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ESTIMATED EFFECTS OF INCREASED INCOME ON HOMEOWNER REPAIR EXPENDITURES

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PREFACE

This note reports the application of a model of homeowner repair expenditures, based on data for Brown County, Wisconsin, and St. Joseph County, Indiana. The model is used to predict the additional repair expenditures that would be made by elderly homeowners whose incomes were augmented. The predictions support a U.S. Department of Housing and Urban Development (HUD) study of the effects of reverse annuity mortgages on elderly homeowners and their housing.

The work reported here applies a general model of homeowner repair activity that is being developed as part of the Housing Assistance Supply Experiment. Daniel Relles of Rand provided statistical and computational assistance to the author. The note has benefited from careful reviews by John Mulford, Relles, and Ira S. Lowry. Charlotte Cox edited the text and supervised production of the final copy, which was typed by Robin Boynton.

The tables presented here were submitted to HUD on 14 May 1979, in response to a specific request for data. The work was performed under HUD Contract H-1789, Task 2.19.

SUMMARY

This note estimates how much more elderly homeowners would spend on repairs if they received reverse annuity mortgage (RAM) payments amounting to $600, $1,200, or $2,400 annually. The estimates were requested for a U.S. Department of Housing and Urban Development study of the desirability of RAMs.

A two-stage model of homeowner repair expenditures predicts expected expenditure as a function of 14 household and housing-unit characteristics. The first stage predicts the probability of making some expenditure during the calendar year; the second predicts the expected value of positive expenditures. Coefficients of each equation are estimated using baseline data from the Housing Assistance Supply Experiment (HASE) survey of homeowners. Residuals analysis finds no systematic prediction biases along the dimensions tested. Overall, the probability model fits the data quite well, although predictions from the positive expenditure model have high variance.

Predictions are given for 15 categories of elderly households using coefficients estimated from HASE baseline survey data, as well as elderly household descriptors from U.S. annual housing survey data. There is a prediction for each household type given its original income and the augmented incomes under the hypothetical RAM programs.

The estimated income elasticity of demand for repair and improvement expenditures falls between .83 and 1.16 for elderly homeowners. A one percent increase in their income would therefore imply a 0.83 to 1.16 percent increase in repair and improvement expenditures. In absolute dollars, the expenditure change would be modest. Average repair expenditures would typically increase by less than 10 percent of the annual RAM payment (e.g., plans offering $600 annually would increase repair expenditures less than $60).

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TABLES

I. INTRODUCTION

For housing policymakers to evaluate the reverse annuity mortgage (RAM) concept requires estimates of its housing effects. This note uses a predictive model of homeowner repair expenditures to estimate how much more elderly households would spend on home repairs if they received RAM payments of $600, $1,200, or $2,400 annually.* The model is calibrated using data from the baseline survey of homeowners in Brown County, Wisconsin (1974), and St. Joseph County, Indiana (1975),** the two sites of the Housing Assistance Supply Experiment (HASE). Repair expenditures are predicted as a function of household income, household structure, age of household head, education of household head, length of occupancy, property value, number of rooms, and age of structure. RAM payments are treated as additional income.

Section II specifies the equations, defines the dependent and independent variables, and reports the estimated parameters. Section III summarizes tests of the model's validity, considering only data for elderly households. Section IV presents predictions for 15 categories of elderly households, with the income increments specified above. The Appendix derives formulas for the income elasticities of demand given in the text and provides supplementary technical tables.

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*Repairs include all home repairs, replacements, alterations, and additions.

**The data apply to the preceding calendar year.

II. DEFINING AND FITTING THE MODEL

The model estimates a homeowner's expected annual repair expenditure as the product of (a) the probability of his having at least one positive expenditure during the year and (b) the expected value of his annual expenditures, given that at least one is made. The probability of a positive expenditure and the conditional expenditure are assumed to be independent.

A two-stage approach is adopted because no one-stage technique seems appropriate. Homeowners' actual expenditures are zero in about 20 percent of each sample. It is therefore inappropriate to fit a one-stage model using ordinary least squares (OLS), since the observations for the dependent variable are concentrated at a lower limit. A one-stage model using TOBIT analysis* would be appropriate if the actual expenditures (including zero expenditures) could be explained by a threshold effect. There is, however, some evidence in the literature that the TOBIT model does not fit repair expenditures well.** We therefore chose to treat homeowners' actual expenditures as inherently stochastic and to use the two-stage model to predict their expected rather than their actual expenditure.

We estimated the coefficients in both of the model's equations for several household and housing-unit characteristics. The probability of making a repair was estimated using maximum likelihood LOGIT;*** for the expected value of positive expenditures, we used OLS.

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*An estimation technique appropriate for continuous dependent variables with a lower or upper limit (repair expenditures have zero as a lower limit). James Tobin, "Estimation of Relationships for Limited Dependent Variables," *Econometrica*, Vol. 26, January 1958, pp. 24-36, explains the model and a method for estimating its parameters.

**Robert Mendelsohn, "Empirical Evidence on Home Improvements," *Journal of Urban Economics*, Vol. 4, 1977, p. 463.

***A technique for estimating the probability that a dichotomous qualitative variable will take the value one. The technique uses the cumulative logistic distribution function, $1/(1 + e^{-t})$, where t is determined as a linear function of the independent variables. Henri Theil, *Principles of Econometrics*, John Wiley & Sons, New York, 1971, pp. 628-636, explains the technique in detail.

The dependent variable in the OLS equation is sharply skewed to the right, necessitating a logarithmic transformation of expenditures.

Equations (1) through (4) summarize the model. Expected expenditures are derived from

$$E(R) = P(R > 0) \times E(R|R > 0), \tag{1}$$

where R = repair expenditures,
E = expected value function,
P = probability function.

The probability of a positive expenditure is estimated by

$$P(R > 0) = \frac{1}{1 + e^{-\gamma' X}}, \tag{2}$$

where e = the base of the natural logarithm (2.718),
γ = vector of LOGIT coefficients,
X = vector of household and housing characteristics.

The expected value of positive expenditures is estimated by

$$E(R|R > 0) = e^{\beta' X + \sigma^2/2}, \tag{3}$$

where β = vector of coefficients determined by an OLS fit for the logarithm of expenditures (positive expenditures only),
X = vector of household and housing characteristics identical to that used in the LOGIT model,
σ^2 = variance of a future observation about the logarithmic prediction $\beta' X$.*

Thus, the homeowner's expected repair expenditure is

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*The $\sigma^2/2$ term corrects for bias, since the expected value of the residual in a log-normal equation is $\exp(\sigma^2/2)$ instead of zero. The variance σ^2 is defined as the sum of the logarithmic regression variance and the variance of $\beta' X$ about its expected value.

$$E(R) = \frac{e^{\beta' X + (\sigma^2/2)}}{1 + e^{-\gamma' X}} . \qquad (4)$$

DEPENDENT VARIABLES

The dependent variable in the LOGIT equation takes the value one for any positive expenditure and zero otherwise. The dependent variable in the OLS equation is the natural logarithm of the total repair expenditures a homeowner reported for the calendar year preceding baseline.* Because only observations with positive values are used in the OLS model, the logarithmic transformation is always possible. Tests showing that the distribution of positive expenditures is approximately log-normal justify the transformation.

INDEPENDENT VARIABLES

Table 1 lists the 14 variables used in both the LOGIT and OLS models. Those variables were selected over others because there is comparable information in the 1976 Annual Housing Survey (AHS),** and because earlier analyses suggested that they could jointly characterize the repair behavior of all households.***

The seven continuous variables LNTHI, HAGE, HEDUC, LNSTAY, LNROOMS, LNVALU, and BAGE were agreed to in conversations between the author and HUD.† We added two interaction terms, ETHI and ELDAGE, to allow the effect of additional income or additional age on repair expenditures to differ for elderly and nonelderly households. Finally, five binary variables, ELDCOMP, ESINGFML, ESINGMAL, OTHER, and OLDTIMER, describe differences in household structure or age between elderly households.

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*Repair categories not included in the U.S. Bureau of the Census reports on residential alterations and repairs (series C50) were excluded from the totals. Only three HASE repair categories, air conditioners, appliances, and landscaping, were involved.

**Sponsored by the U.S. Department of Housing and Urban Development (HUD) and conducted by the Census Bureau.

***The models are fit to HASE survey data, but the predictions in Sec. IV use 1976 AHS data on different types of elderly households.

†We used logarithmic transforms for four of the variables.

Table 1

INDEPENDENT VARIABLES USED TO ESTIMATE HOMEOWNER REPAIR EXPENDITURES

Name	Definition
	Household Characteristics
LNTHI	Log of total household income.
ETHI	Slope shift: log of total household income for elderly households, zero for others.
ELDCOUP	1 for elderly couples, zero for others.
ESINGFML	1 for elderly single female head, zero for others.
ESINGMAL	1 for elderly single male head, zero for others.
OTHER	1 for elderly single-headed households when other adults are present, zero otherwise.
OLDTIMER	1 when one household head is at least 75 years old, zero otherwise.
HAGE	Age of the household head (years).
ELDAGE	Slope shift: age of the household head for elderly households, zero for others.
HEDUC	Years of education for household head.
LNSTAY	Log of duration of occupancy (years).
	Housing Characteristics
LNROOMS	Log of number of rooms.
LNVALU	Log of property value.
BAGE	Building age (years).

SOURCE: Defined by HASE staff.

NOTE: A household is elderly if at least one head is 62 or over. All logarithmic transformations are natural logarithms to the base e (2.718).

ESTIMATED COEFFICIENTS

Tables 2 and 3 report the estimated coefficients of the probability-of-repair equation and the expenditure equation, separately for Brown and St. Joseph counties. Sample sizes, t-values, and goodness-of-fit tests are included. Log-likelihood and F-ratio tests show that all the equations have explanatory power at the 99 percent level of confidence. But only the individual coefficients for income, value, age, and education can be distinguished from zero in any of the four equations.

As expected, the income coefficients are all positive, and with

Table 2

PARAMETER ESTIMATES FOR REPAIR MODEL: BROWN COUNTY

Independent Variable	Dependent Variable: Probability of Repairs		Dependent Variable: Expected Expenditure ($)	
	Coefficient (β_i)	t-Value	Coefficient (γ_i)	t-Value
LNTHI	1.12	3.78[a]	.56	2.81[a]
ETHI	-.51	-1.12	.14	0.44
ELDCOUP	4.99	0.93	-6.15	-1.55
ESINGFML	4.58	0.87	-5.54	-1.43
ESINGMAL	4.35	0.80	-5.08	-1.27
OTHER	-.43	-0.50	-.89	-1.12
OLDTIMER	-.33	-0.48	-1.03	-1.88
HAGE	.04	-2.88[a]	-.0037	-0.39
ELDAGE	.01	0.25	.07	2.11[a]
HEDUC	.08	2.04[a]	.03	1.29
LNSTAY	.19	1.21	.07	0.67
LNROOMS	-.09	-0.17	.53	1.68
LNVALU	-1.36	-3.93[a]	-.29	-1.22
BAGE	.001	0.17	-.0002	-0.05
CONSTANT	5.21	1.40	1.53	0.64
Statistics	N = 639 Log-likelihood ratio = 35.09		N_2 = 509 R^2 = .077 F = 2.946	

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in Brown County.

[a]Significant at 95 percent confidence level (two-tailed t-test).

the exception of the probability equation for St. Joseph County, are significant at the 95 percent confidence level. The elderly income interaction terms are negative in the probability equations and positive in the expenditure equations. Those terms are nowhere significantly different from zero.

INCOME ELASTICITIES*

The interaction terms give different elasticities of demand for

*The equations in this section are derived in the Appendix.

Table 3

PARAMETER ESTIMATES FOR REPAIR MODEL: ST. JOSEPH COUNTY

Independent Variable	Dependent Variable: Probability of Repairs		Dependent Variable: Expected Expenditure ($)	
	Coefficient (β_i)	t-Value	Coefficient (γ_i)	t-Value
LNTHI	.07	0.19	.77	3.62[a]
ETHI	-.02	-0.03	.36	0.86
ELDCOUP	-1.60	-0.22	.17	0.03
ESINGFML	-2.13	-0.30	.73	0.14
ESINGMAL	-1.89	-0.26	-.74	-0.13
OTHER	-.14	-0.15	-.04	-0.04
OLDTIMER	-1.38	-1.81	1.14	1.70
HAGE	-.01	-0.64	-.007	-0.64
ELDAGE	.03	0.51	-.05	-1.00
HEDUC	.09	1.74	.002	0.06
LNSTAY	-.21	-0.97	-.18	-0.85
LNROOMS	.40	0.65	-.09	-0.22
LNVALU	-.09	-0.28	-.21	-1.04
BAGE	.001	0.91	-.00005	-0.17
CONSTANT	1.21	0.32	1.05	0.45
Statistics	N = 376 Log-likelihood ratio = 17.66		N_2 = 302 R^2 = .123 F = 2.869	

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in St. Joseph County.

[a]Significant at 95 percent confidence level (two-tailed t-test).

the repair expenditures of nonelderly as against elderly households. The elasticities are as follows:

$$\text{Nonelderly:} \quad \eta_j = \beta_{LNTHI} + \gamma_{LNTHI}\,(1 - P_j); \tag{5}$$

$$\text{Elderly:} \quad \eta_j = \beta_{LNTHI} + \beta_{ETHI} + (\gamma_{LNTHI} + \gamma_{ETHI})(1 - P_j);$$

where η_j = income elasticity of demand of homeowner j,

β_i = coefficient of the i^{th} variable in the OLS equation,

γ_i = coefficient of the i^{th} variable in the LOGIT equation,

P_j = probability homeowner j will make an expenditure.

An income elasticity for each stage in the model can be obtained by dividing the joint elasticity formula (Eq. 5) into its component parts. For the probability of making repairs, the elasticity is the sum of the γ_is for income multiplied by one minus the probability of making repairs. For the expected level of positive expenditure, the elasticity is simply the sum of the β_is for income. The values of all three elasticities are reported in Table 4.

Table 4

COMPONENT INCOME ELASTICITIES

Household Type	Probability of $R > 0$	Expected Expenditure Given $R > 0$	Expected Expenditure (unconditional)
Brown County			
Nonelderly	.19	.55	.74
Elderly	.17	.70	.87
St. Joseph County			
Nonelderly	.01	.77	.78
Elderly	.02	1.13	1.15

NOTE: The elasticity for the unconditional expectation in column 3 is the sum of the components in columns 1 and 2.

In both counties, the income elasticity for total repair expenditures is lower for nonelderly households than for elderly households. The difference may be due to elderly households' greater reliance on contract labor, or it may simply reflect different tastes. In addition, the income elasticity of the probability of making repairs is much smaller than the elasticity with respect to positive expenditures. It contributes less to the overall elasticity of total expenditures (about 20 percent in Brown County but only 1.5 percent in St. Joseph County).

Comparable elasticity estimates in the literature are few. Mendelsohn estimates the income elasticity of total expenditures at the

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N-1192-HUD ESTIMATED EFFECTS OF INCREASED INCOMES ON HOMEOWNER REPAIR EXPENDITURES. Lawrence Helbers. November 1979.

Reports the application of a model of homeowner repair expenditures, using baseline Housing Assistance Supply Experiment data for Brown County, Wisconsin, and St. Joseph County, Indiana. Estimates how much more elderly homeowners, divided into 15 categories, would spend on repairs if they received reverse annuity mortgage (RAM) payments amounting to $600, $1200, or $2400 annually. The income elasticity of demand for repair and improvement expenditures is estimated to fall between .83 and 1.16, with average repair expenditures typically increasing by less than 10 percent of the annual RAM payment. 32 pp. (CC)

mean of his sample to be .61[*]--somewhat less than the above estimates. Struyk and Devine estimate the elasticity of the probability of elderly homeowners making an expenditure as between .05 and .20, according to location;[**] our estimates encompass nearly the same range (.02 to .17).

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[*] Mendelsohn, "Empirical Evidence on Home Improvements," p. 466.

[**] Raymond J. Struyk and Deborah Devine, *Determinants of Dwelling Maintenance Activity of Elderly Households*, U.S. Department of Housing and Urban Development, January 1978, p. 23.

III. MODEL VALIDATION

Equations (2) and (3) were validated by analyzing residuals and reviewing the sample sizes for certain variables pertaining to the structure of elderly households.* Briefly, the analysis of residuals showed that the LOGIT model predicts quite well, without biases associated with the independent variables. Although the regression estimates of expenditures have a large variance, that model also has no systematic prediction biases. The review of sample sizes showed too few single, male-headed households and single-headed households with other adults present to inspire confidence in the coefficients for those household types.

To assess the LOGIT model, we grouped the data in seven different ways using intervals of selected independent variables (e.g., homeowners with an income of between $0 and $3,999 form a group).** The grouping variables were household income, household income by household structure, age of household head, education of household head, household size, property value, and age of building. Collectively, the grouping variables formed 31 categories of households. The actual proportion of homeowners in each group making repair expenditures was then compared with the mean predicted probability of making a repair. For elderly households, in only 4 of the 31 comparisons did the actual proportion deviate from the mean predicted probability by more than one standard deviation. For no grouping variable did such a deviation occur more than once. Further, the pattern of residuals showed no systematic bias, and the standard errors were generally less than .08. The findings validate the LOGIT equation and the reliability of its fitted parameters, at least along the tested dimensions.

The regression model was tested by plotting the residuals against the predicted value of repair expenditures, income, age of household

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*Residuals analysis for nonelderly households yielded results very similar to those described below.

**Details are provided in the Appendix, Table A.1.

head, and property value. Again, for elderly households only, we found that the residuals displayed a high variance about the predicted value; but the plots were elliptical, showed no covariance with the conditioning variables, and revealed no extreme outliers that would strongly influence the coefficients. We conclude that there are no systematic problems with the functional form, but also that either it omits important variables, or repair expenditures are intrinsically stochastic.

The last validation step was to review the samples for the four elderly household types (elderly couples, single females, single males, others) used for the predictions in Sec. IV. The samples were quite small for elderly single males (9 in Brown County, 7 in St. Joseph County) and other elderly singles with other adults present (7 and 7). In contrast, the samples were larger for elderly couples (85 and 57) and elderly single females (39 and 32). The variances of our predictions for elderly single males and other elderly singles are consequently much greater than those for elderly couples or elderly single females. We therefore do not place much confidence in either the coefficient estimates of ESINGMAL and OTHER reported in Tables 2 and 3 or the predictions for those household types given in Tables 5 through 18.*

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*The effect on the predictions should be more serious for absolute expenditure levels than for relative changes in expenditures, since the income coefficients were constrained to be identical for all elderly households. This condition is true for Tables 5 through 18, where the most suspicious predictions appear in Tables 13 through 18. Recall that the bias correction in Eq. (3) makes the predictions sensitive to σ^2 (see p. 3).

IV. PREDICTIONS

This section predicts repair expenditures for 15 categories of elderly households, using the estimated coefficients in Tables 2 and 3 and descriptions of those households from the 1976 AHS. Predictions are made for both original income and for income augmented by RAMs of $600, $1,200, or $2,400 annually.* The predictions treat the added available cash as income, though technically it amounts to dissaving.**

The household categories are defined by the age of the household head and the composition of the household. Age takes the ranges 65-69, 70-74, and 75+. Households are categorized as headed by couples, consisting of single males or single females, and all others. That cross-classification defines 12 categories. Another three categories (13 through 15) are defined as likely candidates for receiving RAMs--elderly couples in each age category with a large ($67,000) equity but low ($4,000) annual income.***

HUD derived values for the continuous independent variables from 1976 AHS data.† They also chose the ages of 65, 70, and 76 for the HAGW and ELDAGE variables. We completed the array of independent variables by adding binary variables defining different household structures. The values of the independent variables are given in the Appendix (Table A.2).

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*The standard warning about using cross-sectional data to infer longitudinal behavior applies here. The differences should be interpreted as longrun rather than shortrun shifts.

**This assumption could be problematic. For example, since assets are excluded from the model, we have not allowed the dissaving to have its probable negative effect through asset reduction.

***Few (less than 3) elderly homeowners of any income in either sample had equities this large, so we are wary about the predictions for categories 13 through 15.

†We deflated 1976 dollars to 1973 dollars in Brown County and to 1974 dollars in St. Joseph County. After making the predictions, we adjusted the dollar amounts back to 1976 values. The adjustment factors were 1.281 in Brown County and 1.154 in St. Joseph County.

The tables below report the predictions separately for each county. Values are given for (predicted) original income and three RAM-augmented incomes, except that when differences or percentages are reported, there are no entries for original income. Tables 5 and 6 report income elasticities; Tables 7 and 8, additional expenditures; Tables 9 and 10, percentage expenditure increases; Tables 11 and 12, additional expenditures as a percentage of increased income; Tables 13 and 14, total expenditures; Tables 15 and 16, the probability of making an expenditure; and Tables 17 and 18, expected positive expenditures.

Table 5

INCOME ELASTICITY OF REPAIR EXPENDITURES AT DIFFERENT INCOME LEVELS: SELECTED HOUSEHOLD TYPES, BROWN COUNTY

Type of Household			Income Elasticity at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	.85	.85	.84	.83
2	65-69	Other[a]	.98	.97	.96	.95
3	65-69	Single male[a]	.97	.96	.95	.94
4	65-69	Single female	.92	.91	.90	.89
5	70-74	Husband-wife	.90	.89	.88	.87
6	70-74	Other[a]	1.01	1.01	1.00	.99
7	70-74	Single male[a]	.91	.91	.90	.89
8	70-74	Single female	.99	.98	.97	.95
9	75+	Husband-wife	.97	.97	.96	.95
10	75+	Other[a]	1.08	1.07	1.07	1.05
11	75+	Single male[a]	1.05	1.04	1.03	1.02
12	75+	Single female	1.06	1.05	1.04	1.02
13	65-69	Husband-wife[b]	1.05	1.04	1.03	1.01
14	70-74	Husband-wife[b]	1.08	1.07	1.06	1.04
15	75+	Husband-wife[b]	1.15	1.14	1.14	1.12

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in Brown County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 6

INCOME ELASTICITY OF REPAIR EXPENDITURES AT DIFFERENT INCOME LEVELS: SELECTED HOUSEHOLD TYPES, ST. JOSEPH COUNTY

Type of Household			Income Elasticity at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	1.14	1.14	1.14	1.14
2	65-69	Other[a]	1.14	1.14	1.14	1.14
3	65-69	Single male[a]	1.14	1.14	1.14	1.14
4	65-69	Single female	1.14	1.14	1.14	1.14
5	70-74	Husband-wife	1.14	1.14	1.14	1.14
6	70-74	Other[a]	1.14	1.14	1.14	1.14
7	70-74	Single male[a]	1.14	1.14	1.14	1.14
8	70-74	Single female	1.14	1.14	1.14	1.14
9	75+	Husband-wife	1.15	1.15	1.15	1.15
10	75+	Other[a]	1.16	1.16	1.16	1.16
11	75+	Single male[a]	1.16	1.16	1.16	1.16
12	75+	Single female	1.16	1.16	1.16	1.16
13	65-69	Husband-wife[b]	1.14	1.14	1.14	1.14
14	70-74	Husband-wife[b]	1.14	1.14	1.14	1.14
15	75+	Husband-wife[b]	1.15	1.15	1.15	1.15

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in St. Joseph County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 7

CHANGE IN ANNUAL REPAIR EXPENDITURES AS INCOME INCREASES: SELECTED HOUSEHOLD TYPES, BROWN COUNTY

Type of Household			Expenditure Change ($) at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	--	13.9	27.8	55.0
2	65-69	Other[a]	--	14.0	28.0	55.9
3	65-69	Single male[a]	--	45.7	91.2	181.8
4	65-69	Single female	--	29.6	58.9	116.7
5	70-74	Husband-wife	--	18.6	37.1	73.6
6	70-74	Other[a]	--	19.3	38.6	77.4
7	70-74	Single male[a]	--	85.0	169.7	337.8
8	70-74	Single female	--	36.5	72.9	145.2
9	75+	Husband-wife	--	9.3	18.7	37.3
10	75+	Other[a]	--	9.1	18.4	37.2
11	75+	Single male[a]	--	32.5	65.3	131.2
12	75+	Single female	--	18.2	36.6	73.7
13	65-69	Husband-wife[b]	--	9.8	19.7	39.1
14	70-74	Husband-wife[b]	--	11.3	22.6	45.3
15	75+	Husband-wife[b]	--	4.9	10.0	20.2

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in Brown County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 8

CHANGE IN ANNUAL REPAIR EXPENDITURES AS INCOME INCREASES: SELECTED HOUSEHOLD TYPES, ST. JOSEPH COUNTY

Type of Household			Expenditure Change ($) at:			
Code	Age of Head	Household Composition	Original Income	Original Income plus $600	Original Income plus $1,200	Original Income plus $2,400
1	65-69	Husband-wife	--	46.8	94.5	192.2
2	65-69	Other[a]	--	78.4	159.0	325.9
3	65-69	Single male[a]	--	22.0	44.5	90.9
4	65-69	Single female	--	76.0	154.6	318.6
5	70-74	Husband-wife	--	39.4	79.7	162.4
6	70-74	Other[a]	--	65.4	132.5	271.9
7	70-74	Single male[a]	--	18.7	37.8	77.3
8	70-74	Single female	--	55.0	112.2	232.7
9	75+	Husband-wife	--	55.1	111.5	227.5
10	75+	Other[a]	--	89.1	180.8	371.2
11	75+	Single male[a]	--	22.5	45.7	93.9
12	75+	Single female	--	73.0	149.1	309.9
13	65-69	Husband-wife[b]	--	35.8	72.5	148.3
14	70-74	Husband-wife[b]	--	30.3	61.4	126.0
15	75+	Husband-wife[b]	--	41.5	84.2	172.8

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in St. Joseph County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 9

PERCENTAGE CHANGE IN REPAIR EXPENDITURES AS INCOME INCREASES: SELECTED HOUSEHOLD TYPES, BROWN COUNTY

Type of Household			Change (%) at:			
Code	Age of Head	Household Composition	Original Income	Original Income plus $600	Original Income plus $1,200	Original Income plus $2,400
1	65-69	Husband-wife	--	6.0	12.0	23.7
2	65-69	Other[a]	--	9.0	18.1	36.0
3	65-69	Single male[a]	--	8.7	17.3	34.5
4	65-69	Single female	--	10.7	21.3	42.3
5	70-74	Husband-wife	--	6.8	13.5	26.8
6	70-74	Other[a]	--	8.7	17.5	35.0
7	70-74	Single male[a]	--	7.5	15.0	29.8
8	70-74	Single female	--	13.7	27.4	54.5
9	75+	Husband-wife	--	8.0	15.9	31.8
10	75+	Other[a]	--	9.6	19.2	38.7
11	75+	Single male[a]	--	11.5	23.1	46.4
12	75+	Single female	--	16.3	32.7	65.7
13	65-69	Husband-wife[b]	--	14.4	28.8	57.2
14	70-74	Husband-wife[b]	--	15.1	30.2	60.3
15	75+	Husband-wife[b]	--	16.5	33.2	67.1

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in Brown County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 10

PERCENTAGE CHANGE IN REPAIR EXPENDITURES AS INCOME INCREASES: SELECTED HOUSEHOLD TYPES, ST. JOSEPH COUNTY

Type of Household			Change (%) at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	--	8.2	16.6	33.8
2	65-69	Other[a]	--	11.0	22.2	45.5
3	65-69	Single male[a]	--	10.1	20.4	41.7
4	65-69	Single female	--	14.0	28.4	58.5
5	70-74	Husband-wife	--	8.9	18.0	36.6
6	70-74	Other[a]	--	10.4	21.0	43.1
7	70-74	Single male[a]	--	9.4	18.9	38.7
8	70-74	Single female	--	16.7	34.1	70.8
9	75+	Husband-wife	--	9.6	19.3	39.4
10	75+	Other[a]	--	10.6	21.4	44.0
11	75+	Single male[a]	--	12.3	25.0	51.2
12	75+	Single female	--	18.3	37.3	77.4
13	65-69	Husband-wife[b]	--	15.4	31.1	63.6
14	70-74	Husband-wife[b]	--	15.8	32.1	65.8
15	75+	Husband-wife[b]	--	16.0	32.5	66.7

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in St. Joseph County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 11

EXPENDITURE CHANGE AS PERCENTAGE OF INCREASED INCOME: BROWN COUNTY

Type of Household			Change (%) at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	--	2.3	2.3	2.3
2	65-69	Other[a]	--	2.3	2.3	2.3
3	65-69	Single male[a]	--	7.6	7.6	7.6
4	65-69	Single female	--	4.9	4.9	4.9
5	70-74	Husband-wife	--	3.1	3.1	3.1
6	70-74	Other[a]	--	3.2	3.2	3.2
7	70-74	Single male[a]	--	14.2	14.1	14.1
8	70-74	Single female	--	6.1	6.1	6.1
9	75+	Husband-wife	--	1.6	1.6	1.6
10	75+	Other[a]	--	1.5	1.5	1.6
11	75+	Single male[a]	--	5.4	5.4	5.5
12	75+	Single female	--	3.0	3.1	3.1
13	65-69	Husband-wife[b]	--	1.6	1.6	1.6
14	70-74	Husband-wife[b]	--	1.9	1.9	1.9
15	75+	Husband-wife[b]	--	0.8	0.8	0.8

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in Brown County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 12

EXPENDITURE CHANGE AS PERCENTAGE OF INCREASED INCOME: ST. JOSEPH COUNTY

Type of Household			Change (%) at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	--	7.8	7.9	8.0
2	65-69	Other[a]	--	13.1	13.3	13.6
3	65-69	Single male[a]	--	3.7	3.7	3.8
4	65-69	Single female	--	12.7	12.9	13.3
5	70-74	Husband-wife	--	.6.6	6.6	6.6
6	70-74	Other[a]	--	10.9	11.0	11.3
7	70-74	Single male[a]	--	3.1	3.2	3.2
8	70-74	Single female	--	9.2	9.4	9.7
9	75+	Husband-wife	--	9.2	9.3	9.5
10	75+	Other[a]	--	14.9	15.1	15.5
11	75+	Single male[a]	--	3.8	3.8	3.9
12	75+	Single female	--	12.2	12.4	12.9
13	65-69	Husband-wife[b]	--	6.0	6.0	6.2
14	70-74	Husband-wife[b]	--	5.1	5.1	5.3
15	75+	Husband-wife[b]	--	6.9	7.0	7.2

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in St. Joseph County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 13

TOTAL PREDICTED EXPENDITURES: BROWN COUNTY

Type of Household			Expenditures ($) at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	232.0	245.9	259.8	287.0
2	65-69	Other[a]	155.2	169.3	183.3	211.2
3	65-69	Single male[a]	526.5	572.3	617.8	708.4
4	65-69	Single female	276.2	305.8	335.1	392.9
5	70-74	Husband-wife	275.3	293.9	312.4	348.9
6	70-74	Other[a]	221.2	240.6	259.9	298.7
7	70-74	Single male[a]	1,134.5	1,219.5	304.2	1,472.3
8	70-74	Single female	266.4	302.9	339.3	411.6
9	75+	Husband-wife	117.4	126.8	136.2	154.8
10	75+	Other[a]	96.1	105.3	114.5	133.3
11	75+	Single male[a]	282.8	315.3	348.1	414.0
12	75+	Single female	112.2	130.4	148.8	185.9
13	65-69	Husband-wife[b]	68.5	78.4	88.2	107.7
14	70-74	Husband-wife[b]	75.1	86.5	97.8	120.5
15	75+	Husband-wife[b]	30.2	35.1	40.2	50.4

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in Brown County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 14

TOTAL PREDICTED EXPENDITURES: ST. JOSEPH COUNTY

Type of Household			Expenditures ($) at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	568.5	615.4	663.1	760.8
2	65-69	Other[a]	716.6	795.1	875.6	1,042.6
3	65-69	Single male[a]	217.9	240.0	262.5	308.9
4	65-69	Single female	544.6	620.7	699.2	863.3
5	70-74	Husband-wife	443.9	483.3	523.6	606.3
6	70-74	Other[a]	631.1	696.5	763.7	903.1
7	70-74	Single male[a]	200.0	218.8	237.9	277.4
8	70-74	Single female	328.8	383.9	441.1	561.6
9	75+	Husband-wife	577.7	632.9	689.2	805.3
10	75+	Other[a]	844.1	933.3	1025.0	1,215.4
11	75+	Single male[a]	183.2	205.8	229.0	277.1
12	75+	Single female	400.1	473.2	549.2	710.0
13	65-69	Husband-wife[b]	233.1	269.0	305.7	381.4
14	70-74	Husband-wife[b]	191.5	221.8	253.0	317.5
15	75+	Husband-wife[b]	258.9	300.5	343.1	431.7

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in St. Joseph County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 15

PROBABILITY OF MAKING AN EXPENDITURE: BROWN COUNTY

Type of Household			Probability at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	.739	.747	.754	.768
2	65-69	Other[a]	.533	.546	.559	.580
3	65-69	Single male[a]	.548	.561	.573	.594
4	65-69	Single female	.629	.645	.658	.682
5	70-74	Husband-wife	.667	.677	.686	.703
6	70-74	Other[a]	.472	.484	.495	.516
7	70-74	Single male[a]	.634	.645	.655	.673
8	70-74	Single female	.507	.527	.545	.575
9	75+	Husband-wife	.539	.552	.563	.583
10	75+	Other[a]	.364	.376	.387	.407
11	75+	Single male[a]	.411	.426	.440	.465
12	75+	Single female	.393	.414	.432	.464
13	65-69	Husband-wife[b]	.409	.430	.448	.480
14	70-74	Husband-wife[b]	.357	.377	.395	.425
15	75+	Husband-wife[b]	.242	.258	.272	.298

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in Brown County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 16

PROBABILITY OF MAKING AN EXPENDITURE: ST. JOSEPH COUNTY

Type of Household			Probability at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	.783	.783	.784	.785
2	65-69	Other[a]	.659	.660	.661	.662
3	65-69	Single male[a]	.715	.715	.716	.718
4	65-69	Single female	.690	.691	.692	.694
5	70-74	Husband-wife	.781	.782	.782	.783
6	70-74	Other[a]	.680	.681	.682	.683
7	70-74	Single male[a]	.753	.754	.755	.756
8	70-74	Single female	.678	.679	.681	.683
9	75+	Husband-wife	.487	.488	.489	.491
10	75+	Other[a]	.366	.367	.368	.369
11	75+	Single male[a]	.408	.409	.410	.412
12	75+	Single female	.371	.373	.374	.377
13	65-69	Husband-wife[b]	.765	.767	.768	.770
14	70-74	Husband-wife[b]	.751	.752	.753	.755
15	75+	Husband-wife[b]	.464	.466	.467	.470

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in St. Joseph County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 17

EXPECTED POSITIVE EXPENDITURES: BROWN COUNTY

Type of Household			Expenditures ($) at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	314.0	329.3	344.4	373.8
2	65-69	Other[a]	291.3	309.9	328.2	364.1
3	65-69	Single male[a]	960.1	1,019.5	1,077.9	1,192.4
4	65-69	Single female	439.2	474.4	508.9	576.0
5	70-74	Husband-wife	412.8	434.2	455.3	496.7
6	70-74	Other[a]	469.1	497.0	524.7	578.9
7	70-74	Single male[a]	1,788.6	1,890.5	1,991.2	2,189.2
8	70-74	Single female	525.2	574.6	622.9	716.5
9	75+	Husband-wife	217.8	230.0	242.1	265.7
10	75+	Other[a]	263.8	280.1	296.2	327.8
11	75+	Single male[a]	687.6	739.6	790.6	890.6
12	75+	Single female	285.7	315.4	344.5	400.7
13	65-69	Husband-wife[b]	167.5	182.5	196.9	224.5
14	70-74	Husband-wife[b]	210.4	229.5	247.9	283.3
15	75+	Husband-wife[b]	125.0	136.5	147.8	169.4

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in Brown County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Table 18

EXPECTED POSITIVE EXPENDITURES: ST. JOSEPH COUNTY

Type of Household			Expenditures ($) at:			
				Original Income plus		
Code	Age of Head	Household Composition	Original Income	$600	$1,200	$2,400
1	65-69	Husband-wife	726.3	785.6	845.8	969.1
2	65-69	Other[a]	1,088.1	1,205.4	1,325.6	1,574.4
3	65-69	Single male[a]	305.0	335.5	366.5	430.4
4	65-69	Single female	789.4	898.0	1,010.0	1,243.6
5	70-74	Husband-wife	568.3	618.3	669.3	773.9
6	70-74	Other[a]	928.2	1,023.1	1,120.3	1,321.9
7	70-74	Single male[a]	265.6	290.1	315.2	367.0
8	70-74	Single female	485.0	565.0	648.0	822.3
9	75+	Husband-wife	1,186.1	1,296.6	1,409.3	1,640.8
10	75+	Other[a]	2,307.2	2,544.2	2,787.1	3,290.4
11	75+	Single male[a]	449.5	503.4	558.5	672.6
12	75+	Single female	1,078.0	1,269.0	1,467.1	1,883.7
13	65-69	Husband-wife[b]	304.6	350.9	398.2	495.6
14	70-74	Husband-wife[b]	255.1	295.0	335.8	420.4
15	75+	Husband-wife[b]	558.0	645.1	734.2	918.5

SOURCE: Tabulated by HASE staff from records for the baseline survey of homeowners in St. Joseph County.

[a]Predictions are subject to much greater variance than for other categories. Some are suspect.

[b]Predictions for households with $67,000 in equity and $4,000 in annual income require extrapolation well beyond the limits of the HASE data.

Appendix

SUPPLEMENTARY TECHNICAL INFORMATION

This appendix derives the income elasticity formulas used in Sec. II and lists the categories used in the LOGIT residual analysis (Table A.1) and the data matrix used for the predictions in Sec. IV (Table A.2).

The income elasticity of demand for repair expenditures is defined as the percentage change in expenditures given a one percent increase in income, with prices constant. The point income elasticity is the percentage change for infinitesimal income shifts about the point (along the tangent) and is defined as

$$\eta_R = \frac{\partial R}{\partial Y}\frac{Y}{R} \tag{A.1}$$

or

$$\eta_R = \frac{\partial(\log R)}{\partial(\log Y)}, \tag{A.2}$$

where η_R = income elasticity of repairs expenditures,
R = repair expenditures,
Y = income.

The point elasticity formula reported in Eq. (A.2) will prove easiest to use here.

From Eq. (4) (Sec. II) we know that repair expenditures are

$$R = \frac{e^{\beta'X+(\sigma^2/2)}}{1 + e^{-\gamma'X}}. \tag{A.3}$$

Taking the logarithm of both sides of the equation, we have

$$\log (R) = \beta'X + \frac{\sigma^2}{2} - \log (1 + e^{-\gamma'X}). \tag{A.4}$$

The derivative of log (R) with respect to log (Y) is

$$\frac{\partial(\log R)}{\partial(\log Y)} = \beta_{\log(Y)} + \gamma_{\log(Y)} \frac{e^{-\gamma' X}}{1 + e^{-\gamma' X}}, \qquad \text{(A.5)}$$

but the far-right term equals $(1 - P)$, where P is the probability of making repairs. Therefore,

$$\eta_R = \frac{\partial(\log R)}{\partial(\log Y)} = \beta_{\log(Y)} + \gamma_{\log(Y)} (1 - P). \qquad \text{(A.6)}$$

The income elasticity differs for nonelderly and elderly households (see Table 1). Substituting the income terms for each group into Eq. (A.6) yields the following equations:

$$\begin{aligned} &\text{Nonelderly:} \quad \eta_R = \beta_{\text{LNTHI}} + \gamma_{\text{LNTHI}} (1 - P) \\ &\text{Elderly:} \quad \eta_R = \beta_{\text{LNTHI}} + \beta_{\text{ETHI}} + (\gamma_{\text{LNTHI}} + \gamma_{\text{ETHI}}) (1 - P) \end{aligned} \qquad \text{(A.7)}$$

LNTHI and ETHI are defined in Table 1 (p. 5).

Table A.1

INDEPENDENT VARIABLES USED IN LOGIT RESIDUAL ANALYSIS

Variable	Categories
Income	$0-$3,999; $4,000-$7,999; $8,000-$11,999; $12,000+
Income by household structure	Elderly couples: $0-$3,999; $4,000-$7,999; $8,000-$11,999; $12,000+
	Elderly singles: $0-$3,999; $4,000+
Head's age	Elderly: 62-65 yrs.; 65-69 yrs.; 70-74 yrs.; 75+ yrs.
Household size	1, 2, 3, 4+ persons
Education	Elementary school (0-8 yrs.)
	Some high school (9-11 yrs.)
	High school (12 yrs.)
	College (13-16 yrs.)
	Postgraduate (17+ yrs.)
Property value	$0-$15,000; $15,001-$20,000; $20,001-$25,000; $25,001+
Building age	1-20 yrs.; 20-40 yrs.; 40-60 yrs.; 60+ yrs.

SOURCE: Selected by HASE staff.

Table A.2

PREDICTED VALUES OF INDEPENDENT VARIABLES

Household Code	LNTHI	ETHI	ELDCOUP	ESINGFML	ESINGMAL	OTHER	OLDTIMER	HAGE	ELDAGE	HEDUC	LNSTAY	LNROOMS	LNVALU	BAGE
1	8183	8183	1.0	0.0	0.0	0.0	0.00	65	65	9.45	18.7	5.03	32491	36.0
2	6518	6518	0.0	0.9	0.1	1.0	0.00	65	65	9.49	19.6	5.31	30261	36.9
3	6714	6714	0.0	0.0	1.0	0.0	0.00	65	65	9.07	18.1	4.70	33356	24.9
4	5077	5077	0.0	1.0	0.0	0.0	0.00	65	65	10.29	18.9	4.83	29583	32.6
5	7706	7706	1.0	0.0	0.0	0.0	0.09	70	70	9.05	17.9	5.98	33975	25.3
6	7132	7132	0.0	0.9	0.1	1.0	0.00	70	70	8.87	20.2	6.32	32284	36.5
7	7521	7521	0.0	0.0	1.0	0.0	0.00	70	70	8.91	20.6	5.97	24192	39.0
8	4289	4289	0.0	1.0	0.0	0.0	0.00	70	70	8.88	19.9	5.03	32604	29.9
9	7224	7224	1.0	0.0	0.0	0.0	1.00	76	76	7.84	18.9	5.13	32761	33.9
10	7033	7033	0.0	0.9	0.1	1.0	1.00	76	76	8.12	20.4	6.74	29238	41.0
11	5593	5593	0.0	0.0	1.0	0.0	1.00	76	76	7.41	20.1	5.24	25995	31.4
12	3921	3921	0.0	1.0	0.0	0.0	1.00	76	76	8.65	20.5	5.16	30237	42.0
13	4000	4000	1.0	0.0	0.0	0.0	0.00	65	65	9.54	18.8	4.97	67000	37.0
14	4000	4000	1.0	0.0	0.0	0.0	0.09	70	70	9.20	18.9	4.97	67000	25.0
15	4000	4000	1.0	0.0	0.0	0.0	1.00	76	76	8.12	19.9	5.07	67000	28.3

SOURCE: HUD.

NOTE: Logarithms of the LNTHI, ETHI, LNSTAY, LNROOMS, and LNVALU variables were calculated after the values listed here were entered into the computer. The values for ESINGFML and ESINGMAL for other elderly (OTHER = 1) households are averages obtained from HASE baseline survey data.