (361 percent) reduces this volume to 37 percent.

TABLE X-21

STRATIFIED LOG-LINEAR EXPENDITURE FUNCTIONS
FOR THE MOVERS SAMPLE
(PITTSBURGH)

INDEPENDENT VARIABLES	ALL HOUSEHOLDS					NONMINORITY HOUSEHOLDS					MINORITY HOUSEHOLDS				
	Constant	Income Elas-ticity	Price Elas-ticity	SEE	R^2	Constant	Income Elas-ticity	Price Elas-ticity	SEE	R^2	Constant	Income Elas-ticity	Price Elas-ticity	SEE	R^2
All households	2 768** (0 322)	0 359** (0.053)	-0.213** (0.064)	0.28	0 178 (N=234)	2 606** (0 346)	0 386** (0 057)	-0 210** (0.069)	0.28	0 204 (N=196)	3.643** (0 899)	0 212 (0.148)	-0 204 (0.179)	0.30	0 0705 (N=38)
Single-person households	3.272** (1 048)	0.274 (0 184)	-0 077 (0 189)	0 28	0 069 (N=33)	3 352** (1.196)	0.258 (0.210)	-0.072 (0.202)	0.30	0.053 (N=30)	Only 3 observations				
Single heads of house-hold with others	3 958** (0 605)	0 165 (0 102)	-0 156† (0 092)	0.27	0.051 (N=98)	3.881** (0.629)	0 182† (0 107)	-0.121 (0 096)	0 25	0 057 (N=77)	4 121† (1 845)	0.133 (0.307)	-0.303 (0.296)	0.35	0.058 (N=21)
Households headed by a couple	1 131* (0 566)	0 613** (0 090)	-0 364** (0.096)	0 27	0 333 (N=103)	0.792 (0.622)	0.668** (0.100)	-0 377** (0.104)	0.27	0.368 (N=89)	3.059† (1.506)	0 301 (0.237)	-0.193 (0 279)	0.27	0.128 (N=14)

INDEPENDENT VARIABLE	ELDERLY				
	Constant	Income Elas-ticity	Price Elas-ticity	SEE	R^2
All households	3.391* (1.470)	0.237 (0.256)	-0 211 (0.256)	0 31	0 049 (N=24)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.
DATA SOURCES Initial and monthly Household Report Forms and payments file
NOTE Standard error in parentheses Dependent Variable ln(Rent)
† t-statistic significant at the 0.10 level.
* t-statistic significant at the 0.05 level
** t-statistic significant at the 0.01 level.
SEE = Standard Error of Estimate

TABLE X-21, continued

STRATIFIED LOG-LINEAR EXPENDITURE FUNCTIONS
FOR THE MOVERS SAMPLE
(PHOENIX)

INDEPENDENT VARIABLES	ALL HOUSEHOLDS Constant	ALL HOUSEHOLDS Income Elasticity	ALL HOUSEHOLDS Price Elasticity	ALL HOUSEHOLDS SEE	ALL HOUSEHOLDS R^2	NONMINORITY HOUSEHOLDS Constant	NONMINORITY HOUSEHOLDS Income Elasticity	NONMINORITY HOUSEHOLDS Price Elasticity	NONMINORITY HOUSEHOLDS SEE	NONMINORITY HOUSEHOLDS R^2	MINORITY HOUSEHOLDS Constant	MINORITY HOUSEHOLDS Income Elasticity	MINORITY HOUSEHOLDS Price Elasticity	MINORITY HOUSEHOLDS SEE	MINORITY HOUSEHOLDS R^2
All households	2.796**	0.370**	-0.219**	0.31	0.230	2.463**	0.431**	-0.287**	0.27	0.347	3.643	0.177*	-0.179†	0.34	0.072
	(0.260)	(0.043)	(0.060)		(N=285)	(0.286)	(0.047)	(0.068)		(N=185)	(0.493)	(0.083)	(0.105)		(N=100)
Single-person households	2.179**	0.480**	-0.245†	0.20	0.566	2.407**	0.444**	-0.147	0.21	0.455	Only 5 observations				
	(0.457)	(0.080)	(0.138)		(N=32)	(0.570)	(0.099)	(0.157)		(N=27)					
Single heads of household with others	2.995**	0.342	-0.128	0.31	0.165	2.563**	0.410**	-0.297*	0.29	0.256	3.771**	0.213	0.029	0.32	0.054
	(0.429)	(0.072)	(0.087)		(N=121)	(0.555)	(0.091)	(0.115)		(N=71)	(0.757)	(0.132)	(0.132)		(N=50)
Households headed by a couple	2.669**	0.383**	-0.327**	0.33	0.192	2.739**	0.390**	-0.290**	0.27	0.257	3.415**	0.227	-0.415*	0.34	0.154
	(0.518)	(0.083)	(0.100)		(N=132)	(0.503)	(0.080)	(0.104)		(N=87)	(1.092)	(0.178)	(0.177)		(N=45)

INDEPENDENT VARIABLE	ELDERLY Constant	ELDERLY Income Elasticity	ELDERLY Price Elasticity	ELDERLY SEE	ELDERLY R^2	SPANISH AMERICAN Constant	SPANISH AMERICAN Income Elasticity	SPANISH AMERICAN Price Elasticity	SPANISH AMERICAN SEE	SPANISH AMERICAN R^2	BLACK Constant	BLACK Income Elasticity	BLACK Price Elasticity	BLACK SEE	BLACK R^2
All households	2.559*	0.422†	-0.018	0.21	0.202	4.148**	0.133	-0.137	0.33	0.04	3.524**	0.224	-0.255	0.37	0.12
	(1.121)	(0.206)	(0.184)		(N=20)	(0.606)	(0.101)	(0.122)		(N=72)	(0.965)	(0.188)	(0.217)		(N=28)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms and payments file

NOTE: Standard error in parentheses. Dependent Variable: ln(Rent)

† t-statistic significant at the 0.10 level

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level

SEE = Standard Error of Estimate

TABLE X-22

RENT FOR MOVERS BY STRATIFIED DEMOGRAPHICS
POOLED SITES

INDEPENDENT VARIABLES	CONSTANT	PHOENIX	INCOME ELASTICITY	PRICE ELASTICITY	SEE	R^2	SAMPLE SIZE
All households	2.723** (0.201)	0.096** (0.026)	0.366** (0.033)	-0.217** (0.044)	0.30	0.230	(519)
Nonminority households	2.433** (0.219)	0.145** (0.028)	0.413** (0.036)	-0.249** (0.048)	0.27	0.325	(381)
Minority households	3.818** (0.431)	-0.006 (0.063)	0.184** (0.071)	-0.183* (0.089)	0.33	0.072	(138)
Single-person households	2.389** (0.473)	0.111† (0.064)	0.426** (0.083)	-0.175 (0.116)	0.25	0.337	(65)
Single heads of household with others present	3.210** (0.345)	0.066† (0.040)	0.294** (0.058)	-0.137* (0.063)	0.29	0.125	(219)
Households headed by a couple	2.032** (0.382)	0.111** (0.040)	0.468** (0.061)	-0.327 (0.070)	0.30	0.264	(235)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

NOTE: Standard error in parentheses. Dependent variable: ln(Rent)

† t-statistic significant at the 0.10 level.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

SEE = Standard Error of Estimate.

TABLE X-23

CHANGES IN RATES OF PASSING LOWEST HOUSING STANDARDS
FROM ENROLLMENT TO TWO YEARS FOR
CONTROL AND PERCENT OF RENT HOUSEHOLDS

TREATMENT GROUP	PERCENTAGE PASSING LOWEST HOUSING STANDARDS: At Enrollment	PERCENTAGE PASSING LOWEST HOUSING STANDARDS: At Two Years	CHANGE IN PERCENTAGE PASSING[a]	SAMPLE SIZE
		PITTSBURGH		
All Percent of Rent households	81%	84%	+3	(391)
Percentage rebate:				
20%	82	84	+2	(62)
30%	77	77	0	(88)
40%	78	86	+8	(106)
50%	86	87	+1	(107)
60%	79	89	+10	(28)
Control households	81	80	-1	(299)
Unconstrained households	74	77	+3	(61)
		PHOENIX		
All Percent of Rent households	72	75	+3	(279)
Percentage rebate:				
20%	73	75	+2	(44)
30%	67	68	+1	(79)
40%	74	84	+10	(62)
50%	78	78	0	(77)
60%	59	65	+6	(17)
Control households	66	74	+8	(258)
Unconstrained households	62	82	+20	(39)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluations Forms.

NOTE: See Appendix III for full description of lowest physical housing standards.

a. Percentage points.

TABLE X-24

CHANGES IN RATES OF PASSING PROGRAM HOUSING STANDARDS FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND PERCENT OF RENT HOUSEHOLDS

TREATMENT GROUP	PERCENTAGE PASSING PROGRAM HOUSING STANDARDS: At Enrollment	At Two Years	CHANGE IN PERCENTAGE PASSING[a]	SAMPLE SIZE
	PITTSBURGH			
All Percent of Rent households	37%	34%	-3%	(391)
Percentage rebate:				
20%	27	31	+4	(62)
30%	39	27	-12	(88)
40%	30	37	+7	(106)
50%	47	39	-8	(107)
60%	39	32	-7	(28)
Control households	33	29	-4	(299)
Unconstrained households	25	31	+6	(61)
	PHOENIX			
All Percent of Rent households	33	40	+7	(279)
Percentage rebate:				
20%	30	48	+18	(44)
30%	27	39	+11	(79)
40%	39	44	+5	(62)
50%	38	39	+1	(77)
60%	24	29	+5	(17)
Control households	28	36	+8	(258)
Unconstrained households	28	41	+13	(39)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluation Forms.

NOTE: See Appendix III for full description of program physical housing standards.

a. Percentage points.

TABLE X-25

CHANGES IN RATES OF PASSING PROGRAM OCCUPANCY STANDARDS FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND PERCENT OF RENT HOUSEHOLDS

TREATMENT GROUP	PERCENTAGE PASSING PROGRAM OCCUPANCY STANDARDS: At Enrollment	At Two Years	CHANGE IN PERCENTAGE PASSING[a]	SAMPLE SIZE
	PITTSBURGH			
All Percent of Rent households	49%	47%	-2%	(390)
Percentage rebate:				
20%	44	47	-3	(62)
30%	48	48	0	(87)
40%	51	50	-1	(106)
50%	51	42	-9	(107)
60%	54	46	-8	(28)
Control households	46	41	-5	(299)
Unconstrained households	46	44	-2	(61)
	PHOENIX			
All Percent of Rent households	43%	55%	+12%	(279)
Percentage rebate:				
20%	43	52	+9	(44)
30%	42	53	+11	(79)
40%	37	58	+21	(62)
50%	54	58	+4	(77)
60%	24	35	+11	(17)
Control households	38	53	+15	(258)
Unconstrained households	46	64	+18	(39)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms.

NOTE: See Appendix III for full description of program occupancy standards.

a. Percentage points.

TABLE X-26

CHANGES IN RATES OF PASSING LOWEST HOUSING STANDARDS FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND PERCENT OF RENT HOUSEHOLDS FOR THE MOVERS SAMPLE

TREATMENT GROUP	PERCENTAGE PASSING LOWEST HOUSING STANDARDS: At Enrollment	PERCENTAGE PASSING LOWEST HOUSING STANDARDS: At Two Years	CHANGE IN PERCENTAGE PASSING[a]	SAMPLE SIZE
	PITTSBURGH			
All Percent of Rent households	75%	85%	+10%	(142)
Percentage rebate:				
20%	81	88	+7	(16)
30%	77	71	-6	(35)
40%	68	91	+23	(44)
50%	86	89	+3	(36)
60%	[55]	[91]	[+36]	(11)
Control households	82	79	-3	(98)
Unconstrained households	70	87	+17	(23)
	PHOENIX			
All Percent of Rent households	69	77	+8	(163)
Percentage rebate:				
20%	64	72	+8	(25)
30%	67	77	+10	(39)
40%	68	82	+14	(34)
50%	74	79	+5	(53)
60%	[67]	[67]	[0]	(12)
Control households	67	82	+15	(126)
Unconstrained households	59	95	+36	(22)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluation Forms.

NOTE: See Appendix III for full description of lowest housing standards. Brackets indicate entries based on 15 or fewer observations.

a. Percentage points.

TABLE X-27

CHANGES IN RATES OF PASSING LOWEST HOUSING STANDARDS FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND PERCENT OF RENT HOUSEHOLDS FOR THE NONMOVER SAMPLE

TREATMENT GROUP	PERCENTAGE PASSING LOWEST HOUSING STANDARDS At Enrollment	At Two Years	CHANGE IN PERCENTAGE PASSING[a]	SAMPLE SIZE
	PITTSBURGH			
All Percent of Rent households	84%	84%	0	(249)
Percentage rebate:				
20%	83	83	0	(46)
30%	77	81	+4	(53)
40%	86	82	+4	(62)
50%	86	86	0	(71)
60%	94	88	-6	(17)
Control households	81	81	0	(201)
Unconstrained households	76	71	-5	(38)
	PHOENIX			
All Percent of Rent households	77	72	-5	(116)
Percentage rebate:				
20%	84	79	-5	(19)
30%	68	60	-8	(40)
40%	82	86	+4	(28)
50%	88	75	-13	(24)
60%	[40]	[60]	[+20]	(5)
Control households	65	67	+2	(132)
Unconstrained households	65	65	0	(17)

SAMPLE: Percent of Rent and Control nonmovers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluation Forms.

NOTE: See Appendix III for full description of lowest housing standards. Brackets indicate entries based on 15 or fewer observations.

a. Percentage points.

TABLE X-28

CHANGES IN RATES OF PASSING PROGRAM HOUSING STANDARDS FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND PERCENT OF RENT HOUSEHOLDS FOR THE MOVER SAMPLE

TREATMENT GROUP	PERCENTAGE PASSING PROGRAM HOUSING STANDARDS: At Enrollment	PERCENTAGE PASSING PROGRAM HOUSING STANDARDS: At Two Years	CHANGE IN PERCENTAGE PASSING[a]	SAMPLE SIZE
		PITTSBURGH		
All Percent of Rent households	30%	37%	+7	(142)
Percentage rebate:				
20%	19	44	+25	(16)
30%	43	26	-17	(35)
40%	18	46	-28	(44)
50%	36	36	0	(36)
60%	[36]	[27]	[-9]	(11)
Control households	32	29	-3	(98)
Unconstrained households	17	35	+18	(23)
		PHOENIX		
All Percent of Rent households	31	42	+11	(163)
Percentage rebate:				
20%	20	44	+24	(25)
30%	28	54	+26	(39)
40%	38	41	+3	(34)
50%	34	38	+4	(53)
60%	[33]	[25]	[-8]	(12)
Control households	25	38	+13	(126)
Unconstrained households	18	45	+27	(22)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluation Forms.

NOTE: See Appendix III for full description of program physical housing standards. Brackets indicate entries based on 15 or fewer observations.

a. Percentage points.

TABLE X-29

CHANGES IN RATES OF PASSING PROGRAM HOUSING STANDARDS FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND PERCENT OF RENT HOUSEHOLDS FOR THE NONMOVER SAMPLE

TREATMENT GROUP	PERCENTAGE PASSING PROGRAM HOUSING STANDARDS		CHANGE IN PERCENTAGE PASSING[a]	SAMPLE SIZE
	At Enrollment	At Two Years		
	PITTSBURGH			
All Percent of Rent households	41%	32%	-9%	(249)
Percentage rebate:				
20%	30	26	-4	(46)
30%	36	28	-8	(53)
40%	39	31	-8	(62)
50%	52	41	-11	(71)
60%	41	35	-6	(17)
Control households	34	29	-5	(201)
Unconstrained households	29	29	0	(38)
	PHOENIX			
All Percent of Rent households	34	38	+4	(116)
Percentage rebate:				
20%	42	53	+11	(19)
30%	25	22	-3	(40)
40%	39	46	+7	(28)
50%	46	42	-4	(24)
60%	[0]	[40]	[+40]	(5)
Control households	30	33	+3	(132)
Unconstrained households	41	35	-6	(17)

SAMPLE: Percent of Rent and Control nonmovers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluation Forms.

NOTE: See Appendix III for full description of program physical housing standards. Brackets indicate entires based on 15 or fewer observations.

a. Percentage points.

TABLE X-30

CHANGES IN RATES OF PASSING PROGRAM OCCUPANCY STANDARDS FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND PERCENT OF RENT HOUSEHOLDS FOR THE MOVER SAMPLE

TREATMENT GROUP	PERCENTAGE PASSING PROGRAM OCCUPANCY STANDARDS: At Enrollment	PERCENTAGE PASSING PROGRAM OCCUPANCY STANDARDS: At Two Years	CHANGE IN PERCENTAGE PASSING[a]	SAMPLE SIZE
	PITTSBURGH			
All Percent of Rent households	44%	47%	+3%	(142)
Percentage rebate:				
20%	38	62	+24	(16)
30%	43	49	+6	(35)
40%	50	50	0	(44)
50%	42	39	-3	(36)
60%	[36]	[36]	[0]	(11)
Control households	36	31	-5	(98)
Unconstrained households	17	39	+22	(23)
	PHOENIX			
All Percent of Rent households	44	53	+9	(163)
Percentage rebate:				
20%	40	52	+12	(25)
30%	49	62	+13	(39)
40%	32	53	+21	(34)
50%	53	55	+2	(53)
60%	[25]	[25]	[0]	(12)
Control households	36	59	+23	(126)
Unconstrained households	41	59	+18	(22)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms.

NOTE: See Appendix III for full description of program occupancy standards.

Brackets indicate entries based on 15 or fewer observations.

a. Percentage points.

TABLE X-31

CHANGES IN RATES OF PASSING PROGRAM OCCUPANCY STANDARDS FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND PERCENT OF RENT HOUSEHOLDS FOR THE NONMOVER SAMPLE

TREATMENT GROUP	PERCENTAGE PASSING PROGRAM OCCUPANCY STANDARDS: At Enrollment	At Two Years	CHANGE IN PERCENTAGE PASSING[a]	SAMPLE SIZE
	PITTSBURGH			
All Percent of Rent households	53%	46%	-7%	(248)
Percentage rebate:				
20%	46	41	-5	(46)
30%	52	48	-4	(52)
40%	52	50	-2	(62)
50%	56	44	-12	(71)
60%	65	53	-12	(17)
Control households	51	46	-5	(201)
Unconstrained households	55	47	-8	(38)
	PHOENIX			
All Percent of Rent households	43	56	+13	(116)
Percentage rebate:				
20%	47	53	+6	(19)
30%	35	45	+10	(40)
40%	43	64	+21	(28)
50%	58	67	+9	(24)
60%	[20]	[60]	[+40]	(5)
Control households	39	48	+9	(132)
Unconstrained households	53	71	+18	(17)

SAMPLE: Percent of Rent and Control nonmovers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms and Housing Evaluation Forms.

NOTE: See Appendix III for full description of program occupancy standards.

Brackets indicate entries based on 15 or fewer observations.

a. Percentage points.

TABLE X-32

CHANGES IN HOUSING ADEQUACY
FROM ENROLLMENT TO TWO YEARS FOR
CONTROL AND PERCENT OF RENT HOUSEHOLDS

TREATMENT GROUP	PERCENTAGE IN MINIMALLY ADEQUATE HOUSING			PERCENTAGE IN CLEARLY INADEQUATE HOUSING			SAMPLE SIZE
	At Enrollment	At Two Years	Change[a]	At Enrollment	At Two Years	Change[a]	
PITTSBURGH							
All Percent of Rent households	31%	28%	-3%	41%	35%	-6%	(391)
Percentage rebate:							
20%	24	22	-2	52	40	-12	(63)
30%	29	20	-9	38	41	+3	(85)
40%	27	32	+5	42	32	-10	(109)
50%	40	33	-7	34	29	-5	(106)
60%	36	32	-4	43	39	-4	(28)
Control households	29	25	-4	38	35	-3	(301)
Unconstrained households	19	32	+13	46	34	-12	(59)
PHOENIX							
All Percent of Rent households	36	39	+3	44	39	-5	(284)
Percentage rebate:							
20%	42	51	+9	42	33	-9	(45)
30%	28	32	+4	54	46	-8	(80)
40%	40	48	+8	38	33	-5	(60)
50%	44	35	-9	35	35	0	(78)
60%	14	29	+15	67	52	-15	(21)
Control households	35	37	+2	45	41	-4	(256)
Unconstrained households	27	46	+19	54	30	-24	(37)

SAMPLE: Percent of Rent and Control household active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluations Forms.

NOTE: See Appendix III for full description of the adequacy measure.

a. Percentage points.

TABLE X-33

CHANGES IN HOUSING ADEQUACY
FROM ENROLLMENT TO TWO YEARS FOR
CONTROL AND PERCENT OF RENT MOVERS

TREATMENT GROUP	PERCENTAGE IN MINIMALLY ADEQUATE HOUSING: At Enrollment	At Two Years	Change[a]	PERCENTAGE IN CLEARLY INADEQUATE HOUSING: At Enrollment	At Two Years	Change[a]	SAMPLE SIZE
			PITTSBURGH				
All Percent of Rent households	22%	35%	+13%	45%	31%	-14%	(143)
Percentage rebate:							
20%	18	41	+23	53	24	-29	(17)
30%	33	21	-12	42	42	0	(33)
40%	13	43	+30	51	32	-19	(47)
50%	26	34	+8	34	23	-11	(35)
60%	[27]	[36]	[+9]	[45]	[27]	[-18]	(11)
Control households	25	26	+1	43	32	-11	(100)
Unconstrained households	14	41	+27	55	23	-32	(22)
			PHOENIX				
All Percent of Rent households	32	40	+8	48	38	-10	(170)
Percentage rebate:							
20%	30	44	+14	52	37	-15	(27)
30%	25	42	+17	50	32	-18	(40)
40%	30	42	+12	42	42	0	(33)
50%	43	37	-6	43	37	-6	(54)
60%	19	31	+12	69	44	-25	(16)
Control households	37	43	+6	45	31	-14	(127)
Unconstrained households	19	57	+38	62	19	-43	(21)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluations Forms.

NOTE: See Appendix III for full description of the adequacy measure.

TABLE X-34

CHANGES IN HOUSING ADEQUACY
FROM ENROLLMENT TO TWO YEARS FOR
CONTROL AND PERCENT OF RENT NONMOVERS

TREATMENT GROUP	PERCENTAGE IN MINIMALLY ADEQUATE HOUSING: At Enrollment	At Two Years	Change[a]	PERCENTAGE IN CLEARLY INADEQUATE HOUSING: At Enrollment	At Two Years	Change[a]	SAMPLE SIZE
			PITTSBURGH				
All Percent of Rent households	36%	24%	-12%	38%	38%	0%	(248)
Percentage rebate:							
20%	26	15	-11	52	46	-6	(46)
30%	27	19	-8	35	40	+5	(52)
40%	37	24	-13	35	32	-3	(62)
50%	46	32	-14	34	32	-2	(71)
60%	41	29	-12	41	47	+6	(17)
Control households	31	25	-6	36	36	0	(201)
Unconstrained households	22	27	+5	41	41	0	(37)
			PHOENIX				
All Percent of Rent households	42	38	-4	39	40	+1	(114)
Percentage rebate:							
20%	61	61	0	28	28	0	(18)
30%	30	22	-12	58	60	+2	(40)
40%	52	56	+4	33	22	-11	(27)
50%	46	29	-17	17	29	+12	(24)
60%	[0]	[20]	[+20]	[60]	[80]	[+20]	(5)
Control households	33	30	-3	46	51	+5	(129)
Unconstrained households	38	31	-7	44	44	0	(16)

SAMPLE: Percent of Rent and Control nonmovers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Housing Evaluations Forms.

NOTE: See Appendix III for full description of the adequacy measure.

a. Percentage points.

TABLE X-35

CHANGE IN HEDONIC HOUSING SERVICES INDEX
FROM ENROLLMENT TO TWO YEARS
FOR CONTROL AND PERCENT OF RENT HOUSEHOLDS

TREATMENT GROUP	MEAN HEDONIC INDEX: At Enrollment	MEAN HEDONIC INDEX: At Two Years	MEAN CHANGE IN INDEX: AMOUNT	MEAN CHANGE IN INDEX: PERCENTAGE: Mean of Ratio	MEAN CHANGE IN INDEX: PERCENTAGE: Ratio of Means	SAMPLE SIZE
PITTSBURGH						
All Percent of Rent households	$114	$121	$ 7	9%	6%	(353)
Percentage rebate:						
20%	107	116	9	9	8	(58)
30%	114	119	5	6	4	(80)
40%	116	123	7	9	6	(100)
50%	116	123	7	8	6	(90)
60%	115	127	12	16	10	(25)
Control households	114	120	5	6	4	(273)
Unconstrained households	106	116	11	12	10	(52)
PHOENIX						
All Percent of Rent households	132	149	17	16	13	(241)
Percentage rebate:						
20%	135	150	15	20	11	(36)
30%	130	142	12	11	9	(71)
40%	135	153	19	15	14	(54)
50%	136	153	17	14	13	(65)
60%	[110]	[141]	[31]	[37]	[28]	(15)
Control households	128	144	16	17	13	(231)
Unconstrained households	132	158	26	34	20	(34)

SAMPLE: Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Third Periodic Interviews.

NOTE: Brackets indicate entries based on 15 or fewer observations.

TABLE X-36

CHANGES IN HEDONIC HOUSING SERVICES INDEX
FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND
PERCENT OF RENT HOUSEHOLDS FOR THE MOVER SAMPLE

TREATMENT GROUP	MEAN HEDONIX INDEX At Enrollment	MEAN HEDONIX INDEX At Two Years	MEAN CHANGE IN INDEX AMOUNT	MEAN CHANGE IN INDEX PERCENTAGE Mean of Ratio	MEAN CHANGE IN INDEX PERCENTAGE Ratio of Means	SAMPLE SIZE
		PITTSBURGH				
All Percent of Rent households	$111	$128	$17	19%	15%	(121)
Percentage rebate:						
20%	[106]	[121]	[15]	[17]	[14]	(12)
30%	112	124	12	15	11	(30)
40%	114	130	17	19	15	(41)
50%	112	130	18	18	16	(29)
60%	[103]	[130]	[27]	[40]	[26]	(9)
Control households	114	126	12	13	11	(92)
Unconstrained households	105	131	27	31	26	(19)
		PHOENIX				
All Percent of Rent households	133	157	24	22	18	(134)
Percentage rebate:						
20%	127	146	18	29	14	(19)
30%	138	159	21	17	15	(38)
40%	138	165	27	20	20	(30)
50%	135	157	22	18	16	(42)
60%	[106]	[147]	[41]	[49]	[39]	(10)
Control households	126	155	30	32	24	(109)
Unconstrained households	125	166	41	50	33	(18)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Third Periodic Interviews.

NOTE: Brackets indicate entries based on 15 or fewer observations.

TABLE X-37

CHANGES IN HEDONIC HOUSING SERVICES INDEX
FROM ENROLLMENT TO TWO YEARS FOR CONTROL AND
PERCENT OF RENT HOUSEHOLDS FOR THE NONMOVER SAMPLE

TREATMENT GROUP	MEAN HEDONIC INDEX: At Enrollment	MEAN HEDONIC INDEX: At Two Years	MEAN CHANGE IN INDEX: AMOUNT	MEAN CHANGE IN INDEX: PERCENTAGE: Mean of Ratio	MEAN CHANGE IN INDEX: PERCENTAGE: Ratio of Means	SAMPLE SIZE
PITTSBURGH						
All Percent of Rent households	$115	$118	$ 2	3%	2%	(232)
Percentage rebate:						
20%	108	115	7	7	6	(46)
30%	115	116	1	1	1	(50)
40%	117	118	1	3	1	(59)
50%	118	120	2	3	2	(61)
60%	122	125	3	3	2	(16)
Control households	114	116	2	2	2	(181)
Unconstrained households	106	108	1	1	1	(33)
PHOENIX						
All Percent of Rent households	131	139	8	7	6	(107)
Percentage rebate:						
20%	144	156	12	9	8	(17)
30%	123	128	5	5	4	(38)
40%	131	139	8	9	6	(24)
50%	137	146	9	7	7	(23)
60%	[118]	[129]	[11]	[12]	[9]	(5)
Control households	130	134	4	5	3	(122)
Unconstrained households	139	149	10	14	7	(16)

SAMPLE: Percent of Rent and Control nonmovers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Third Periodic Interviews.

NOTE: Brackets indicate entries based on 15 or fewer observations.

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TABLE X-38

SEARCH EFFORT FOR LAST MOVE

HOUSEHOLD GROUP	MEAN SEARCH TIME (days)		MEAN NUMBER OF UNITS SEEN		MEAN NUMBER OF CALLS MADE		SAMPLE SIZE	
	Percent of Rent Households	Control Households	Percent of Rent Households	Control Households	Percent of Rent Households	Control Households	Percent of Rent Households	Control Households
				PITTSBURGH				
All Movers	97	119	6.6	7.8	13.2	16.0	(143)	(102)
Nonminority movers	97	117	6.6	7.3	13.5	16.4	(118)	(82)
Black movers	98	129	6.5	9.8	12.1	14.3	(25)	(20)
				PHOENIX				
All Movers	34	46	6.3	6.2	10.2	8.1	(162)	(140)
Nonminority movers	31	37	7.1	7.6	12.6	10.4	(108)	(90)
All minority movers	40	62	4.8	3.7	5.5	4.0	(54)	(50)
Spanish American movers	28	76[a]	4.4	4.5	6.0[b]	5.4	(40)	(31)

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and Periodic Interviews.

a. T-test comparing means of Percent of Rent and Control Spanish American households significant at the 0.05 level (one-tail test), t = 1.81.

b. T-test comparing means of nonminority and Spanish American Percent of Rent households significant at the 0.05 level (one-tail test), t = 1.74.

TABLE X-39

DEMAND FOR RENT COMPONENTS

DEPENDENT VARIABLE	INDEPENDENT VARIABLE Constant	$\ln(1-a)$[a]	$\ln\left(\begin{matrix}\text{Monthly}\\ \text{Income}\end{matrix}\right)$[b]	STANDARD ERROR OF ESTIMATE	R^2
		PITTSBURGH			
Rent (expenditures definition)	2.893** (.324)	-0.230** (.065)	0.338** (.054)	0.27	0.18
Hedonic index of housing services	3.402** (.287)	-0.113* (.057)	0.226** (.047)	0.24	0.10
Hedonic residual	-0.462* (.236)	-0.159** (.047)	0.089* (.039)	0.20	0.06
Tenure characteristics	-0.065 (.063)	0.027* (.013)	0.019† (.010)	0.05	0.04
Definitional differences in rent[c]	0.018 (.063)	0.000 (.013)	0.004 (.010)	0.05	0.01
Sample size	(214)				

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

a. a = percentage rebate.

b. Three-year average income is used here as a measure of permanent income.

c. Between the expenditures definition and the definition used for estimation of hedonic index.

† t-statistic significant at the 0.10 level.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

TABLE X-39, continued

DEMAND FOR RENT COMPONENTS

DEPENDENT VARIABLE	INDEPENDENT VARIABLE: Constant	INDEPENDENT VARIABLE: ln(1-a)[a]	INDEPENDENT VARIABLE: ln(Monthly Income)[b]	STANDARD ERROR OF ESTIMATE	R^2
		PHOENIX			
Rent (expenditure definition)	2.901** (.278)	-0.215** (.064)	0.353** (.046)	0.31	0.21
Hedonic index of housing services	2.739** (.259)	-0.045 (.060)	0.375** (.043)	0.29	0.23
Hedonic residual	0.097 (.208)	-0.193** (.048)	-0.021 (.034)	0.23	0.06
Tenure characteristics	0.029 (.050)	0.017 (.011)	0.001 (.008)	0.06	0.01
Definitional differences in rent[c]	0.035 (.031)	0.005 (.007)	-0.002 (.005)	0.04	0.00
Sample size	(257)				

SAMPLE: Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, and payments file.

a. a = percentage rebate.

b. Three-year average income is used here as a measure of permanent income.

c. Between the expenditures definition and the definition used for estimation of hedonic index.

† t-statistic significant at the 0.10 level.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

TABLE X-40

STRATIFIED LOG-LINEAR HOUSING SERVICES FUNCTIONS
FOR THE OVERALL SAMPLE
(PITTSBURGH)

INDEPENDENT VARIABLES	ALL HOUSEHOLDS					NONMINORITY HOUSEHOLDS					MINORITY HOUSEHOLDS				
	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2
All households	3.378**	0 224**	-0 106**	0 22	0.142	3 319**	0 234**	-0 122**	0 21	0 167	3.622**	0 181**	-0 019	0.25	0.076
	(0 135)	(0 022)	(0 030)		(N=635)	(0 144)	(0.024)	(0 031)		(N=509)	(0 343)	(0 057)	(0 083)		(N=126)
Single-person households	2 870**	0 310**	-0 188**	0 24	0 158	2.725**	0.340**	-0 202**	0 24	0 179	3 664**	0.143	-0 093	0.24	0 065
	(0 390)	(0 070)	(0 072)		(N=128)	(0.432)	(0.077)	(0 074)		(N=109)	(0.814)	(0.148)	(0 218)		(N=19)
Single heads of household with others	4 131**	0 103*	-0.042	0 22	0 022	3.700**	0.174**	-0 092†	0 21	0.073	5 407**	-0.103	0.147	0 22	0.040
	(0 279)	(0 047)	(0 048)		(N=241)	(0.315)	(0.053)	(0.053)		(N=171)	(0 571)	(0 094)	(0 103)		(N=70)
Households headed by a couple	2 696**	0.329**	-0 140**	0 20	0.213	2.647**	0.339**	-0 125**	0 19	0 221	2 949**	0.277*	-0.235	0.24	0.191
	(0.248)	(0 040)	(0 044)		(N=265)	(0 268)	(0.043)	(0.045)		(N=229)	(0.676)	(0.109)	(0 144)		(N=37)

INDEPENDENT VARIABLE	ELDERLY				
	Constant	Income Elasticity	Price Elasticity	SEE	R^2
All households	2 914**	0 298**	-0.248**	0.25	0.173
	(0.430)	(0 077)	(0 080)		(N=107)

SAMPLE Pittsburgh Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing

DATA SOURCES Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Periodic Interviews

NOTE Standard error in parentheses

† t-statistic significant at the 0.10 level
* t-statistic significant at the 0 05 level
** t-statistic significant at the 0.01 level

SEE = Standard Error of Estimate.

TABLE X-40, continued

STRATIFIED LOG-LINEAR HOUSING SERVICES FUNCTIONS
FOR THE OVERALL SAMPLE
(PHOENIX)

INDEPENDENT VARIABLES	ALL HOUSEHOLDS					NONMINORITY HOUSEHOLDS					MINORITY HOUSEHOLDS				
	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2
All households	2.776**	0.359**	-0.090*	0.28	0.238	2.616**	0.391**	-0.125*	0.25	0.305	3.417**	0.228**	-0.071	0.30	0.112
	(0.178)	(0.030)	(0.045)		(N=486)	(0.205)	(0.034)	(0.051)		(N=319)	(0.303)	(0.051)	(0.076)		(N=167)
Single-person households	2.669**	0.376**	-0.101	0.29	0.246	3.333**	0.265**	-0.047	0.28	0.118	1.245†	0.589**	-0.645*	0.20	0.746
	(0.399)	(0.070)	(0.117)		(N=93)	(0.487)	(0.086)	(0.126)		(N=78)	(0.578)	(0.104)	(0.231)		(N=15)
Single heads of household with others	2.558**	0.401**	0.047	0.27	0.259	2.141**	0.475**	-0.150†	0.23	0.354	3.933**	0.151†	0.033	0.28	0.042
	(0.310)	(0.052)	(0.066)		(N=173)	(0.407)	(0.067)	(0.077)		(N=98)	(0.502)	(0.087)	(0.100)		(N=75)
Households headed by a couple	2.554**	1.385**	-0.128**	0.29	0.189	2.463**	0.412**	-0.156*	0.25	0.292	3.258**	0.247*	-0.123	0.31	0.076
	(0.350)	(0.056)	(0.071)		(N=220)	(0.350)	(0.056)	(0.076)		(N=143)	(0.711)	(0.116)	(0.123)		(N=77)

INDEPENDENT VARIABLE	ELDERLY					SPANISH AMERICAN					BLACK				
	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2
All households	2.520**	0.405**	-0.096	0.24	0.209	3.234**	0.261**	-0.057	0.29	0.135	3.477**	0.204	-0.459*	0.39	0.182
	(0.515)	(0.093)	(0.129)		(N=109)	(0.361)	(0.060)	(0.087)		(N=124)	(0.774)	(0.136)	(0.204)		(N=44)

SAMPLE Phoenix Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Periodic Interviews

NOTE: Standard error in parentheses.

† t-statistic significant at the 0.10 level.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level

SEE = Standard Error of Estimate.

TABLE X-41

STRATIFIED LOG-LINEAR HOUSING SERVICES FUNCTIONS
FOR THE MOVER SAMPLE
(PITTSBURGH)

INDEPENDENT VARIABLES	ALL HOUSEHOLDS					NONMINORITY HOUSEHOLDS					MINORITY HOUSEHOLDS				
	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2
All households	3.402** (0.287)	0.226** (0.047)	-0.113† (0.057)	0.24	0.101 (N=214)	3.126** (0.291)	0.269** (0.048)	-0.143* (0.057)	0.22	0.1585 (N=180)	4.922** (0.923)	-0.012 (0.151)	0.067 (0.201)	0.30	0.004 (N=34)
Single-person households	3.338** (0.929)	0.241 (0.163)	-0.118 (0.168)	0.25	0.073 (N=32)	3.135** (1.025)	0.275 (0.180)	-0.112 (0.174)	0.25	0.084 (N=29)	Only 3 observations				
Single heads of household with others	3.745** (0.562)	0.181† (0.095)	-0.038 (0.085)	0.23	0.0425 (N=87)	3.316** (0.627)	0.245* (0.107)	-0.121 (0.091)	0.22	0.096 (N=69)	6.639** (0.993)	-0.273 (0.165)	0.275 (0.166)	0.18	0.227 (N=18)
Households headed by a couple	1.681** (0.473)	0.489** (0.076)	-0.246** (0.080)	0.21	0.322 (N=95)	1.742** (0.471)	0.484** (0.075)	-0.202** (0.077)	0.19	0.349 (N=82)	0.941 (1.738)	0.575† (0.274)	-0.611 (0.353)	0.31	0.338 (N=13)

INDEPENDENT VARIABLE	ELDERLY				
	Constant	Income Elasticity	Price Elasticity	SEE	R^2
All households	3.387* (1.246)	0.222 (0.217)	-0.215 (0.219)	0.26	0.067 (N=23)

SAMPLE Pittsburgh Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing

DATA SOURCES. Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Periodic Interviews

NOTE Standard error in parentheses

† t-statistic significant at the 0.10 level

* t-statistic significant at the 0.05 level

** t-statistic significant at the 0.01 level

SEE = Standard Error of estimate.

TABLE X-41, continued

STRATIFIED LOG-LINEAR HOUSING SERVICES FUNCTIONS
FOR THE MOVER SAMPLE
(PHOENIX)

INDEPENDENT VARIABLES	ALL HOUSEHOLDS					NONMINORITY HOUSEHOLDS					MINORITY HOUSEHOLDS				
	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2
All households	2.739*	0 375**	-0 045	0 29	0 232	2 379**	0 440**	-0 129*	0 24	0 377	3 962**	0 154†	0 023	0.32	0 038
	(0 259)	(0 043)	(0 050)		(N=257)	(0 272)	(0 045)	(0.065)		(N=168)	(0.501)	(0 085)	(0 106)		(N=89)
Single-person households	2 201**	0 464**	-0 366†	0 25	0.478	2 309**	0 454**	-0 249	0 25	0.396	Only 5 observations				
	(0 578)	(0 101)	(0 197)		(N=29)	(0 711)	(0 123)	(0 225)		(N=24)					
Single heads of household with others	2 549**	0 416**	0.045	0 27	0 270	2 042**	0 497**	-0 145	0 24	0 381	3 752**	0 205†	0 185	0.29	0 101
	(0 401)	(0 067)	(0 081)		(N=111)	(0 497)	(0 082)	(0.101)		(N=64)	(0 704)	(0 122)	(0 125)		(N=47)
Households headed by a couple	2 753**	0 365**	-0 121	0.31	0 154	2.315**	0 448**	-0 123	0.25	0.325	4.906**	-0 012	-0 120	0 35	0.011
	(0 510)	(0 082)	(0 098)		(N=117)	(0 464	(0 074)	(0 097)		(N=80)	(1.229)	(0.199)	(0 193)		(N=37)

INDEPENDENT VARIABLE	ELDERLY					SPANISH AMERICAN					BLACK				
	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2	Constant	Income Elasticity	Price Elasticity	SEE	R^2
All households	0.927	0 714*	-0 207	0 26	0 315	4 345**	0 100	0 116	0 31	0 033	3 818**	0 159	-0 138	0 35	0 59
	(1 490)	(0 272)	(0 297)		(N=18)	(0.611)	(0 102)	(0 121)		(N=62)	(0 949)	(0.165)	(0 218)		(N=27)

SAMPLE Phoenix Percent of Rent and Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Periodic Interviews.

NOTE Standard error in parentheses

† t-statistic significant at the 0 10 level

* t-statistic significant at the 0 05 level

** t-statistic significant at the 0 01 level.

SEE = Standard Error of Estimate.

TABLE X-42

MEAN MONTHLY HOUSING SERVICES AT ENROLLMENT AND AT TWO YEARS AFTER ENROLLMENT FOR THE MOVER SAMPLE BY RACE/ETHNICITY

TREATMENT GROUP	MEAN HOUSING SERVICES: At Enrollment	MEAN HOUSING SERVICES: At Two Years	MEAN CHANGE IN HOUSING SERVICES: AMOUNT	MEAN CHANGE IN HOUSING SERVICES: PERCENTAGE: Mean of the Ratio	MEAN CHANGE IN HOUSING SERVICES: PERCENTAGE: Ratio of the Means	SAMPLE SIZE
PITTSBURGH						
Nonminority households						
Percent of Rent households	$113	$126	$13	15%	12%	(102)
Control households	114	125	10	11	9	(76)
Unconstrained households	[104]	[132]	[28]	[35]	[27]	(14)
Minority (black) households						
Percent of Rent households	103	136	34	41	33	(19)
Control households	[110]	[128]	[18]	[22]	[16]	(15)
Unconstrained households	[105]	[132]	[27]	[26]	[26]	(4)
PHOENIX						
Nonminority households						
Percent of Rent households	$145	$168	$24	21%	17%	(86)
Control households	137	162	25	24	18	(68)
Unconstrained households	[142]	[169]	[27]	[27]	[19]	(9)

(continued)

SAMPLE: Percent of Rent Unconstrained and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

TABLE X-42 (continued)

MEAN MONTHLY HOUSING SERVICES AT ENROLLMENT AND AT TWO YEARS AFTER ENROLLMENT FOR THE MOVER SAMPLE BY RACE/ETHNICITY

TREATMENT GROUP	MEAN HOUSING SERVICES		MEAN CHANGE IN HOUSING SERVICES			SAMPLE SIZE
				PERCENTAGE		
	At Enrollment	At Two Years	AMOUNT	Mean of the Ratio	Ratio of the Means	
			PHOENIX (continued)			
Minority households						
Percent of Rent households	$111	$134	$23	23%	21%	(46)
Control households	102	142	40	49	39	(38)
Unconstrained households	[108]	[163]	[55]	[74]	[51]	(9)
Black households						
Percent of Rent households	[118]	[131]	[13]	[11]	[11]	(11)
Control households	[90]	[124]	[33]	[57]	[37]	(12)
Unconstrained households	[106]	[189]	[83]	[79]	[79]	(1)
Spanish-American households						
Percent of Rent households	109	135	26	28	24	(35)
Control households	108	151	43	46	40	(26)
Unconstrained households	[109]	[160]	[51]	[74]	[47]	(8)

SAMPLE: Percent of Rent Unconstrained and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

TABLE X-43

STRATIFIED LOG-LINEAR HOUSING EXPENDITURES, HOUSING SERVICES, AND HEDONIC RESIDUALS ELASTICITIES FOR THE MOVER SAMPLE

INDEPENDENT VARIABLES	PITTSBURGH				PHOENIX			
	EXPENDITURES	HOUSING SERVICES	HEDONIC RESIDUAL	SAMPLE SIZE	EXPENDITURES	HOUSING SERVICES	HEDONIC RESIDUAL	SAMPLE SIZE
All Households								
Income elasticity	0.338**	0.226**	0.089*	(214)	0.353**	0.375**	-0.021	(257)
	(0.054)	(0.047)	(0.039)		(0.046)	(0.043)	(0.034)	
Price elasticity	-0.230**	-0.113*	-0.159**		-0.215**	-0.045	-0.193**	
	(0.065)	(0.057)	(0.047)		(0.064)	(0.060)	(0.048)	
Single-Person Households								
Income elasticity	0.283	0.241	0.143	(32)	0.476**	0.464**	0.011	(29)
	(0.180)	(0.163)	(0.032)		(0.079)	(0.101)	(0.058)	
Price elasticity	-0.055	-0.118	0.032		-0.404**	-0.366†	-0.111	
	(0.185)	(0.168)	(0.094)		(0.154)	(0.197)	(0.112)	
Single Heads of Household with Others								
Income elasticity	0.222*	0.181†	-0.021	(87)	0.321**	0.416**	-0.086	(111)
	(0.105)	(0.095)	(0.089)		(0.076)	(0.067)	(0.058)	
Price elasticity	-0.216*	-0.038	-0.245**		-0.073	0.045	-0.129†	
	(0.093)	(0.085)	(0.079)		(0.092)	(0.081)	(0.070)	
Households Headed by a Couple								
Income elasticity	0.560**	0.489**	0.085	(95)	0.364**	0.365**	0.005	(117)
	(0.094)	(0.076)	(0.067)		(0.088)	(0.082)	(0.065)	
Price elasticity	-0.349**	-0.246**	-0.137†		-0.356**	-0.121	-0.272**	
	(0.099)	(0.080)	(0.071)		(0.106)	(0.098)	(0.078)	
Nonminority Households								
Income elasticity	0.358**	0.269**	0.071†	(180)	0.406**	0.440**	-0.042	(168)
	(0.059)	(0.048)	(0.038)		(0.050)	(0.045)	(0.038)	
Price elasticity	-0.233**	-0.143*	-0.136**		-0.290**	-0.129*	-0.197**	
	(0.070)	(0.057)	(0.045)		(0.073)	(0.065)	(0.056)	
Minority Households								
Income elasticity	0.232†	-0.012	0.194	(34)	0.169†	0.154†	0.028	(89)
	(0.136)	(0.151)	(0.140)		(0.091)	(0.085)	(0.071)	
Price elasticity	-0.207	0.067	-0.280		-0.154	0.023	-0.180*	
	(0.181)	(0.201)	(0.187)		(0.115)	(0.106)	(0.090)	
Black Households								
Income elasticity	---[a]	---	---		0.214	0.159	0.003	(27)
					(0.173)	(0.165)	(0.160)	
Price elasticity	---	---	---		-0.277	-0.138	-0.132	
					(0.228)	(0.218)	(0.211)	
Spanish American Households								
Income elasticity	---	---	---		0.113	0.100	0.058	(62)
					(0.113)	(0.102)	(0.080)	
Price elasticity	---	---	---		-0.081	0.116	-0.211*	
					(0.136)	(0.121)	(0.096)	

SAMPLE. Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, and Baseline and Periodic Interviews.

NOTE Standard error in parentheses. ISE indicates that the overall F-statistic for the equation was not significant at the 0.10 level or less.

a. All minority households in Pittsburgh are black.

† t-statistic significant at the 0.10 level.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

TABLE X-44

LOG-LINEAR EXPENDITURE FUNCTIONS FOR HOUSING SERVICES USING FULL SAMPLE AND SUBMARKET HEDONIC INDICES FOR PHOENIX

INDEPENDENT VARIABLES	WHITE HOUSEHOLDS	MINORITY HOUSEHOLDS	SPANISH AMERICAN HOUSEHOLDS
Full Sample Index			
Constant	2.446** (0.273)	3.883** (0.488)	4.205** (0.543)
Ln(1-a)	-0.109 (0.067)	0.023 (0.104)	0.098 (0.120)
Ln(monthly income)	0.430** (0.045)	0.167 (0.083)	0.122 (0.099)
R^2	0.37	0.04	0.04
Standard error of estimate	0.25	0.32	0.31
Sample size	(166)	(91)	(63)
Spanish American Submarket Index			
Constant	2.401** (0.284)	3.927** (0.491)	4.182** (0.063)
Ln(1-a)	-0.117† (0.070)	0.027 (0.083)	0.099 (0.122)
Ln(monthly income)	0.441** (0.047)	0.164* (0.083)	0.129 (0.101)
R^2	0.36	0.04	0.04
Standard error of estimate	0.26	0.33	0.31
Sample size	(166)	(91)	(63)

SAMPLE: Phoenix Percent of Rent and Control movers active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Housing Evaluation Forms, 1970 Census of Population, Baseline and Periodic Interviews.

NOTE: Standard error in parentheses.

† t-statistic significant at the 0.10 level.

* t-statistic significant at the 0.05 level.

** t-statistic significant at the 0.01 level.

TABLE X-45

ESTIMATE OF LOG(NORMAL RENT) AT
TWO YEARS AFTER ENROLLMENT

INDEPENDENT VARIABLE	PITTSBURGH COEFFICIENT	PITTSBURGH STANDARD ERROR	PHOENIX COEFFICIENT	PHOENIX STANDARD ERROR
MOVERS[a]				
Constant (two years)	3.848	(0.335)	3.026	(0.275)
Constant (at enrollment)	3.673	(0.322)	2.866	(0.272)
Log(monthly income)	0.178	(0.054)	0.328	(0.045)
Serial correlation	0.447		0.406	
R^2	0.32		0.34	
Sample size	(95)		(126)	
NONMOVERS[b]				
Constant	0.307	(0.153)	0.442	(0.160)
Log(enrollment rent)	0.959	(0.033)	0.919	(0.034)
R^2	0.81		0.85	
Standard error of estimate	0.14		0.16	
Sample size	(200)		(130)	

SAMPLE: Control households active at two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms.

a. Estimated using Seemingly Unrelated Regression.

b. Estimated using Ordinary Least Squares.

APPENDIX XI

EVALUATION OF SAMPLE SELECTION BIAS IN ESTIMATED PRICE ELASTICITIES[1]

The procedures used to select the sample of households offered enrollment in the Demand Experiment were carefully designed to provide a probability sample of a well-defined, low-income population in both sites, randomly assigned to the various Experimental and Control plans.[2] The demand functions presented in Chapters 4 and 5 were estimated on a different sample of households--households that accepted the enrollment offer, were verified to be within the income eligibility limit, remained in the experiment, and moved sometime between enrollment and two years after enrollment. Each of these selection criteria may have introduced bias in the estimated coefficients, so that they may differ from the population coefficients, as follows:

> Acceptance bias. Households offered higher payments may have been more likely to accept the enrollment offer than households offered lower payments. Since, for each rebate level, payment increased with housing expenditures, households that accepted the Percent of Rent offers may have tended to spend more for housing than Control households. In this case, cross-sectional comparison of Percent of Rent and Control households might overestimate the effect of the rebate.
>
> Attrition bias. Likewise, households may have been more likely to remain in the program if they received higher payments. Again, Percent of Rent households that tended to spend more on housing regardless of the experiment may have been more likely to remain in the experiment.
>
> Mobility bias. In theory, households move to change their housing and hence should be, other things equal, more likely to move the larger their desired changes. Households may move in order to spend less or to spend more on housing. The rent rebates offered to Percent of Rent households would be expected to encourage moving

---

[1]This appendix was written by Stephen Kennedy. He has benefited greatly from comments by Walter Stellwagen and David Hoaglin, as well as many helpful discussions with the authors of this report, Joseph Friedman and Daniel Weinberg. The appendix also reflects the helpful comments of David Wise on a more general discussion presented at the summer meetings of the Econometric Society (Kennedy, 1978). Responsibility for errors, of course, remains with the author.

[2]Random assignment was modified for certain plans to reflect special income limits. This is accounted for in the analysis.

by households that would have moved to increase their spending. Thus the sample of Percent of Rent movers may not be comparable to the sample of Control movers.[1]

Heckman (1976) provides a general framework for addressing sample selection bias for cases in which the selection process is observed. This appendix essentially applies a modified version of Heckman's model to the sample selections described above. While it is often difficult to find the identifying variables required for the Heckman solution, it appears that serial correlation can provide a relatively simple test for sample selection. When there is serial correlation, differences in the normal consumption levels of selected and nonselected households will be reflected in proportional differences in preprogram consumption levels. Unfortunately, the factor of proportionality depends very much on the dynamics of the decision-making process involved in the selection. However, plausible models can be proposed which lead to the convenient factor of one.

The appendix is organized as follows. Section XI.1 describes the sample selection problem and indicates problems in the application of the Heckman solution. Section XI.2 derives a simple correction for sample selection based on serial correlation and discusses its sensitivity to assumptions concerning the dynamics of decision-making. Finally, Section XI.3 examines the empirical results concerning the size of the sample selection bias and the appropriate corrections in the analyses of Chapters 4 and 5.

XI.1 THE SAMPLE SELECTION PROBLEM

The sample selection problem has been nicely described in Heckman (1976) and also, following Heckman, by Hausman and Wise (1977). Specifically, consider the log-linear expenditure function of Chapter 4:

$$R = X\beta + \varepsilon \tag{1}$$

[1] One other possible bias is not considered here. If the price elasticity is itself stochastic, then households that moved during the first two years might tend to include more "high response" households. Estimates based on these households would overestimate the responses of later movers. As discussed in Section 6.1, there is no consistent evidence of declining response over time.

where

R = the logarithm of housing expenditures

X = a matrix of independent variables (a constant, $\ln(Y)$, and $\ln(1-a)$, where Y is household income and "a" is the percentage rebate)

β = the vector of behavioral parameters with elements β_0 (the constant), β_1 (the income elasticity), and β_2 (the price elasticity), and

ε = a stochastic term, assumed to be independently normally distributed with mean zero and standard deviation σ_ε.

The potential selection biases described above suggest that the probability that a household falls into the selected sample varies systematically with ε and X, so that

(2) $$E(\varepsilon|S) = X\gamma$$

where $E(\varepsilon|S)$ is the expected value of ε for the selected sample, S, and γ is a vector of parameters representing the selection bias. In this case, Ordinary Least Squares estimates of Equation (1) will be biased, since

(3) $$\hat{\beta} = \beta + (X'X)^{-1}X'\varepsilon$$

implying

(4) $$E(\hat{\beta}|S) = \beta + \gamma.$$

In words, if γ_2 is non-zero, the estimated price elasticity, $\hat{\beta}_2$, will confuse the actual effects of the Percent of Rent rebates on expenditures, β_2, with the selection of the higher expenditure households at higher rebate levels, γ_2. Estimated effects will overstate the actual impact of the rebates on expenditures.

Specifically, say that the probability of being selected, π, is some function of the determinants of R (X and ε) and other variables (Z):

(5) $$\pi = \pi(X,Z,\varepsilon).$$

Then

(6) $$E(\varepsilon|X,Z,S) = \frac{\int \varepsilon\pi(X,Z,\varepsilon)f(\varepsilon)d\varepsilon}{\int \pi(X,Z,\varepsilon)f(\varepsilon)d\varepsilon}$$

where $f(\varepsilon)$ is the density function of ε.

If the form of π is known, then the expected value of π over ε, $\tilde{\pi} = \int \pi(X,Z,\varepsilon)f(\varepsilon)d\varepsilon$ can be estimated. If in addition, ε is normally distributed and π can be written as a linear function in X, Z, and ε, then as shown in Note A:

(7) $$\tilde{\pi} = \pi(X\gamma + Z\theta + \lambda\varepsilon)$$

leading to

(8) $$\pi(X\gamma + Z\theta) = \int \pi(X\gamma + Z\theta + \lambda\varepsilon)f(\varepsilon)d\varepsilon$$

and

(9) $$E(\varepsilon|S,X,Z) = \lambda\sigma_\varepsilon^2 \frac{1}{\tilde{\pi}(\tilde{y})} \frac{\partial\tilde{\pi}(\tilde{y})}{\partial\tilde{y}}$$

where

$$\tilde{y} = X\gamma + Z\theta.$$

Thus, if $\tilde{\pi}$ can be estimated, under the assumptions stated above, the bias in the expectation of ε can be expressed in terms of the estimated function, $\hat{\pi}$, and the unknown coefficient $\lambda\sigma_\varepsilon^2$.[1]

---

[1] Heckman (1976) and Hausman and Wise (1977) formulate the problem in a slightly more restrictive way. They start by defining π in terms of the standard probit model:

(i) $$\pi = \text{Prob}(V > 0)$$

(ii) $$V = X\gamma + Z\theta + \delta$$

where δ and ε (the error term from Equation (1)) are bivariate normal with correlation

$$\tilde{\lambda} = \lambda \frac{\sigma_\varepsilon}{\sigma_\delta}.$$

In this case

(iii) $$\pi = 1 - F(-X\gamma - Z\theta),$$

(iv) $$E(\delta|S,X,\theta) = \mu_\delta + \sigma_\delta^2 \frac{f(-X\gamma-Z\theta)}{1-F(-X\gamma-Z\theta)}$$

and

(v) $$E(\varepsilon|S,X,\theta) = \frac{\tilde{\lambda}\sigma_\varepsilon}{\sigma_\delta} E(\delta|S,X,\theta).$$

The formulation in the text is slightly more general, since it does not restrict the form of π to the Probit distribution. More importantly it may aid modeling by emphasizing the behavioral basis of the problem--the fact that ε affects the probability of selection.

Heckman suggests two solutions to the selection problem based on Equation (9) for cases in which the selection process is observed. First, in a two-stage procedure, if $\tilde{\pi}$ is estimated, then the variable $\left(\frac{1}{\tilde{\pi}}\frac{\partial\tilde{\pi}}{\partial\tilde{y}}\right)$ may be added to Equation (1) to yield

(10) $$R = X\beta + \lambda\sigma_{\varepsilon}^{2}\left(\frac{1}{\tilde{\pi}} \frac{\partial\tilde{\pi}}{\partial\tilde{y}}\right) + \nu$$

where ν is uncorrelated with X in the selected sample. Second, the system

(11) $$\begin{cases} R = X\beta + \varepsilon \\ \pi = \int \pi(X\gamma + Z\theta + \lambda\varepsilon)f(\varepsilon)d\varepsilon \end{cases}$$

may be estimated using maximum likelihood techniques.

The critical problem, in either case, is finding the identifiers, Z. In the context of the expenditure function estimates of Chapter 4, Z variables must be factors that affect acceptance, attrition, or mobility, but are known not to affect housing expenditures. No strong identifiers have been found.[1]

XI.2 SERIAL CORRELATION

Given the difficulty in finding identifiers, an alternative is available if the descriptors, X, and the stochastic term, ε, only enter the participation selection process through their effect on R. In this case, π may be written as

(12) $$\pi = \pi[\lambda(X\beta+\varepsilon) + Z\theta].$$

It is apparent that this will provide enough information to identify λ and β. Unfortunately, however, this will not generally be the case. Demographic descriptors such as age or income seem quite likely to influence acceptance, attrition, and mobility apart from R.

One variable that clearly would be expected to affect π in the say way as ε is past values of ε. There is a strong serial correlation between present and past values for ε for housing. If ε can be written as

---

[1]David Wise has pointed out that there need not in fact be any identifiers. The form $(1/\tilde{\pi})(\partial\tilde{\pi}/\partial\tilde{y})$ is nonlinear in $\tilde{y}$ and this will often be enough to estimate β and $\lambda\sigma_{\varepsilon}^{2}$ in Equation (10). However, this puts a heavy reliance on the proper specification of R(X) as a linear form in the first place, something about which little is usually known.

$$(13) \qquad \varepsilon_1 = \tau_1\varepsilon_0 + \delta_1$$

where subscripts indicate time periods, then it seems reasonable to specify that[1]

$$(14) \qquad \pi = \pi(X\gamma + Z\theta + \lambda(\tau_1\varepsilon_0 + \delta_1)).$$

But from Equation (13) it is immediate that

$$(15) \qquad \varepsilon_0 = \tau_0\varepsilon_1 + \delta_0$$

where

$$\tau_0 = \left(\sigma^2_{\varepsilon_0} \Big/ \sigma^2_{\varepsilon_1}\right)\tau_1.$$

Thus

$$(16) \qquad E(\varepsilon_0|S,X,Z) = \tau_0 \; E(\varepsilon_1|S,X,Z)$$

since there is no direct selection on ε_0 (so that $E(\delta_0|S,X,Z)$ in Equation (15) is zero).[2]

---

[1] Hausman and Wise (1977) use such a specification.

[2] Equation (16) can also be derived from Equations (9), (13), and (14). If

$$(i) \qquad \tilde{\pi} = \iint \pi \; f_1(\varepsilon_0) f_2(\delta_1) d\varepsilon_0 d\delta_1$$

then by Equation (9)

$$(ii) \qquad \frac{1}{\tilde{\pi}} \frac{\partial \tilde{\pi}}{\partial \tilde{Y}} = \sigma^2_{\varepsilon_0} \; \lambda\tau_1(E(\varepsilon_0|S,X,Z) = \sigma^2_{\varepsilon_1} \; \lambda E(\delta_1|S,X,Z).$$

By Equation (13)

$$(iii) \qquad E(\varepsilon_1|S,X,Z) = \tau_1 E(\varepsilon_0|S,X,Z) + E(\delta_1|S,X,Z).$$

Substituting (ii) into (iii)

$$(iv) \qquad E(\varepsilon_1|S,X,Z) = E(\varepsilon_0|S,X,Z) \left(\tau_1 + \frac{\sigma^2_{\varepsilon_1}}{\sigma^2_{\varepsilon_0}\tau_1}\right).$$

But from Equation (13)

$$(v) \qquad \sigma^2_{\varepsilon_1} = \tau_1^2\sigma^2_{\varepsilon_0} + \sigma^2_{\delta_1}.$$

Thus

$$(vi) \qquad E(\varepsilon_1|S,X,Z) = E(\varepsilon_0|S,X,Z) \frac{\sigma^2_{\varepsilon_1}}{\sigma^2_{\varepsilon_0}\tau_1}$$

$$= \frac{1}{\tau_0} \; E(\varepsilon_0|S,X,Z).$$

(footnote continued)

Equation (16) offers a particularly easy test for sample selection bias. If there are initial observations on the full sample, then sample selection on ε_1 may be tested by testing for sample selection on ε_0--i.e., by testing the equality of the estimated coefficients of Equation (1), based on the initial observations, for households that are subsequently selected and those that are not. Likewise, the value of τ_0 may be estimated using the entire sample, by regressing ε_0 on ε_1, since selection on ε_1 should not disturb the regression of ε_0 on ε_1.

Thus, sample selection bias may be tested for by estimating

(17) $$R_0 = X_0\beta + \varepsilon_0$$

for the entire population and then regressing $\hat{\varepsilon}_0$ on X, for the selected sample

(18) $$\tilde{\varepsilon}_0 = \tilde{X}_1\gamma + \tilde{\eta}$$

where $\tilde{\varepsilon}_0$ and $\tilde{X}_1$ refer to observations for the selected sample.[1] A consistent estimate of $E(\varepsilon_1|S,X)$ is then given by

(19) $$\hat{E}(\varepsilon_1|S,X) = \frac{1}{\hat{\tau}_0}\hat{\gamma}$$

where $\hat{\tau}_0$ is the estimated regression coefficient of $\hat{\varepsilon}_0$ on $\hat{\varepsilon}_1$ for the selected sample.[2]

(footnote continued)

Notice, however, that the direct proof presented in the text does not require that ε be normally distributed. This can be useful. Analysis of income reporting errors in the Demand Experiment, for example, indicated that the distribution of errors was decidedly longer-tailed than would be the case for a normal distribution. This hampered attempts to correct for truncation effects. See Hoaglin and Joseph (1978).

[1] The estimate γ will then have variance $\sigma_0^2[(\tilde{X}_1'\tilde{X}_1)^{-1}-(\tilde{X}_1'\tilde{X}_1)^{-1}(\tilde{X}_1\tilde{X}_0)(\tilde{X}_0'\tilde{X}_0)^{-1}(\tilde{X}_0'\tilde{X}_1)(\tilde{X}_1'\tilde{X}_1)^{-1}]$. For the special case of experimental effects, where the experimental variables have the same value at both periods, $\hat{\gamma}$ may be obtained by simply taking the difference in estimated coefficients for the full sample and the selected sample and the variance reduces to $\sigma_0^2[(\tilde{X}'\tilde{X})^{-1}-(\tilde{X}_0'\tilde{X}_0)^{-1}]$.

[2] More efficient procedures are undoubtedly available. For example, Hausman and Wise (1977) incorporate serial correlation into maximum likelihood estimates. These have not been considered because, as discussed below, there are reasons to believe that the multiplicative factor in Equation (19) $(1/\hat{\tau}_0)$ can be dropped.

There remains an important problem, however. The model of Equation (13) involves only two periods. As will be seen below, this can be a critical assumption in determining the exact relation between $E(\varepsilon_0|S)$ and $E(\varepsilon_1|S)$. Most experiments and programs run for some time before and after the point of analysis. It seems reasonable to suppose that selection does not simply occur at the point of analysis, but is an ongoing process. But if selection decisions are based on normal expenditure levels in other periods as well as t_0 and t_1 (and hence select on other ε_t's), then the ratio of $E(\varepsilon_1|S)$ to $E(\varepsilon_0|S)$ will no longer be τ_0^{-1} as in Equation (16).

The rest of this section explores several simple descriptions of dynamic decisions in order to explore their effect on the ratio of $E(\varepsilon_1|S)$ to $E(\varepsilon_0|S)$. It is shown that alternative models can generate a range of ratios from τ_0^{-1} to τ_0. At the same time a plausible case can be made for a ratio of one. This yields a particularly convenient correction for selection bias. The descriptions are not intended to be convincing models of decision-making. They are intended to indicate the sensitivity of the serial correlation bias correction to dynamic specifications.

Say, for example, that there is attrition in each period based on that period's values of R. Thus in each period, the mean value of ε is shifted by some amount, B, in addition to the effects of attrition in previous periods.[1] Assume further that value of ε in different periods are serially correlated such that[2]

(20) $$\varepsilon_t = \rho^t \varepsilon_0 + \delta_0 .$$

In this case

(21) $$E(\varepsilon_0|S_1 \ldots S_N) = \rho E(\varepsilon_N|S_1 \ldots S_N)$$

---

[1] The constancy of B is convenient, but not especially plausible. For example, if ε_0 is normally distributed, then the distribution of ε_t in each succeeding period will also be normal if the selection probability, $\pi(\tilde{y}+\lambda\varepsilon)$ is itself a normal distribution function. The assumption that the additional shift in the mean, B, is constant, however, requires that the attrition probability change over time (for example, that λ increase), since the moments of the net-of-previous attrition distribution will be different in each time period.

[2] For the rest of this section, the variance of ε over time is assumed to be constant so that $\tau_0 = \tau_1 = \rho$ where ρ is the correlation between ε_0 and ε_1.

where $(E(\varepsilon_1|S_1 \ldots S_N)$ is the expected value given successive selections in each period, t_1 to t_N.[1]

Notice, however, that ρ is the one-period correlation rather than the correlation between ε_0 and ε_N (which is ρ^N). Thus, for a given value of ρ^N, as the number of selections assumed to have occurred becomes large, the appropriate inflator for the $E(\varepsilon_0|S)$ approaches one.[2]

Alternatively, consider the sort of serial correlation generated by a components-of-variance model. Under this model, the error term for the i^{th} individual is the sum of a value for that individual, μ_i, plus a stochastic term, η_{it}:

(22) $$\varepsilon_{it} = \mu_i + \theta_t + \eta_{it}.$$

Suppressing the time term, θ_t,

(23) $$\varepsilon_t = \rho\varepsilon_0 + \delta_1.$$

Thus, the multiperiod and one-period correlations are the same for this model. In this case,[3]

(24) $$E(\varepsilon_0|S_1 \ldots S_N) = \left(1 + \frac{1}{\rho(N-1)}\right)^{-1} E(\varepsilon_N|S_1 \ldots S_N).$$

Again, for a given correlation, as the number of periods involved grows large, the factor applied to $E(\varepsilon_0|S)$ in order to obtain $E(\varepsilon_N|S)$ approaches one.

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[1] Equation (21) is proved as follows:

(i) $$E(\varepsilon_N|S_1 \ldots S_N) = \sum_1^N \rho^{N-t}B = \frac{1-\rho^N}{1-\rho} B$$

and

(ii) $$E(\varepsilon_0|S_1 \ldots S_N) = \sum_1^N \rho^{t}B = \frac{\rho(1-\rho^N)}{1-\rho} B .$$

[2] Note also that if the initial observation were subject to the same process, so that selection also occurs on ε_0 (as might be the case for pre-program data on participants in an ongoing program), then $E(\varepsilon_0|S) = E(\varepsilon_N|S)$.

[3] Equation (24) follows from

$$E(\varepsilon_N|S_1 \ldots S_N) = B[(N-1)\rho+1]$$

and

$$E(\varepsilon_0\ S_1 \ldots S_N) = B[(N-1)\rho].$$

Finally, in either of the above models, if attrition operates with a lag so that attrition in the i^{th} period is determined by ε_{t-1}, the expressions in Equations (21) and (24) reverse, so that

$$(25) \quad \begin{cases} E(\varepsilon_0|S) = \frac{1}{\rho} E(\varepsilon_N|S) & \text{under Equation (20)} \\ E(\varepsilon_0|S) = 1 + \frac{1}{\rho(N-1)} E(\varepsilon_N|S) & \text{under Equation (23).} \end{cases}$$

The sort of repeated selections described above may also be justified if households only reassess their situations from time to time. In this case, at any given instant, the periods on which current participants based their decisions may be distributed over the past, giving for the "average" participant, the equivalent of repeated selections. Alternatively, it might seem reasonable that households base their decisions on longer-run considerations. But this leads to the same sort of conclusion. Thus in the components of variance model, selection based on the expected value of R over many periods will lead to selection in terms of the μ_i term alone. But this again gives a situation in which $E(\varepsilon_0|S)$ equals $E(\varepsilon_N|S)$.

Such arguments are hardly conclusive. Their purpose is to indicate some of the problems involved in using serial correlation to correct for sample selection and to suggest that a case can frequently be made for adopting the correction

$$(26) \quad E(\varepsilon_1|S) = E(\varepsilon_0|S).$$

This is clearly a very convenient decision, since (if the variance of ε is constant over time) it eliminates the necessity of estimating τ_0 to develop the correction in Equation (19) and provides an unbiased estimate of the correction term with the usual small-sample distribution properties.

XI.3 EMPIRICAL EVIDENCE

The empirical results show no evidence of important bias due to sample selection. Table XI-1 presents results for expenditures.[1] There is a significant bias in Phoenix, indicating that expenditure price elasticities may have been overestimated in Phoenix. The numbers for Pittsburgh, while

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[1] The regressions from which these numbers are taken are shown in Note B.

Table XI-1

SELECTION EFFECTS FOR EXPENDITURE PRICE ELASTICITIES

	PITTSBURGH	PHOENIX
Estimated Price Elasticities		
(1) All enrolled households	-0.035 (0.034)	-0.010 (0.038)
(2) Households active two years after enrollment	-0.048 (0.037)	-0.103* (0.049)
(3) Households active two years after enrollment that moved between enrollment and two years	0.041 (0.063)	-0.098 (0.062)
Selection Effect		
Active households [(2)-(1)]	-0.013 (0.015)	-0.093** (0.031)
Movers [(3)-(1)]	0.076 (0.053)	0.087† (0.049)

SOURCE: See Appendix XI, Note B.
NOTE: Standard error in parentheses.
† t-statistic significant at the 0.10 level.
* t-statistic significant at the 0.05 level.
** t-statistic significant at the 0.01 level.

not significant, indicate an underestimate for that site only somewhat less than the overestimate in Phoenix. While only the Phoenix estimates are significant, the nearly opposite and equal effects in the two sites suggest random noise due to sampling error more than they do systematic selection. Indeed, application of corrections in each site would have little effect on the average estimated elasticity for the two sites.

Using the model developed in Section XI.2, the total correction for the estimated elasticity in each site would be

$$C = -E_S - \rho E_I \tag{27}$$

where

C = correction

E_S = selection effect

E_I = initial elasticity, and

ρ = serial correlation between residuals at enrollment and two years after enrollment.

This yields an overall correction for the price elasticity for movers of -0.059 in Pittsburgh and +0.092 in Phoenix. Thus while the unbiased Phoenix elasticity might be smaller (in absolute value), the Pittsburgh elasticity might be larger, leaving the two-site average almost unchanged.

Much larger corrections would be indicated, of course, if the original model of Section XI.2--which would require that E_S be divided by ρ--were followed. Nevertheless, in this case the corrections for the two sites would again largely cancel.[1]

Results for the hedonic index of housing services, presented in Table XI-2, show no significant selection effect in either site. The overall correction for movers (following Equation (27)) would be -0.008 in Pittsburgh and +0.052 in Phoenix. The difference in corrections for expenditures and for the hedonic index suggests that there may have been a small additional shopping effect of about 0.05 in Pittsburgh; and further, about 0.04 points of the effect in Phoenix may have been due to misestimation. These possible corrections are nevertheless well within the errors of estimate indicated in Chapter 5.

[1] The correction would be -0.142 in Pittsburgh and +0.193 in Phoenix.

Table XI-2

SELECTION EFFECTS FOR HOUSING SERVICES
PRICE ELASTICITIES

	PITTSBURGH	PHOENIX
Estimated Price Elasticities		
(1) All enrolled households	-0.068** (0.026)	0.016 (0.034)
(2) Households active two years after enrollment	-0.081** (0.029)	-0.030 (0.044)
(3) Households active two years after enrollment that moved between enrollment and two years	-0.032 (0.049)	-0.042 (0.057)
Selection Effect		
Active households [(2)-(1)]	-0.013 (0.013)	-0.046 (0.028)
Movers [(3)-(1)]	0.036 (0.042)	-0.058 (0.046)

SOURCE: See Appendix XI, Note B.
NOTE: Standard error in parentheses.
** t-statistic significant at the 0.01 level.

APPENDIX XI NOTE A

SUBSAMPLE MOMENTS WHEN THE ERROR IS NORMALLY DISTRIBUTED

Say that the probability that a household is observed, π, can be expressed as

(A1) $$\pi = \pi(\tilde{y} + \lambda\varepsilon)$$

where ε is a stochastic term distributed $N(\mu,\sigma)$ and $\tilde{y}$ is some function of observed variables.

Define

(A2) $$\tilde{\pi}(\tilde{y}) = \int \tilde{\pi}(\tilde{y} + \lambda\varepsilon) f(\varepsilon) d\varepsilon .$$

In theory, $\tilde{\pi}(\tilde{y})$ can be estimated from observations of the selection process. If $f(\varepsilon)$ is normal, then the moments of the stochastic term, ε, in the observed subpopulations, S, can be described in terms of $\tilde{\pi}$, λ, and the total population parameters of $f(\varepsilon)$, as shown below. If $f(\varepsilon)$ is normal, then

(A3) $$\frac{df(\varepsilon)}{d\varepsilon} = \left(\frac{\varepsilon-\mu}{\sigma^2}\right) f(\varepsilon) .$$

Substitute

(A4) $$\theta = \tilde{y} + \lambda\varepsilon$$

in Equation (A2) so that

(A5) $$\tilde{\pi}(\tilde{y}) = \int \pi(\theta) f\left(\frac{\theta-\tilde{y}}{\lambda}\right)\left(\frac{1}{\lambda}\right) d\theta .$$

Thus

(A6) $$\begin{aligned} \frac{\partial\tilde{\pi}}{\partial\tilde{y}} &= \int \pi(\theta) \left(\frac{\theta-\tilde{y}}{\lambda} - \mu\right) \frac{1}{\sigma^2} f\left(\frac{\theta-\tilde{y}}{\lambda}\right)\left(\frac{1}{\lambda}\right)^2 d\theta \\ &= \frac{\tilde{\pi}}{\sigma^2\lambda}\left[\frac{\int \varepsilon \Pi(\tilde{y}+\lambda\varepsilon) f(\varepsilon) d\varepsilon}{\tilde{\pi}} - \mu\right] \end{aligned}$$

But the term in brackets is the difference between the expected values of ε in the observed population and in the entire population. Thus

(A7) $$E(\varepsilon|\tilde{y},S) = \sigma^2\lambda\left(\frac{1}{\tilde{\pi}}\frac{\partial\tilde{\pi}}{\partial\tilde{y}}\right) + \mu$$

where

$E(\varepsilon|\tilde{y},S)$ = the mean value of ε in the observed population, S

μ,σ^2 = the mean and variance of ε in the total population

λ = the coefficient of ε in π [Equation (A2)], and

$\tilde{\pi}(\tilde{y})$ = the expected value of the probability that a household is observed, given $\tilde{y}$.

This procedure may be repeated to obtain the subpopulation variance of ε,

(A8) $$E(\varepsilon^2|\tilde{y},S) = \left(\frac{\partial^2\tilde{\pi}}{\partial\tilde{y}^2}\frac{(\lambda\sigma)^2}{\tilde{\pi}} + 1\right)\sigma^2$$

or

(A9) $$E(\varepsilon^2|\tilde{y},S) - (E(\varepsilon|\tilde{y},S))^2 = \sigma^2 + \lambda^2\sigma^4\left[\frac{1}{\tilde{\pi}}\frac{\partial^2\tilde{\pi}}{\partial\tilde{y}^2} - \left(\frac{1}{\tilde{\pi}}\frac{\partial\tilde{\pi}}{\partial\tilde{y}}\right)^2\right].$$

Alternatively,

(A10) $$\lambda^2\sigma^4\frac{\partial^2\pi}{\partial\tilde{y}^2} + \sigma^2\tilde{\pi} - \int\varepsilon^2\pi(\tilde{y}+\lambda\varepsilon)f(\varepsilon)d\varepsilon = 0$$

so that if λ and π are known, summing Equation (A10) across the values of $\tilde{y}$ allows the subpopulation variance to be used to form an estimate of σ^2.

APPENDIX XI NOTE B

SOURCES OF TABLES XI-1 AND XI-2

The following tables present the estimated coefficients for three regressions in each site, first for expenditures and then for the hedonic index of housing services.

Equation (1) estimated at enrollment is

(B1) $$R^F = \beta_0^F + \beta_1^F \ln(Y_0) + \beta_2^F \ln(1-a) + \varepsilon_0^F$$

where the superscript, F, indicates that all enrolled households were used in the estimation, Y_0 is household income, and "a" is the percentage rebate offered the household. Taking account of selection

(B2) $$R^F = \beta_0^A + \beta_1^A \ln(Y_0) + \beta_2^A \ln(1-a) + \gamma_0^A d_A + \gamma_2^A d_A \ln(1-a) + \varepsilon_0^A$$

where again the full sample was used, but a dummy variable, d_A, was used to estimate a separate intercept and price elasticity for households active at two years after enrollment, and

(B3) $$R^F = \beta_0^M + \beta_1^M \ln(Y_0) + \beta_2^M \ln(1-a) + \gamma_0^M d_M + \gamma_2^M d_M \ln(1-a) + \varepsilon_0^M$$

which repeats Equation (B2) except that the dummy variable, d_M, now refers to movers.

The numbers in Tables XI-1 and XI-2 are constructed from the estimates of Equations (B1) through (B3) as presented in Tables XI-3 and XI-4 for expenditures and housing services respectively, as follows:

(1) <u>Price Elasticity for All Enrolled Households</u>

Elasticity: $\hat{\beta}_2^F$

Error of Estimate: $\sigma(\hat{\beta}_2^F)$

Table XI-3

ESTIMATION OF THE SELECTION EFFECT FOR EXPENDITURES

COEFFICIENT	EQUATION (B1)	EQUATION (B2)	EQUATION (B3)
	PITTSBURGH		
β_0	3.031** (0.141)	3.044** (0.141)	3.026** (0.141)
β_1	0.282** (0.024)	0.281** (0.024)	0.281** (0.024)
β_2	-0.035 (0.034)	0.065 (0.082)	-0.064 (0.041)
γ_0	---	-0 009 (0.031)	0.043 (0.031)
γ_2	---	-0.118 (0.090)	0 105 (0.750)
R^2	0.134	0.136	0.136
F-statistic (significance)	69.94 (0.01)	35.53 (0.01)	35.55 (0.01)
Standard error of estimate	0.29	0.29	0.29
Sample size	(904)	(904)	(904)
	PHOENIX		
β_0	2.686** (0.133)	2.790** (0.134)	2.697** (0.133)
β_1	0 362** (0.022)	0.356** (0.022)	0.362** (0.022)
β_2	-0.010 (0.382)	0 108† (0.061)	0.039 (0.049)
γ_0	---	-0.127** (0.028)	-0 053† (0.031)
γ_2	---	-0.211† (0.078)	-0.137† (0 079)
R^2	0.215	0 231	0.218
F-statistic (significance)	133.30 (0.01)	73.02 (0.01)	67.64 (0.01)
Standard error of estimate	0.33	0.33	0.33
Sample size	(975)	(975)	(975)

SAMPLE: Enrolled Percent of Rent and Control households, excluding those with incomes over the eligibility limits.

DATA SOURCES Initial and montnly Household Report Forms, and Baseline and Periodic Interviews

† t-statistic significant at the 0.10 level (two-tailed test)

* t-statistic significant at the 0.05 level (two-tailed test).

** t-statistic significant at the 0.01 level (two-tailed test).

Table XI-4

ESTIMATION OF THE SELECTION EFFECT FOR HOUSING SERVICES

COEFFICIENT	EQUATION (B1)	EQUATION (B2)	EQUATION (B3)
	PITTSBURGH		
β_0	3.543** (0.101)	3.551** (0.104)	3.543** (0.101)
β_1	0.192** (0.017)	0.191** (0.017)	0.192** (0.017)
β_2	-0.068** (0.026)	-0.012 (0.055)	-0.088** (0.030)
γ_0	---	-0.005 (0.020)	-0.019 (0.023)
γ_2	---	-0.069 (0.062)	+0.055 (0.058)
R^2	0.124	0.126	0.129
F-statistic (significance)	64.89 (0.01)	32.80 (0.01)	33.84 (0.01)
Standard error of estimate	0.22	0.22	0.22
Sample size	(917)	(917)	(917)
	PHOENIX		
β_0	3.118** (0.114)	3.181** (0.116)	3.138** (0.114)
β_1	0.286** (0.019)	0.280** (0.019)	0.285** (0.019)
β_2	0.016 (0.034)	0.067 (0.053)	0.037 (0.043)
γ_0	---	-0.059† (0.024)	-0.052† (0.027)
γ_2	---	-0.097 (0.069)	-0.079 (0.071)
R^2	0.202	0.207	0.205
F-statistic (significance)	116.16 (0.01)	59.78 (0.01)	59.08 (0.01)
Standard error of estimate	0.28	0.28	0.28
Sample size	(921)	(921)	(921)

SAMPLE Enrolled Percent of Rent and Control households, excluding those with incomes over the eligibility limits.

DATA SOURCES Initial and monthly Household Report Forms, and Baseline and Periodic Interviews.

† t-statistic significant at the 0.10 level (two-tailed test).

* t-statistic significant at the 0.05 level (two-tailed test)

** t-statistic significant at the 0.01 level (two-tailed test).

(2) Price Elasticity for Active Households

Elasticity: $\hat{\beta}_2^A + \hat{\gamma}_2^A$

Error of Estimate:[1] $\sqrt{\sigma^2(\hat{\gamma}_2^A)-\sigma^2(\hat{\beta}_2^A)}$

(3) Price Elasticity for Mover Households

Elasticity: $\hat{\beta}_2^M + \hat{\gamma}_2^M$

Error of Estimate:[1] $\sqrt{\sigma^2(\hat{\gamma}_2^M)-\sigma^2(\hat{\beta}_2^M)}$

Finally, Table XI-5 gives the serial correlation coefficient between enrollment and two years for the expenditure and hedonic index residuals, respectively. These were estimated, using Control households only, by comparing the correlation of residuals (assuming equal variance) at enrollment and two years after enrollment from the equation

(B4) $$R_t = \beta_{0t} + \beta_{1t} \ln(Y_t) + \varepsilon_t$$

where

R_t = log expenditures or log of the hedonic index of housing services, and

Y_t = household income.

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[1] This is an approximation that ignores any possible covariance in separate estimates for the two groups due to the common income elasticity.

Table XI-5

CORRELATION OF RESIDUALS FOR CONTROL HOUSEHOLDS
AT ENROLLMENT AND TWO YEARS AFTER ENROLLMENT

	PITTSBURGH	PHOENIX
Expenditures		
All households	0.701	0.642
Sample size	(250)	(213)
Households that moved between enrollment and two years after enrollment	0.478	0.461
Sample size	(82)	(98
Housing Services		
All households	0.666	0.599
Sample size	(250)	(213)
Households that moved between enrollment and two years after enrollment	0.415	0.383
Sample size	(82)	(98)

SAMPLE: Control households active at the end of two years after enrollment, excluding those with enrollment incomes over the eligibility limits and those living in their own homes or in subsidized housing.

DATA SOURCES: Initial and monthly Household Report Forms, Baseline and Periodic Interviews, and Housing Evaluation Forms.

REFERENCES

Hausman, Jerry A. and David A. Wise, "Attrition in Experimental and Panel Data: The Gary Income Maintenance Experiment," (mimeo), May 1977.

Heckman, James J., "The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models," Annals of Economic and Social Measurement, Vol. 5, no. 4, Fall 1976.

Hoaglin, David C. and Catherine A. Joseph, Income Reporting and Verification in the Housing Allowance Demand Experiment, Cambridge, Mass., Abt Associates Inc., 1978 (revised June 1980).

Kennedy, Stephen D., "Sample Selection and the Analysis of Constrained Transfers: Some Evidence from the Housing Allowance Demand Experiment," paper presented at the summer meetings of the Econometric Society, June 1978.