

The Demand For Housing Capital Expenditures By The Elderly

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Preservation of the existing housing stock has become increasingly important in both national and local housing objectives. This article reports on a study of housing capital expenditures made by a sample of elderly homeowners in Tompkins County, New York. A two stage consumer decision model is used to examine the effects of demographic, income, home asset, and dwelling unit factors on the probability of an elderly household making a housing capital expenditure and, for those who made such expenditures, on the amount of housing capital expenditures. It is found that lump sum income and elderly households who rent out part of their home are positively related to the probability of making housing capital expenditures, while wage income, business income, and households with some college education are positively related to the amount of housing capital expenditures.

Expenditures on housing capital projects, here defined to include maintenance, repairs, and improvements, is a sizable amount, reaching \$42 billion in 1979 (U. S. Bureau of the Census, 1980). Since an above average percentage of elderly households own homes, the importance of housing as an asset to the elderly makes the size of their housing capital expenditure a significant decision.¹

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Previous research has not been conclusive with respect to factors related to housing capital expenditures. Meeks and Firebaugh (1974) separately examined the determinants of home maintenance expenditures and home improvement expenditures. They found the degree of the owner's maintenance skill and the owner's time available for home maintenance to be positively related to the amount of home maintenance expenditures, while the degree of the owner's home improvement skills was positively related to the amount of home improvement expenditures. The owner's income was not found to be significantly related to either activity. Winger (1973) examined two data sets in investigating the determinants of housing capital expenditures. Using an FHA data set for metropolitan areas, Winger found average dwelling unit size and the proportion of dwellings with septic tanks in a metropolitan area to be positively related to estimates of housing capital ex-

penditures. The second data set contained observations on individual homeowners. Here Winger found household heads with some college education, middle aged (ages 45-54) household heads, and household income to be positively related to improvement and repair expenditures. Controlling for income and education, the very young (25-34) and the very old (age greater than 65) household heads were found to spend less on home improvements and repairs.

This paper reports the results of a study of housing capital expenditures made by a sample of elderly homeowners in Tompkins County, New York. The study focuses on the impacts of household income on housing capital expenditures. One possible explanation for the inconsistent results in previous studies regarding income is that the impact of income may vary by the income source. This possibility is explored in the study. Following Morris and Winter (1978), housing capital expenditures are regarded as investments which adjust the actual level of the owner's housing stock (a combination of quality and quantity characteristics) toward the household's desired level of the stock. Part I of the paper presents the model used to investigate this conception of housing capital expenditures. Part II discusses the data and variables used in the empirical model. The statistical method is discussed in Part III, findings are analyzed in Part IV, and conclusions are offered in Part V.

Model

In this analysis, the elderly household is viewed as considering its housing stock as one element in its portfolio of assets, other elements being, for example, savings account holdings, holdings of stocks and bonds, commercial business investments, and other property holdings. Capital expenditures on housing are made in order to equalize the household's actual level of housing stock to the desired level of housing stock. Capital expenditures on housing may also be stimulated by differences in the desired and actual levels of

other assets, the direction of the relationship depending on whether housing and each other asset are complementary or competitive in the household's portfolio. For example, an increase in desired silver holdings kept at home may stimulate physical improvements in the house related to security. In contrast, an increase in desired commercial business investments may reduce the level of the desired housing stock and housing capital expenditures if housing and commercial business investments are competing assets. In addition, capital expenditures on housing are positively related to the amount of unexpected, or transitory, income received by the household and to depreciation in the dwelling (replacement demand).

Given this perspective, the demand for capital expenditures on housing can be analyzed with two possible models. One model assumes that a capital expenditure is made anytime a difference occurs between the desired and actual housing stocks, between the desired and actual stocks of related assets, or when changes occur in transitory income or replacement demand (Tobin, 1958). The major criticism of this model is that it assumes households are able to continuously adjust their stocks anytime a change occurs in the aforementioned factors. An alternative model states that the housing capital expenditure decision is made in two stages (De-Min Wu, 1965). First, the household decides whether to make an expenditure. The probability of making a housing capital expenditure is related to the size of the gap between the desired and actual housing stocks, the desired and actual stocks of related assets, changes in transitory income, and changes in replacement demand. Second, given a decision to make an expenditure, the amount of housing capital expenditure is also related to the same factors. Due to the less restrictive nature of the two stage decision model, it is used in the analysis.

If observations on the desired levels of the housing stock and other assets are unavailable, the probability of making a housing capital expenditure and, given such a decision, the size of

the housing capital expenditure can each be expressed as a function of demographic characteristics, incomes by type, housing asset characteristics, and structural characteristics of the dwelling (see Appendix):

For household i ,

$$E(Q) = P_i = F(D_i, Y_i, HA_i, S_i),$$

$q = G(D_i, Y_i, HA_i, S_i)$, given $Q = 1$, where:

Q is a random variable taking value 1 with probability P_i and taking value 0 with probability $(1-P_i)$, P_i is the probability of making a housing capital expenditure, E is the mathematical expectation operator, q_i is the size of the housing capital expenditure given the expenditure is undertaken, D_i 's are demographic characteristics, Y_i 's are incomes by type, HA_i 's are housing asset characteristics, and S_i 's are structural characteristics of the dwelling.

Demographic characteristics are expected to influence how elderly households evaluate the benefits and costs of housing capital expenditures. As the elderly household ages and perceives a shorter time horizon, it will likely assign lower benefits to any given expenditure on a durable good such as housing. Therefore, age of the elderly household is expected to be negatively related to the probability of making housing capital expenditures. However, once the elderly household decides to make housing capital expenditures, age may have a different effect on the amount of expenditures made. Although age will also be negatively related to the amount of expenditures due to the shorter time horizons of older elderly households, age should also be positively related to expenditure if age is negatively correlated to the physical capabilities of the elderly homeowner to make housing capital changes. That is, as age increases the elderly household may make greater expenditures for given housing capital jobs because the household is less able to substitute its labor for capital expenditures. Therefore, although the sign of the relationship between age and amount of expenditures cannot be hypothesized, it is expected that the effect of age on the amount of expenditures will be greater

(more positive) than age's effect on the probability of making the expenditure.

Married elderly households may perceive a greater benefit from housing capital expenditures due to the possibility of willing (leaving) the dwelling to a surviving spouse (the bequest motive). Therefore, married elderly households should be associated with both a higher probability of making housing capital expenditures and with greater amounts of such expenditures. Elderly households with more education probably perceive both greater benefits and lower costs to housing capital projects than less educated elderly households. On the benefits side, elderly households with more education likely have longer time horizons and therefore perceive greater benefits from any given housing capital expenditure. On the costs side, elderly households with more education may be more knowledgeable about home maintenance, repair, and improvement procedures and contractors. This would tend to make them more efficient about undertaking any given housing capital project, hence reducing its costs and increasing its net benefits. Thus, elderly households with more education should be positively related to both the probability of making and the amount of housing capital expenditures.

The presence of an unmarried adult child in the household should increase the bequest motive and could decrease the cost of housing capital projects by contributing physical resources. Hence, the presence of an unmarried adult child in the household is expected to be associated with a higher probability of making housing capital expenditures and with greater amounts of such expenditures. Length of residence may also influence the household's perceptions of benefits and costs associated with housing capital jobs. Previous research has found a positive correlation between length of residence and the propensity to remain at the residence (Morris and Winter, 1978:160). This suggests that, controlling for all other relevant factors, households who have lived longer at their residence may perceive a longer future time period to derive benefits from any

given housing capital expenditure. This would make length of residence associated with a higher probability of making housing capital expenditures and with greater amounts of such expenditures.

Incomes generate multiple effects on the demand for housing capital expenditures. Changes in the permanent components of incomes have a direct effect and a set of indirect effects on housing capital expenditures (see Appendix). The direct effect of permanent incomes on housing capital expenditures is positive. However, permanent incomes are also positively related to adjustments in other assets of the household's portfolio, which produce a set of indirect effects on the adjustment in the housing stock. These indirect effects are positive for assets complementary with housing and negative for assets competitive with housing. Under the assumption that unexpected, or transitory, income is invested, the transitory components of incomes are positively related to both the probability of making housing capital expenditures and the amount of housing capital expenditures (Darby, 1972).

When the income types cannot be separated into permanent and transitory components, the effect of each income type on housing capital expenditures will be determined by the size and sign of its components. Since part of permanent income is consumed and part is invested, only the latter fraction is relevant to housing capital expenditures. Therefore, nonasset incomes which are primarily permanent (e.g., retirement income) are expected to have smaller effects (smaller coefficients) than nonasset incomes having both permanent and transitory components (e.g., wage income), although the sign of each coefficient cannot be predicted *a priori*. Nonasset incomes which are largely transitory (e.g., monetary gifts and settlements) are expected to have the largest positive effects among nonasset incomes on both the probability of making and the amount of housing capital expenditures.

Among asset incomes, interest income will have dominant permanent income effects if hou-

seholds plan their savings accounts and bond holdings as sources of permanent return or emergency income. Its effects on both the probability of making and the amount of housing capital expenditures will be zero if interest income's contribution to the adjustment of competing asset stocks counteracts its contribution to the adjustment of housing. Dividends from stocks and investment funds and income from business investments are returns from more speculative assets, and therefore their transitory component should be more important. The larger transitory component should make the effects of dividend and business income on the probability of making and the amount of housing capital expenditures larger (more positive) than the effects of interest income, although the signs of the effects cannot be determined *a priori*. Rental income from the dwelling has both permanent income and transitory income components. Again, the transitory component is positively related to both housing capital expenditure decisions, but the permanent component has both positive direct effects and negative indirect effects. The sign of the relationship of rental income to the housing capital expenditure decisions is not determinable *a priori*.

The household's equity in the dwelling measures its stock of the housing asset. Housing equity influences the housing capital expenditure decisions in two opposite ways. For any given rate of depreciation, the greater the housing equity, the greater the depreciation in the asset. Hence, housing equity is expected to be positively related to both the probability of making and the amount of housing capital expenditures through replacement demand. Conversely, housing equity will be negatively related to both of these housing capital expenditure decisions via the "stock effect" (Phlips, 1974:172 and the Appendix). Controlling for replacement demand, the greater the housing stock the less the need for the household to increase the stock via capital expenditures. The effect of housing equity on either housing capital expenditure decision will therefore depend on the

size of the two opposing effects and hence cannot be established *a priori*.

Structural characteristics of the dwelling are included as indicators of depreciation in the dwelling. It is expected that larger dwellings, dwellings in poorer condition, and dwellings in which the elderly owner rents units to tenants or boarders, undergo greater absolute depreciation and hence require more frequent and greater housing capital expenditures.

Data and Variables

Data in the study are a subset of a 1974 survey of elderly persons in Tompkins County, New York (Daniels, 1976). The subset consists of 118 elderly (over 60 years of age) homeowners. Housing capital expenditures are defined as interior or exterior repairs, maintenance, improvements, or additions to the dwelling made by the owner.

Demographic variables include age of the household head, a dummy variable indicating household heads with more than twelve years of education,² a dummy variable indicating a married household, a dummy variable indicating the presence of an unmarried adult child in the household, and length of residence at the dwelling.

Yearly income is divided into seven sources. Retirement income comprises social security, pensions, and other retirement fund payments. Wage income includes wages, salaries, and commissions. Lump sum income is defined as monetary gifts from children or relatives, and monetary settlements. Business income covers returns from businesses, professional practices, partnerships, and property investments other than rent from the household's home. Interest income comprises returns from savings accounts and bond holdings, and dividends are returns from stocks, mutual funds, and investment clubs. Rental income is income from boarders, roomers, and tenants for elderly homeowners who rented out part of their dwelling or other dwellings. Unfortunately, the survey data did not permit complete separation of rental income derived from the

dwelling in which the household lived, from rental income derived from other dwellings. The size of any property tax reduction (veterans or old age exemptions) is also included with the income variables. A property tax reduction increases the attractiveness of housing as an investment, and therefore is expected to be positively related to both the probability of making and the amount of housing capital expenditures.

The household's estimate of the market value of the dwelling and the outstanding mortgage at the start of the period measure home equity. Structural characteristics of the dwelling are represented by number of rooms and a dummy variable indicating if part of the dwelling was rented to other persons. Neither an explicit quality measure nor age of the dwelling, which is generally negatively correlated with quality, were available from the survey.

Method

Multivariate probit analysis is used to estimate the parameters of the variables influencing the probability of making housing capital expenditures. The technique is applicable to equations with dependent variables having values of zero and one. Ordinary least squares is inadequate because the error terms are heteroscedastic and predicted values are not limited to a zero to one range (Finney, 1952).

The probit model assumes that the probability of observing a response (e.g., making housing capital expenditures) follows a normal distribution:

$$P = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{I^* = B_0 + \sum_i B_i} e^{-\frac{1}{2}u^2} du$$

where I^* is the level of probit index. The index is defined by a linear combination of observed variables (e.g., $I = B_0 + B_1D_i + B_2Y_i + B_3HA_i + B_4S_i$). The statistical task is to estimate the B_i parameters. The index I and the probability P are unobserved, but the response or nonresponse of each observa-

tion is observed. If it is assumed that the probabilities of the observations are statistically independent of each other, then a likelihood function can be defined as the product of the probabilities:

$$L = \prod_{t=1}^T P^{R_t} (1-P)^{1-R_t}$$

where: $R_t = 1$ if a response is observed (e.g., made housing capital expenditures),
 $R_t = 0$ if a nonresponse is observed (e.g., didn't make housing capital expenditures),
and P is the probability defined above.

An iterative technique is used to solve for the parameters (Gladhart, Mount, and Seaman, 1976; Tobin, 1955).

The probit coefficients (B_i) have little intuitive meaning because they correspond to the I function. To find the effect of each independent continuous variable on the probability of making housing capital expenditures, the following equation is solved:

$$\frac{dP}{dX_i} = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}T^2} B_i \left(B_i = \frac{dI}{dX_i} \right) \text{ (Seaman, 1976).}$$

Effects of the dummy variables are calculated as the difference between the mean probability when the characteristic is present (dummy variable = 1) and when the characteristic is absent (dummy variable = 0). These effects are comparable in interpretation to multiple regression coefficients, with the exception that they differ for different values of the independent variables.

The significance of the probit equation is evaluated by a likelihood ratio test with N (number of independent variables) degrees of freedom. The test statistic has a Chi-square distribution.

Given a decision to make housing capital expenditures, the second decision is the amount of the expenditure. For those elderly households in the sample who made housing capital expendi-

tures, the amount of the expenditure is analyzed with a standard multiple regression model.

Findings

Table 1 presents estimated coefficients for variables related to the probability of making housing capital expenditures and, given the decision to make such expenditures, related to the amount of housing capital expenditures.³ Marginal effects of the continuous variables in the probability of making housing capital expenditures equation were computed at the mean of the continuous variables and the modal group of the dummy variables.⁴ Marginal effects of the dummy variables were computed with all other variables set at their mean or modal group value.

Demographic Variables

As expected, head's age is negatively related to the probability of making housing capital expenditures. The marginal effect indicates that the probability decreases by two percentage points with a year's increase in age from the mean. In contrast, head's age has a positive estimated coefficient in the amount of expenditures equation, but the coefficient is not significant at the 10 percent level (two-tail test). However, this result conforms to the hypothesis that older elderly households undertaking housing capital expenditures may make greater expenditures due to their weaker physical condition. Additionally, if the head's age is correlated with the age of the dwelling, its coefficient will include some of the effects of the structure's age on the amount of housing capital expenditures.

Marital status is not significantly related to either housing capital expenditure decision. The education variable's coefficient is positive in both equations, as expected, but is significant only in the amount of expenditure equation. The estimated coefficients for the presence of an unmarried adult child and for length of residence are positive, as hypothesized, in both equations, but

Table 1. — Housing Capital Expenditure

| Dependent Variable: | Decision 1 1 if housing capital expenditures 0 if no housing capital expenditures | | | Decision 2 Amount of housing capital expenditures (OO's) | |
|---|---|----------------------|----------------------|---|----------------------|
| | Probit Coefficient | z-ratio ¹ | Marginal effect | Regression Coefficient | t-ratio ¹ |
| Head's Age | -0.053 | -1.780* | -0.02024 | 0.278 | 1.452 |
| 1 if Married | 0.014 | 0.044 | 0.00523 | -0.987 | -0.529 |
| 1 if Head's Educ. >12 years | 0.317 | 0.704 | 0.11387 | 6.137 | 2.785** |
| 1 if Unmarried Adult Child Present | 0.449 | 0.959 | 0.15579 | 2.713 | 1.044 |
| Length of Residence | 0.009 | 0.849 | 0.00349 | 0.064 | 1.056 |
| Retirement Income (000's) | 0.011 | 0.531 | 0.00410 | -0.030 | -0.345 |
| Wage Income (000's) | 0.071 | 1.360 | 0.02717 | 0.289 | 2.001* |
| Lump Sum Income (000's) | 1.051 | 2.328* | 0.40207 | -0.086 | -0.407 |
| Business Income (000's) | -0.263 | -2.019* | -0.10041 | 1.597 | 1.918** |
| Interest Income (000's) | 0.021 | 0.201 | 0.00809 | 0.010 | 0.019 |
| Dividend Income (000's) | -0.004 | -0.075 | -0.00170 | 0.425 | 1.417 |
| Rental Income (000's) | -0.476 | -1.744** | -0.18189 | 2.436 | 1.616 |
| Prop. Tax Reduction (000's) | 0.042 | 1.232 | 0.01610 | -0.015 | -0.189 |
| Market Value (000's) | 0.019 | 1.503 | 0.00745 | -0.136 | -2.123* |
| Outstanding Mortgage (000's) | -0.006 | -0.203 | -0.00246 | 0.091 | 0.512 |
| Number of Rooms 1 if Rented Part of House | 0.021 | 0.265 | 0.00805 | -0.300 | -0.641 |
| Constant | 1.611 | 2.848** | 0.35689 | -2.492 | -0.953 |
| | 2.745 | | | -14.271 | |
| -2 log likelihood ratio | | | \bar{R}^2 0.167 | | |
| | 40.549**, 17 df. | | F 1.896*, 17, 59 df. | | |
| Sample Size | 118 | | Sample Size 77 | | |

**Significant at 1 percent level

*Significant at 5 percent level

**Significant at 10 percent level

¹Two-tail statistical tests of significance are applied to the coefficients of retirement income, wage income, lump sum income, business income, interest income, dividend income, rental income, market value, and outstanding mortgage amount in both decision equations and to head's age in the second decision equation.

none of the coefficients are significantly different from zero.

Income Variables

The results for nonasset income effects on the probability of making housing capital expenditures conform to, but do not in all cases statistically support, the hypotheses for these variables. Lump sum income, predominantly transitory, has the strongest positive relationship to the probability of making housing capital expenditures. The probability of making such expenditures increases by 40 percentage points with a \$1,000 increase from the mean in lump sum income. The coefficients of wage income and retirement income, although not significant at the ten percent level (two-tail test), rank second and third respectively among nonasset incomes in their influence on the probability of investing in upkeep. In the amount of housing capital expenditures equation, however, only wages among the three nonasset incomes has a significant effect, which is positive.

Among the asset incomes, the negative and significant (two-tail test) coefficient of business income in decision one (the probability of making housing capital expenditures) implies that business investments are competitive with housing when the decision whether to make housing capital expenditures is contemplated. The significant positive coefficient of business income in decision two (the amount of housing capital expenditure) indicates that these competitive effects are submerged after the household has decided to make housing capital expenditures and is deciding on the amount of expenditure to make. As hypothesized, the small coefficients (not statistically different from zero) for interest income support the idea that interest income's contribution to the adjustment of competing assets counteracts its contribution to the adjustment in the housing stock. Apparently, the same phenomenon happens with dividend income.

Rental income has a significant (two-tail test) negative coefficient in decision one and a posi-

tive, although nonsignificant, coefficient in decision two.⁵ Three explanations are offered for the former result. First, the negative indirect effects associated with rental income's contribution to the adjustment of competing assets may dominate the effect in decision one. Second, since we were not able to measure rental income exclusively from the elderly's occupied dwelling, the negative coefficient may result from strong competitive effects of investments in other rental structures when the decision to make capital expenditures in the owner's dwelling is considered. Third, rental income, controlling for size of the structure, may be positively correlated with dwelling unit condition. The negative coefficient could then reflect the expected negative relationship between dwelling unit condition and the probability of making housing capital expenditures.

The size of a property tax reduction received by the owner was expected to be positively related to both housing capital expenditure decisions by making housing a more attractive asset in comparison to other assets. The estimated coefficient of the property tax reduction is positive, but not statistically significant, for the decision to make housing capital expenditures. The coefficient is negative but not statistically different from zero in the second decision.

Home Asset Variables

The significant (two-tail test) negative coefficient of market value in the decision two equation (the amount of housing capital expenditure) suggests that the negative stock effect is dominant when the amount of expenditures is considered. Countering effects of replacement demand and the stock effect in the decision whether to make housing capital expenditures can explain the nonsignificant coefficient of market value in decision one. The coefficient of outstanding home mortgage at the start of the period is not significant in either decision equation. Only fourteen of the households, however, held a home mortgage.

Structural Variables of the Dwelling

As hypothesized, dwellings in which the elderly owner rents units are positively related to the probability of making housing capital expenditures. In contrast, this variable has a negative but nonsignificant effect on the amount of upkeep expenditures. The coefficient of number of rooms is not significantly different from zero in either decision equation.

Conclusion

The complexities of the relationships between demographic, income, home asset, and structural characteristics of the dwelling and the elderly household's housing capital expenditure decisions are revealed by the analysis. In particular, it was found that the effect of income varies by the type of income and by the type of decision. This may explain the inconsistent results of previous studies regarding the impact of income on housing capital expenditure decisions. Increases in lump sum income and renting out part of the home increase the elderly household's probability of making housing capital expenditures, while increases in the household head's age, business income, and rental income decrease the probability. Wage income and business income, and having some college education are positively related to the amount of housing capital expenditures, while market value of the house is negatively related to the amount of housing capital expenditures. Two variables that policy makers can manipulate are retirement income (through Social Security) and property taxes. It is noteworthy that neither of these variables was found to have a statistically significant effect on either housing capital expenditure decision.

The statistically significant negative coefficient of business income in the decision of whether to make a housing capital expenditure is evidence that the decision to undertake such projects is considered in competition with other investments. Once the decision to make such expendi-

tures is made, however, the competitiveness of other assets may be reduced, as indicated by business income's statistically significant positive coefficient in decision two. It also appears that income sources which may stimulate the housing capital investment decision (lump sum income) have little impact on the amount of such expenditures. Instead, the household turns to other sources of income (wages, business income) to finance the project.

Notes

1. In 1977, 70.7 percent of household heads 65 years of age and older were homeowners as compared to 64.8 percent of all household heads (U.S. Bureau of the Census, 1977).
2. The head's education was also entered as a continuous variable, but this form had no statistically significant relationship to either housing capital expenditure decision.
3. Although the probit model is a nonlinear relationship, the specification of the index can incorporate any of the standard variable transformations. The first equation was estimated with linear and logarithmic forms of the independent continuous variables. The estimation with linear relations had a higher level of significance and is the form reported. Four forms of the second equation were calculated — linear, semi-logarithmic, double logarithmic, and inverse semi-logarithmic. The linear form provided a better "fit" to the data and is also the form reported.
4. The modal groups of the dummy variable are married, education twelve years or less, no unmarried adult child present, and did not rent out part of the dwelling.
5. A moderately high correlation existed between rental income and the dummy variable indicating if the household rented out part of the dwelling (0.66 in equation one, 0.67 in equation two). In equation one (the probability of making housing capital expenditures) this collinearity was not a statistical problem because both variables had significant coefficients (Johnston, J. 1972:163). In equation two (the amount of housing capital expenditures) the rental dummy variable was not significant, so the equation was rerun twice, first omitting rental income and then omitting the dummy rental variable. The results did not change. With rental income omitted, the dummy variable remained nonsignificant, and with the dummy rental variable omitted, rental income remained significantly positive. Thus, the collinearity was not considered a statistical problem in equation two.

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APPENDIX: Income Effects In a Stock Adjustment Model

The following formulation is developed from Bryant (1976), De-Min Wu (1965), and Motley (1970).

Consider three assets, housing, X_1 , and two other assets, X_2 and X_3 . The desired stock of each asset, X^*_i , is an ordinary neoclassical demand function, a function of expected rates of return of each asset, R_{ei} , permanent income, Y_p , and a vector of demographic characteristics, D :

$$(1) X^*_i = \gamma_{i0} + \gamma_{i1}R_{e1}^e + \gamma_{i2}R_{e2}^e + \gamma_{i3}R_{e3}^e + \eta_i Y^p$$

The probability of making capital expenditures on housing, P_1 , is a function of the gap between the desired and actual stock of housing, $X^*_1 - X_1$, the gap between the desired and actual stocks of other assets, replacement demand in housing, d_1 , and transitory income, Y^t :

$$(2) P_1 = \alpha_{11}(X^*_1 - X_1) + \alpha_{12}(X^*_2 - X_2) + \alpha_{13}(X^*_3 - X_3) + \lambda_1 d_1 + \mu_1 Y^t$$

where α_{ij} are adjustment rates, α_{ii} is the own adjustment rate, $0 < \alpha_{ii} < 1$; and $\alpha_{ij}(i \neq j)$ is the

cross adjustment rate, $\alpha_{ij} \geq 0$ depending on whether i and j are complementary, independent, or competitive assets.

Divide permanent income into permanent incomes from each asset, Y_i^p , and permanent income from nonasset sources, Y_n^p , and substitute (1) for each asset in (2). The probability of making capital expenditures on housing can then be expressed as:

$$\begin{aligned} (3) P_1 = & \alpha_{11}\gamma_{10} + \alpha_{12}\gamma_{20} + \alpha_{13}\gamma_{30} + (\alpha_{11}\gamma_{11} + \alpha_{12}\gamma_{21} + \alpha_{13}\gamma_{31}) R_1^e \\ & + (\alpha_{11}\gamma_{12} + \alpha_{12}\gamma_{22} + \alpha_{13}\gamma_{32}) R_2^e + (\alpha_{11}\gamma_{13} + \alpha_{12}\gamma_{23} + \alpha_{13}\gamma_{33}) R_3^e \\ & + (\alpha_{11}\eta_{11} + \alpha_{12}\eta_{21} + \alpha_{13}\eta_{31}) Y_1^p + \nu_{11} Y_1^t \\ & + (\alpha_{11}\eta_{12} + \alpha_{12}\eta_{22} + \alpha_{13}\eta_{32}) Y_2^p + \nu_{12} Y_2^t \\ & + (\alpha_{11}\eta_{13} + \alpha_{12}\eta_{23} + \alpha_{13}\eta_{33}) Y_3^p + \nu_{13} Y_3^t \\ & + (\alpha_{11}\eta_{1n} + \alpha_{12}\eta_{2n} + \alpha_{13}\eta_{3n}) Y_n^p + \nu_{1n} Y_n^t \\ & - \alpha_{11}X_1 - \alpha_{12}X_2 - \alpha_{13}X_3 + \lambda_1 d_1 \end{aligned}$$

where γ_{ij} is the effect of asset j 's expected rate of return on the desired stock of asset i , η_{ij} is the effect of permanent income from asset j on the desired stock of asset i ($\eta_{ij} > 0$), η_{in} is the effect of

nonasset permanent income on the desired stock of asset i , ($\eta_{in} > 0$), and μ_1 is the effect of transitory income on the probability of making capital expenditures on housing ($\mu_1 > 0$). The terms " $-\alpha_{11}X_1$ ", " $-\alpha_{12}X_2$ ", and " $-\alpha_{13}X_3$ " are the stock effects of each asset. The own stock effect, " $-\alpha_{11}X_1$ " is unambiguously negative. Replacement demand has a positive effect on the probability of making housing capital expenditures ($\kappa_1 > 0$).

If it is assumed that the expected rates of return, R_i^e , are constant for the households considered, then these terms are incorporated into the constant term ($\alpha_{11}\gamma_{10} + \alpha_{12}\gamma_{20} + \alpha_{13}\gamma_{30}$). Furthermore, if each income type cannot be divided into permanent and transitory components, then the effect of each type will depend on the size and sign of its components. If, for example, housing and assets X_2 and X_3 are competing, α_{12} and α_{13} are < 0 and the terms $\alpha_{12}\eta_{ij}$, $\alpha_{13}\eta_{ij}$, $i=2,3$, $\alpha_{12}\eta_{2n}$, and $\alpha_{13}\eta_{3n}$ are negative indirect permanent income effects attributed to the contribution of the incomes to the adjustment in assets X_2 and X_3 .

A similar development can be formulated for the size of the housing capital expenditure.