The Relation Between Financial and Housing Wealth of Dutch Households

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by

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Abstract

We analyze households' joint investment decisions for financial wealth and homes. In our bivariate censored regression model with endogenous switching, fixed costs or transaction costs are captured by a threshold that has to be passed before the purchase. The model allows for spill–over effects of a binding threshold for one asset on the demand for the other asset. We find that tenure choice affects the level of financial wealth. Our results do not support the view that people first accumulate financial wealth before acquiring homes. This can be due to the absence of down payment constraints in the Netherlands.

Keywords: housing demand, household saving, portfolio choice, limited dependent variables

JEL classification: *C34, D12, G11, R21*

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1 Introduction

Housing wealth is the most important asset in households' portfolios, both for homeowners and in total, across all age groups and in many countries.[1] Together with financial assets it forms the biggest group within bequeathable wealth. In this paper we investigate how the investment decisions for housing and financial wealth of households are interrelated.

This relationship is an important one to understand for various reasons: First of all, it might be the case that saving behavior of home owners differs from that for renters, and thus the home ownership rate might have implications for the aggregate saving rate as well. Moreover, house price developments will have not only an impact on the demand for housing but also affect financial wealth holdings; for instance, as has been stressed in the recent literature, down payment constraints can influence renters' decisions to save. But there is no reason to expect a one way causal relationship — financial and housing wealth are the joint outcomes of one decision process, and are therefore jointly determined. In this paper, we therefore allow for a simultaneous choice of investments. Clearly, as a substantial part of the wealth of home owners is held in the form of housing wealth, the home ownership decision and the amount of housing wealth will have an impact on the level and the structure of financial assets. Moreover, changes in returns to housing wealth or restrictions in the housing market may lead to spill–over effects on financial wealth holdings, but just as well, changes in the financial wealth market may affect the housing wealth decisions.

This shows that the two decisions should be modeled simultaneously. Theoretical models of this nature have been around since Henderson and Ioannides (1983). But in the empirical literature on household portfolio choice and home ownership and housing wealth, the joint nature of the decision has, to our knowledge, never been modeled explicitly.[2]

Analyzing a Dutch cross section data set drawn in 1988, we develop an empirical model explaining the joint determination of housing investment demand and financial wealth holdings. The model relates to the empirical literature on household portfolio choice.[3] More than half of the households in our sample are renters and thus do not hold any housing wealth. Also, many households report not to hold any financial wealth. We explicitly account for these zero financial and housing asset holdings in the econometric model. Hence, the model distinguishes several regimes, according to whether asset amounts are zero or not. It is similar to the demand system of Lee and Pitt (1986), which

[1] See, among others, Alessie et al. (1995) for the Netherlands, Banks and Blundell (1995) for the UK, Kessler and Wolff (1991) for France and the US, and Wolff (1994) for the US.

[2] Most of the empirical literature on housing focuses on consumption of housing services, and neglects the investment aspect. Papers which do consider housing investment usually treat it in isolation of other investment possibilities. An exception is Ioannides (1989), where housing wealth related variables are explained from non–housing wealth variables and vice versa, but without taking account of the endogeneity in either case.

[3] See, for instance, King and Leape (1987) or Ioannides (1989).

is characterized by different demand functions for each commodity, for the case that non-negativity constraints on demands for other commodities are binding or not. Here we allow for differences between the demand for financial wealth between home owners and renters, and between the demand for housing wealth of those who do and those who do not hold financial wealth. Endogeneity of the regime choice is accounted for by analyzing the bivariate model as a whole.

While the model of Lee and Pitt (1986) explains zero amounts from non–negativity constraints only, we allow for household specific thresholds which can be seen as minimum amounts of assets held. If the optimal amount is lower than the threshold, the amount actually held will be zero. The thresholds can be interpreted as reflecting fixed (transaction) costs. We estimate the model separately for gross asset amounts and for equity, i.e. amounts net of debts.

The relation between financial and housing wealth has gained attention in the recent literature to assess the relevance of down payment constraints for households' saving behavior (Engelhardt (1994, 1996), Haurin et al. (1996) and Sheiner (1995)). It has been argued that due to such constraints higher house prices induce those households who have a desire to own a house to save more in the year(s) prior to homebuying in order to meet that down payment constraint. Our findings do not support this, which may reflect the absence of effective down payment constraints in the Netherlands: our estimated age polynomial implies that the prime home–buying years are roughly between 20 and 40 of age. Comparing age patterns for home ownership and financial wealth holdings, we find no evidence that younger households hold high amounts of financial wealth at ages before they typically would buy a home. We also find that renters possess fewer financial resources than homeowners. As house prices rise, financial wealth holdings of renters decrease (while the number of renters increases). If renters were saving to buy a house, we would expect the reverse relation.

The interaction effects in the model imply that the demand for financial wealth of home owners differs significantly from that of renters. Simulations show that lowering the threshold for housing wealth, which can be interpreted as liberalizing the mortgage market, decreases the financial wealth ownership rate but increases the level of financial wealth, conditional upon ownership. Again, the saving for the down payment story cannot explain this. First, it would imply that lower thresholds would lead to higher financial wealth ownership rates since fewer people are discouraged from accumulating financial assets for buying a house in the future. Second, for those who do accumulate financial assets, the required level would decrease instead of increase.

The remainder of the paper is organized as follows. In Section 2 we briefly sketch the organization of the Dutch housing market, which differs substantially from that in other countries. In Section 3 we summarize our data and present some simple estimates showing that asset holdings of home owners differ substantially from those of renters, even after controlling for wealth and other variables. Section 4 sketches a theoretical model for the joint determination of financial and housing investment along the lines of Henderson and Ioannides (1983). We introduce our empirical model in Section 5. Results are presented in Section 6. Section 7 discusses model implications as estimated parameter values are changed. Section 8 concludes.

2 Institutional Settings: the Housing Market in the Netherlands

The housing market in the Netherlands is characterized by a large fraction of renters, most of whom live in rent–regulated housing. In international perspective, the homeownership rate is comparatively low. In 1990, about 45% of all households lived in their own home, compared to an EC average of 62%,[4] and 64% in the US.[5] The owner–occupied sector increased considerably during the last decade. Main supplier of rental accommodation is the non–profit sector with a share of 77%. Private ownership of rental housing is frequently indirect via institutional investors (43% of privately owned rental dwellings). Only 13% of all rental dwellings are directly owned by private persons.

The housing market is strongly influenced by government policy, both directly in terms of provision of dwellings via municipal housing associations, and indirectly via incentives schemes (taxation and subsidies). Dwellings built by municipal housing associations served to buffer fluctuations in the private market. In the past decade, however, housing associations have become more independent or were privatized, and subsidies have been cut back (see Van der Krabben (1995) on this issue and for a recent survey of the structure of the Dutch housing market).

The large share of housing wealth in owner–occupiers' bequeathable wealth implies that the overall wealth position of owners depends critically on house prices. Both capital appreciation and depreciation can be substantial (Poterba (1991), Holmans (1994)). Figure 1 shows that average real house prices in the period 1965–1990 in the Netherlands have been quite volatile. Between 1976 and 1978 they surged by 52%. and fell by 38% from 1979 to 1982. They remained at a low level until 1985 and have been increasing since 1986.[6]

[4]1991; average of home ownership rates in 12 EC countries (excl. former East Germany), weighted by total dwelling stock; source: European Commission.

[5]1989; cf. Holmans (1994).

[6]Mankiw and Weil (1989, with discussion) have initiated a debate in the U.S. literature, focusing on the question whether house prices are forecastable from overall demographic trends and whether these changes are in fact anticipated by current homeowners (cf. also Poterba (1991), and Hoynes and McFadden (1994)). This is particularly relevant in the presence of volatile house prices. House price changes might to some extent be forecastable from long–run demographic developments, and yet households might not re–adjust their portfolios and rather not downsize their housing wealth when they age. If this is the case,

figure 1 about here

An important determinant of housing demand and of house prices is the development of household size and composition. Individual demand for housing (persons per room) tends to increase over time,[7] and average household size is shrinking (inhabitants per dwelling; see figure 2). According to CBS (1994), the number of households will rise one–and–a–half times as fast as the number of inhabitants in the country in the next two decades. 70% of this increase is accounted for by the expected rise in the number of single person households.

figure 2 about here

House prices are affected by construction costs and after–tax costs of home ownership (Poterba (1991)). Building costs for dwellings have risen sharply in the 1980s. One of the reasons was the comparatively low rate of technological progress in the home building sector. In addition, rising environmental concerns which will raise the costs of land development are likely to become of importance (Van der Krabben (1995)).

There are no explicit down payment constraints in the Netherlands. Prospective home owners can obtain a mortgage loan covering 100% of the value of the house. Obtaining a mortgage loan is effectively restricted due to an income rule (determining the maximum debt servicing) and a wealth rule (determining the overall size of the mortgage loan). Home ownership is therefore positively related to income and the level of financial resources. Mortgage interest rates were at a minimum in 1988. In the same year, the number of newly registered mortgages reached a maximum (Van der Krabben (1995)).

User costs of homeownership depend also on the marginal tax rate faced by the household and on subsidies. The Netherlands have a progressive, broad–based income tax system. The marginal rate in 1988 as a function of taxable income is piece–wise constant in nine brackets. In addition there is a tax–free allowance depending on household composition. Capital gains (both realized and unrealized) are tax–exempt. Interest paid on mortgages and consumer credits is deductible from the income tax base. Since the return on housing as an asset mainly takes the form of capital gains, the tax rules make it attractive to invest in housing for households with a high marginal income tax rate. Apart from the income tax, there is a tax on housing property of about 0.28% of the value of the house per year on average, and a tax of 0.8% on financial and housing wealth exceeding Dfl. 95,000 for singles or Dfl. 120,000 for couples.[8] In addition, there are tax–free amounts

the question for current homeowners is whether they possess sufficient other financial resources to sustain their consumption level in old age if prices drop. The static nature of our analysis implies that we cannot explicitly address these features of the relation between financial and housing wealth.

[7]CBS (1995) publishes six numbers for the postwar period: 1947: 0.90, 1956: 0.80, 1971: 0.64, 1981: 0.57, 1985: 0.54, 1989: 0.51 persons per room.

[8]Only 60% of owner occupied housing wealth is taken into account.

on interest from savings and on dividend income (Dfl. 1000 each for individuals; Dfl. 2000 each for couples). Low income households have preferential access to the regulated rental sector and can benefit from subsidies.[9]

3 Data

The micro data we use in the analysis stem from a survey conducted in 1988 by a group of Dutch banks (Dutch Collective Bank Study, CBO). It comprises 10113 individuals in 3704 households. The survey is targeted at the financial structure of household and individual wealth and at the relationships between consumers and banks or other financial intermediaries. It is designed to be representative of the Dutch population in terms of socio–demographic characteristics. It appears to suffer from underreporting on asset amounts, as other household surveys. Yet, it resembles national figures on financial wealth better than comparable Dutch sources, in particular with respect to ownership rates (see Alessie et al. (1993)).

Questions were asked regarding ownership of single asset units, and conditional on ownership, amounts were asked. While nearly all households provided complete information on ownership, information regarding the amounts is often missing (see Table 3 below). Respondents were the head of household and other household members aged 18 and above. Since this paper deals with the structure of wealth on household level, the individual responses were aggregated by summing over all assets within each asset category and over all respondents per household. Due to either missing values or severe outliers in the explanatory variable on net monthly income, we had to discard 627 observations. Comparing statistics of the remaining 3077 observations with those from the full sample suggests that selection bias due to unobserved income is not a serious problem. The marginal income tax rate is constructed from income, family composition, and labor market status variables. Other background variables pertain to age and family structure, employment status, and a regional house price index. The latter is based on average regional selling prices of houses, provided by the Dutch Association of Real Estate Agents. We differentiated according to the type of dwelling and divided the regional prices by national averages.[10] An overview of the explanatory variables is given in Table 1.

table 1 about here

The questionnaire comprises detailed information on general financial behavior, saving accounts, checking accounts and credit cards, stocks, bonds, loans, mortgages, and insurances. Only information on transferable wealth has been requested. Pension and social

[9] see Koning (1995) for an analysis of rent–allowances and housing demand.

[10] Polinsky (1977) criticizes using regional or metropolitan price information and points at potential biases for estimated elasticities due to neglecting intraregional price variation. Empirically this criticism has found little support, however (cf. Polinsky (1979) and Polinsky and Ellwood (1979)).

security wealth cannot be recovered from the data. Moreover, there is no direct information on amounts in checking account balances, capital accumulation in life insurances, or values of major durables. Thus, total household wealth is not directly observable.

As far as housing wealth and housing consumption are concerned, we do not observe variables related to the quality or location of one's home. We can also not distinguish in our data between owner occupiers and landlords and have no information on rents paid by tenants or rental income received by landlords. These limitations lead us to focus on the portfolio allocation aspect rather than model housing consumption.

Housing equity is constructed as the difference between the self–reported value of the home and the outstanding mortgage debt. House values have been truncated from below at Dfl. 10,000 (set to missing otherwise); mortgages are truncated from below at Dfl. 100. For some types of mortgage, an outstanding debt was imputed using other mortgage information (127 observations).[11] Some negative values of housing equity were set to missing since they seemed implausibly high.[12]

For financial wealth we similarly consider financial assets and financial equity (financial assets net of liabilities; the latter excluding mortgage debt). Financial assets comprise saving accounts, time deposit accounts, saving certificates and certificates of deposit, shares in domestic and foreign companies, shares in investment funds, options, bonds, and mortgage bonds. To construct the equity variable, we subtracted the amount of liabilities. 15.7% of all households in the sample have financial debt as well as a positive amount on their saving account. Only 3.2% have financial debt and zero holdings in financial assets. Holding financial assets and liabilities is virtually uncorrelated (correlation coefficient of –0.012). Only 6.3% of all households hold stocks or bonds, most of them in combination with other, saving related assets.

Table 2 contains summary statistics of financial and housing wealth and equity (missing values excluded). The means suggest that housing wealth is more important for the aggregate composition of wealth than financial assets, in spite of the higher ownership rate for the latter. The distribution of financial assets is strongly skewed to the right. This suggests that a log transformation may be helpful to obtain an empirical model (with normally distributed errors) that fits the data. We shall come back to this in Section 6.

[11]This concerns life insurance and improved life insurance mortgages. For the former, the principal debt is paid off only at the end of the contract with the accumulated capital in a life insurance, without a close link between the life insurance capital and the mortgage debt. For the latter, the link is much closer, and the interest rate paid on the mortgage equals the interest rate received on accumulated capital. For both types the term 'outstanding mortgage debt' is strictly speaking not applicable. We imputed it from the data on principal, interest rate, and year of begin of the mortgage contract, under the assumption of a fixed interest rate (self reported) and a typical total pay–off period of 30 years. In this way, the amount of outstanding debt could be recovered for 127 out of 231 cases of this mortgage type. The remainder was set to missing.

[12]121 observations where the initial mortgage is more than 20% higher than the current value of the house.

table 2 about here

Nonparametric density estimates of the marginal distribution of the log transformed[13] endogenous variables on housing and financial wealth, excluding zero–observations, are provided in figure 3. While the distributions of the wealth variables are not far from normal, those of the equity variables are of a bimodal nature, with a large positive and a small negative mode.

figure 3 about here

Table 3 provides an overview of the numbers of positive, zero, and missing amounts for the wealth and equity variables. 88% of the households hold housing or financial wealth, 84% hold financial assets, 48% invest in residential real estate, 44% in both. For 19.6% of homeowners and 14.2% of financial equity owners, the amount is not observed. The numbers of missings are substantial, and ignoring them may seriously bias the results. We take account of this in the model in Section 5.

tables 3a/b about here

Figure 4 shows ownership rates as a function of age of the head of the household for financial assets, liabilities, homes, and mortgages.[14] The home ownership rate is highest in the age group 30 to 40. In this age class, almost all home owners also have a mortgage. Elderly households are less likely to hold mortgage debt, whereas home–ownership is still common. Old age groups do not seem to have completely liquidized housing equity.[15] Similarly, ownership of financial assets is frequent for all age groups, whereas the financial debt rate peaks at age 40 and is low for the elderly.

figure 4 about here

Figure 5 shows kernel regression estimates on age of the total value of the home, the total value of financial assets, home equity (ie. net of mortgages), and financial equity

[13]To be precise, throughout the paper we use the following sign preserving log transformation:

$$x \mapsto g(x) = \begin{cases} \log(x+1) & \text{if} \quad x \geq 0 \\ -\log(-x+1) & \text{if} \quad x < 0. \end{cases}$$

[14]The dots are the ownership rates for each separate age; the curves are obtained by smoothing these non–parametrically. The number of observations for advanced age groups is small; the non–parametric smoothers do not take account of this.

[15]We do not compare the *same* people over time as they age, but compare different cohorts at one point in time. The patterns reported here therefore do not necessarily reflect life cycle effects. Sheiner and Weil (1992) take account of cohort effects and find that 42% of households leave behind a house when they die.

(assets net of liabilities).[16] For the sample as a whole, housing wealth is hump–shaped with a maximum at age 45. In spite of this, the age pattern of housing is more or less flat for higher ages, corresponding to falling mortgage debts. The age patterns of housing wealth and equity of those with financial debts deviate substantially from those for the whole sample. Financial wealth and financial equity increase with age. In particular, older homeowners hold a sizable amount of financial wealth, as opposed to renters.[17] Among those with financial liabilities, older households have a positive financial equity position, indicating that they hold financial assets at the same time. Interesting as well is the apparent absence of saving for a down payment: we neither observe that young renters hold particularly high levels of financial wealth, nor that young homeowners hold comparatively low levels of financial assets.

figure 5 about here

Are homeowners different? Is the portfolio behavior of households who owner occupy different from that of renters, given total wealth? To answer this question, we estimate some (univariate) probit equations for ownership of various types of assets and debts, conditioning on home ownership, total wealth,[18] and some background variables. The asset types considered are short term savings (saving accounts), long term savings (time deposit accounts, saving certificates & certificates of deposit), life insurance contracts,[19] and stocks or bonds (shares in domestic and foreign companies, shares in investment funds, options, bonds and mortgage bonds). In addition, we model the number of assets held as ordinal probits, both including and excluding financial debt.[20]

table 4 about here

The estimates are displayed in Table 4. Homeowners tend to hold significantly more types of financial assets than renters, even after controlling for wealth and other characteristics. The homeownership dummy is significantly positive in most of the ownership equations, significantly negative in the equation for short term savings, and insignificant only in the stocks and bonds equation. Compared to that of renters, homeowners' investment behavior thus seems to be directed towards the long run. Given wealth, households

[16]Observations with zero holdings of the assets are included in the regressions. Excluded are observations for which the amount is missing.

[17]The age pattern for renters displays a minimum at around 47 and a maximum around 60. The standard errors are rather high, however; moreover, notice the scale in the picture.

[18]We replaced missing values of the total wealth variable by their predictions; otherwise, too many observations would have been lost to estimate the equations for long term savings.

[19]For life insurances we have the information on ownership, but not on amounts.

[20]The structure of household wealth on this aggregation level is as follows: disregarding financial debt, 43% of the 3077 households hold one and 40% hold two of the 4 financial asset types while 11% hold none; including financial debt, 9% hold none, 38% hold one, and 37% hold two of these types.

are free to choose whether they want to invest in housing or not. Therefore, it seems reasonable to assume that the two types of wealth are jointly determined, implying that the conditional regressions in Table 4 do not have structural interpretation. In the remainder of the paper we will therefore focus on setting up and estimating a model for the joint determination of investment in both assets.

4 The Decision Framework

To illustrate the nature of the economic decisions to be taken and to motivate how variables like house prices, tax rates, etc. play a role, we present a theoretical model for investment in housing and financial assets similar to that of Henderson and Ioannides (1983). We will also explain why this model cannot be used as the basis of a structural empirical model.

Assume that a representative household maximizes utility over two periods, 'present' and 'future', and derives utility from housing h and non–housing goods c. In the current period, the realizations of random variables are known. The household can invest its savings in housing wealth H or financial assets F.[21] It can also finance part of its housing wealth by a mortgage loan L. Part of the housing stock corresponding to housing wealth can be owner occupied H^o, the remainder can be let to others $H - H^o$. Thus the household maximizes

$$U(c,h) + \mathrm{E}V(W_1) \tag{1}$$

subject to the constraints

$$\begin{aligned} h &= r^o H^o + h^r & (2)\\ F &= Y_0 + W_0 - H + L - p^c c - p^r h^r & (3)\\ W_1 &= Y_1 + (1+r^f)F + (1+r^h)H - (1+r^L)L + r^l(H - H^o) & (4) \end{aligned}$$

Here, V denotes the value function in period 1, which depends on W_1, wealth in period 1. r^o is the rate at which, in period 0, owner occupied housing wealth is transformed into housing services. It depends negatively on house prices. h^r denotes rented housing services, with price p^r per unit. Variation in p^r is smaller than in house prices, because the renting market is largely regulated. p^r can also be affected by rent subsidies (see section 2). p^c denotes the price of consumption. W_0, Y_0 and Y_1 are initial wealth and non–asset income in periods 0 and 1, respectively. r^f and r^h are the net returns to financial assets and housing wealth, respectively. They are affected by the tax system and by house price changes. r^L is the after tax interest rate on the mortgage.[22] r^l is the net rent received

[21] Brueckner (1995) generalizes the model to allow for a differentiated portfolio choice in financial assets.

[22] In the Netherlands there is no reason to expect that r^L and r^f are the same. For example, mortgage contracts usually have a fixed interest rates for ten or more years, while r^f, if fixed at all, will be fixed for much shorter periods.

per unit. At $t = 0$, r^f, r^h, and Y_1 will be uncertain. Moreover, indirect period 1 utility V can also depend upon other variables which are uncertain in period 0, such as prices of consumption and housing services.

Various inequality constraints should be satisfied as well:

$$L \leq \phi H \tag{5}$$

$$H^o \geq 0 \tag{6}$$

$$H \geq 0 \tag{7}$$

$$F \geq 0 \tag{8}$$

The first constraint assigns a maximum mortgage, which is some fraction of the value of housing. ϕ will usually be around one.[23] The final constraint reflects liquidity constraints. To allow for people with financial debts, it could be relaxed. An explanation for zero financial wealth holdings can then be that r^f is larger if $F < 0$ than if $F > 0$.

Henderson and Ioannides (1983) also assume that $h^r = 0$ if $H > 0$, since families cannot rent part of their house and buy another part. They focus on the moral hazard problem due to the principal–agent relationship between landlords and tenants. This prevents landlords to charge a rent which equals the full costs of utilization (which depends on the tenant's behavior) to the renter. This renting externality makes it unattractive to let ($H > H^o$) and rent simultaneously.

Prices, tax rules, interest rates, etc. enter this type of model in various ways. For different versions of the model, various authors have looked at comparative statics. In principle, for a given functional form and given details of the tax system etc., the model can be solved. Many complications arise, however, if it is to be used to construct a structural empirical model: the time periods are not well defined, initial wealth, future income, (expected) returns are unobserved, the tax rules are complicated and lead to nonconvex budget sets, etc. Moreover, in our data the distinction between H^o and $H - H^o$ is not clear and h^r is not observed. Furthermore, the model does not allow for fixed costs of house ownership, while in empirical models it appears to be important to disentangle the ownership from the amount decision. Therefore, our empirical model in the next section is simplified in that it focuses on the bivariate nature of the financial decision making process and takes some account of price and tax rate variation, but does not incorporate the full structure of the theoretical model.

5 Empirical Model

The empirical model allows for joint determination of financial and housing wealth. The asset demands are derived analogously to demand equations in a commodity demand

[23] There are no explicit down payment constraints in the Netherlands. ϕ will also depend on income, and r^L can depend on ϕ.

system. We allow first explicitly for the existence of non–negativity constraints which will possibly trigger spill–over effects on the demand for other assets. To illustrate the way in which those non–negativity constraints and spill–over effects are introduced, consider notional and conditional demand equations derived from Stone–Geary preferences for the case of three goods: Notional demand equations are those of the linear expenditure system (LES), with expenditures on good i given by[24]

$$p_i q_i^* = p_i \gamma_i + \theta_i (W - \sum_{i=j}^{3} p_j \gamma_j) \tag{9}$$

Here q_i is the quantity and p_i the price of good i. W is the given total budget and θ_i and γ_i are parameters. In our case, $p_1 q_1$ corresponds to housing wealth and $p_2 q_2$ to financial wealth. For p_1 we use a regional house price index, p_2 is normalized to one. The third argument ($p_3 q_3$) remains unspecified. In terms of the two period model in the previous section, we can think of W as the sum of initial wealth and income in period 1, and of $p_3 q_3$ as consumption expenditures in period 1. $p_3 q_3$ may also include investment in durables or other assets not included in financial or housing wealth, however.

Conditional demand equations for good i (denoted $\tilde{q}_i; i = 1, 2$) are derived for the case where non–negativity constraints on one or more of the other goods are binding. For convenience, we assume that there is no binding non–negativity constraint for q_3. Four possible regimes can now be distinguished, according to whether nonnegativity constraints on goods 1 and 2 are binding or not. Suppose the constraint for good 1 is binding, implying that its notional demand is negative and its effective demand is zero. Then the relevant demand equation for good 2 will be the conditional ($\tilde{q}_2$) instead of the notional demand (q_2^*):

$$p_2 \tilde{q}_2 = p_2 \gamma_2 + \theta_2/(1 - \theta_1)(W - p_2 \gamma_2). \tag{10}$$

Using the short–hand notation $\lambda_2 \equiv \theta_2/(1-\theta_1)$, (10) can be written as a linear combination of notional demands (9):

$$p_2 \tilde{q}_2 = p_2 q_2^* + \lambda_2 p_1 q_1^*. \tag{11}$$

The conditional demand for good 1 if the nonnegativity constraint for good 2 is binding can be derived in the same way. Expressed in terms of shadow prices, this means that the shadow price of a rationed asset is lower than its market price. $\lambda_2 > 0$ implies a negative spill–over effect of the non–negativity constraint. Due to its parameter restrictions, LES only allows for negative spill–over effects, i.e. for substitutes ($\lambda_2 > 0$, because LES imposes $\theta_2 > 0$ and $\theta_1 < 1$).

A generalization of the model with non–negativity constraints can be obtained by incorporating stochastic censoring threshold equations reflecting individual hurdles which have to be crossed before a purchase is made (see Nelson (1977) for the univariate case).

[24] For notational convenience we do not carry through a household index in the derivation of the model.

Such thresholds can reflect minimum purchase requirements or fixed transaction costs, for instance.[25] Apart from costs which are linked to the purchase of a home (search costs, legal costs, real estate agent fees and other duties), fixed costs of moving will contribute to the illiquidity of housing wealth. These costs also comprise a psychological component which may depend upon age and other household characteristics. Positive thresholds imply that, once a purchase is made, some minimum amount is bought.

The complete econometric model with thresholds is as follows. We first specify notional expenditure equations and thresholds T_1^* and T_2^*:

$$p_i q_i^* = x\alpha_i + \epsilon_i \qquad (i = 1, 2) \tag{12}$$

$$T_i^* = x\delta_i + u_i \qquad (i = 1, 2) \tag{13}$$

where x is a vector of regressors, including variables which determine the budget (or, in our case, initial wealth and income) and prices. [26] The error terms ϵ_i and u_i account for unobserved heterogeneity.

Conditional demands are then defined by (11) and its analogue for good 1. The thresholds for the conditional demands are modeled in the same way:

$$\begin{aligned} \tilde{T}_1 &= T_1^* + \lambda_1 T_2^* \\ \tilde{T}_2 &= T_2^* + \lambda_2 T_1^*. \end{aligned} \tag{14}$$

It is not intuitively clear why the same λ_1 and λ_2 must be used here as in (11). For example, we could instead use $\tilde{T}_1 = T_1^*$ and $\tilde{T}_2 = T_2^*$. In the appendix we show that this generally leads to an incoherent model, i.e. to a model that is not well-defined in the sense that endogenous variables are not uniquely determined for given values of exogenous variables and error terms (see Heckman (1978), for example). Thus specification (14) is motivated by both computational convenience and the requirement of coherency.

The model can be re–written as a bivariate selection model, introducing $S_i^* = p_i q_i^* - T_i^*$ and $\tilde{S}_i = p_i \tilde{q}_i - \tilde{T}_i$, $(i = 1, 2)$. The selection equations can be written as

$$\begin{aligned} S_i^* &= x\zeta_i + \nu_i \qquad (i = 1, 2) \\ \tilde{S}_1 &= S_1^* + \lambda_1 S_2^* \\ \tilde{S}_2 &= S_2^* + \lambda_2 S_1^*, \end{aligned} \tag{15}$$

[25] Incorporating these explicitly in the LES demand system would require comparing values of the direct utility functions. This leads to non–linear equations and an intractible stochastic specification, from which we are not able to derive empirically tractable expressions.

[26] Since total household wealth W is unobservable due to missing wealth components (life insurances, checking accounts, private pension and social security wealth) we cannot include the total budget itself.

The regime allocation is given by

$$
\begin{array}{ll}
(a) & S_1^* > 0, S_2^* > 0 : \\
& p_1 q_1 = p_1 q_1^*, p_2 q_2 = p_2 q_2^* \\
\\
(b) & \tilde{S}_1 > 0, S_2^* < 0 : \\
& p_1 q_1 = p_1 \tilde{q}_1 = p_1 q_1^* + \lambda_1 p_2 q_2^*; \qquad p_2 q_2 = 0 \\
\\
(c) & S_1^* < 0, \tilde{S}_2 > 0 : \\
& p_1 q_1 = 0; \qquad p_2 q_2 = p_2 \tilde{q}_2 = p_2 q_2^* + \lambda_2 p_1 q_1^* \\
\\
(d) & \tilde{S}_1 < 0, \tilde{S}_2 < 0 : \\
& p_1 q_1 = 0, p_2 q_2 = 0.
\end{array} \tag{16}
$$

Regimes $(a) - (d)$ correspond to the entries in Table 3. The complete empirical model is thus given by (11), (12), (15), and (16). The model reduces to the model with non–negativity constraints if (with probability one) $S_i^* = p_i q_i^*$ $(i = 1, 2)$. Unlike the model with non–negativity constraints only, our specification allows for separation of the ownership and the investment decision. This is important since, for example, it has been claimed that higher house prices decrease the tendency to own but at the same time raise the housing wealth for households conditional on having chosen to own (see Haurin et al. (1996)). Similarly, the discrete ownership decision and the conditional continuous investment decision for financial wealth are disentangled.

We assume that the four error terms in the model are jointly normal and independent of the regressors. The variances of ν_1 and ν_2 are normalized to 1. The general model with a full covariance matrix is only identified due to functional form and distributional assumptions. Exclusion restrictions on the notional demand equations are hard to justify from an economic point of view. Therefore we set the correlation coefficients between selection equations and demand equations to zero. This implies that the demand equations should be interpreted as conditional demand equations, given that the amount is non–zero. Since latent demand for households who do not buy the asset is irrelevant anyhow, this is not as restrictive as it may seem.[27]

According to the LES specification, λ_1 and λ_2 should both be nonnegative (and $\lambda_1 \lambda_2 \leq 1$). Negative values are not compatible with Stone–Geary preferences. Our empirical model, however, can still remain valid if $\lambda_1 < 0$ or $\lambda_2 < 0$. It exploits the LES framework only partially, because the budget is not observed and p_2 does not vary across the sample. The empirical model will therefore also be compatible with other, more flexible systems than LES. In particular, such an alternative demand system could also allow for complements and negative values of λ_1 and λ_2. We therefore do not impose that λ_1

[27]Melenberg and Van Soest (1996) explain this in detail for the univariate selection model.

and λ_2 are positive.

On the other hand, we have to guarantee that the empirical model is coherent. In the appendix we show that coherency is guaranteed iff $\lambda_1\lambda_2 \leq 1$. This is weaker than the constraint $\lambda_1 \geq 0$, $\lambda_2 \geq 0$ and $\lambda_1\lambda_2 \leq 1$ implied by LES. If the coherency conditions are satisfied but the LES inequalities are not, the LES interpretation is lost but the empirical model still makes sense.

6 Empirical Results

We separately consider the model for wealth and equity variables. Estimation is by Maximum Likelihood. We take full account of observations with missing amount information for endogenous variables. For each asset, we distinguish three cases: the amount is zero, the amount is nonzero and observed, or the amount is nonzero and unobserved. This leads to nine regimes in the likelihood (see Table 3). We assume that, conditional on being nonzero, observability of the amount is independent of the error terms in the model. This allows us to estimate the model without explicitly estimating equations for observability.

Since the model does not describe structural economic relationships as outlined in Section 4 we do not have strong a priori reasons to prefer a specification where dependent variables are measured in currency units over a specification with a log transformation. Instead, we select the specification which gives the best fit to the data. For this purpose, we use tests for non–nested models as proposed by Vuong (1989). These lead to the conclusion that the specification in logs is better, for the gross asset as well as the equity variables.[28]

Results for the models in logs are presented in Tables 5a (wealth) and 6a (equity). We set all cross–correlations between the selection part and the demand equations to zero. Joint LM tests on these four constraints ($\rho_{\epsilon_i\nu_j} = 0, i, j = 1, 2$) do not reject the null at the 5% level.

table 5a about here

We first discuss the results for wealth in Table 5a. The effect of income in the demand equations is captured by a quadratic function. Estimates are insignificant except in the

[28] We consider the case of two strictly non–nested models, i.e. models that do not coincide for any parameter values. To make the specifications comparable, the Jacobian of the log transformation is taken into account. The Vuong tests then test the Null that both models are equivalent versus the hypotheses that one model is closer to the true but unknown data generating process than the other. The test statistics are asymptotically standard normal under the Null and are given by $T_1 = n^{-1/2}\mathrm{LR}_n/\widehat{\omega}_n$ and $T_2 = n^{-1/2}\mathrm{LR}_n/\widetilde{\omega}_n$ where $\widetilde{\omega}_n^2 = 1/n\sum \mathrm{LR}_i^2$, $\widehat{\omega}_n^2 = \widetilde{\omega}_n^2 - (1/n\mathrm{LR}_n)^2$; n denotes sample size, LR_i the log likelihood ratio for observation i between both alternative models evaluated at the estimates, and $\mathrm{LR}_n = \sum \mathrm{LR}_i$. For our application, comparing the specification in levels against the log specification, we obtain for the cases with gross wealth $T_1 = -20.11$, $T_2 = -18.91$, and for the cases with equity $T_1 = -3.41$ and $T_2 = -3.41$.

selection equation for housing where we find a u–shaped pattern. The marginal tax rate has a strong positive and significant impact on holding both financial and housing wealth, both in the selection equations and in the demand equations. This reflects the tax favored status of these assets.

The estimated age polynomial for housing wealth is significant for the selection part, implying that the prime home–buying years are roughly between 20 and 40 of age. [29] This is consistent with the pattern in figure 4. Houseowners' wealth held in housing is not significantly influenced by the age of the head of the household, though. Financial assets do not depend on age either — the conditional demand of financial wealth rises with age but the parameter estimates are not significant. Comparing age patterns for home ownership and financial wealth holdings, we find no evidence that younger households hold high amounts of financial wealth at ages before they typically would buy a home. This may reflect the absence of effective down payment constraints.

As expected, the probability of homeownership is significantly lower in regions where housing prices are higher. On the other hand, conditional on ownership, the amount invested in housing increases with the price of the house. This is in line with the findings of Haurin et al. (1996). One interpretation is that households are discouraged from investing in houses where house prices are high, but once they have chosen to do so, they will invest more. The housing price has a significant negative impact on holding financial wealth. Conditional upon holding financial wealth however, the effect of the housing price on the amount held is positive but insignificant at the 5 percent level.

Apart from the impact of housing prices, our model also allows for an interaction between the two assets through the parameters λ_1 and λ_2, which refer to the impact of binding thresholds (equation (11)). While λ_1 is virtually identical to zero, λ_2 is significantly negative. This would imply that the two assets are complements in the Hicksian sense, and this finding is incompatible with the LES specification (9). On the other hand, the coherency condition for the empirical model is amply met. The estimates thus imply that the restriction on financial wealth does not affect the housing decision, whereas the restriction on housing does matter for financial wealth. Whether the conditional demand for financial wealth exceeds or falls short of the notional demand depends on the sign of the notional demand for housing wealth. If this is positive, renters hold less financial assets if the housing threshold is binding than if it were not binding. Actual housing wealth is then zero and therefore below its unrestricted optimal value, and financial wealth will then also below its notional optimum. Thus, in a sense, the two could be called complements. This result is not in line with the idea that renters save for down payments.

[29] Alessie et al. (1995) using Dutch panel data and Banks and Blundell (1995) using a time series of British cross–sections show that age effects must not be confounded with life cycle effects, since in homeownership rates there is usually a strong cohort effect. These studies show that conditional on the cohort, home ownership rates rise over time for all but the oldest age groups.

Demographics and other socio–economic background variables are included for various reasons. First, we have to proxy unobserved total household wealth, as outlined in section 4. Especially higher education, a full–time job (reference category), and marital status are proxies for life–time wealth and also might indicate the inclination for timing and extent of investment in housing wealth. Second, as outlined in section 2, we suspect demographic variables to have a direct impact on housing demand. The estimates by and large confirm our expectations based on other studies in the field.

Finally, we find significant positive correlations between the error terms in the demand equations for the two assets, and also between the error terms in the two selection equations. This points at unobserved characteristics that affect both types of assets in the same direction. Factors that determine life–time income or initial assets would be obvious candidates for this, if they are not captured by current earnings and education.

table 6a about here

Table 6a contains the results on the equity holdings. Results for the selection equation of housing equity are virtually identical to those in Table 5a. The conditional demand for housing equity, however, differs substantially from the conditional demand for housing assets. The marginal tax rate now has a negative sign. This means that it has a stronger (positive) impact on the amount of mortgage than on the chosen value of the house. The house price in the housing equity demand equation is insignificant. Apparently, higher values of homes are compensated by higher mortgages, so that the effect on the net investment is small. Estimates for the financial equity ownership equation are similar to those for financial wealth ownership. For the financial conditional demand equation, estimates are also similar, but significance levels in the equation for financial equity are lower than in the equation for gross financial wealth.

The estimate of λ_2 is again significantly negative, and the spill–over effect from housing to financial equity is larger than for the gross asset amounts (Table 5a). The estimate of λ_1 remains zero, so that spill–over effects from financial to housing equity cannot be found. The strong positive correlations between the error terms have increased as well.

tables 5b/6b about here

Tables 5b and 6b show simulated averages and numbers of observations per regime[30] for both models. Table 5b suggests that the fit of the model to the data, and in particular with respect to the regime choice, is rather good. This is partly attributable to the fact that we work with variables in logs. The fit is much better for gross wealth estimates than for equity, as a comparison of tables 5b and 6b reveals. This may be related to the bimodal

[30] as explained above, we do not model the observability and thus do not distinguish subregimes within $(a) - (d)$.

nature of the distribution of the equity variables, which we saw in Figure 3. In both cases the predicted figures match the data much better than the corresponding estimates for data in levels instead of logs (tables available upon request), which are characterized by more skewed distributions. Splitting by income quintile (Tables 5c/6c) again leads to the conclusion that the model fits the data reasonably well, particularly for gross assets. For the equity variables there are some substantial deviations between conditional means from the model and the data.

tables 5c/6c about here

7 Model Implications

In this section we analyze the model predictions for exogenous changes in the selection mechanism and house prices. This is achieved by simulating the model and averaging over both individuals and replications.

To show the relevance of the thresholds, we study the consequences of changing one of the thresholds by the same percentage for each household. This comes about as a change in the constant of the selection equation.[31] We focus on the effects of lowering thresholds, which can be interpreted as an exogenous relaxation of market or institutional restrictions. One can think of the effects of financial liberalization in the mortgage market or the credit market, for instance.

table 7 about here

Table 7 considers ownership rates and conditional means when thresholds are varied for the model with gross asset components. Changing the threshold for asset i has a strong impact on the ownership rate of the same asset, while the effect on the conditional demand of asset i is small. Lowering the threshold in the housing market by only 1% boosts homeownership by 4.3% points to almost 53%. Conditional mean log house values decrease only slightly. Again, we focus on the spill–over effect on financial wealth ownership from lowering the housing threshold. As the housing thresholds are lowered, financial wealth ownership is reduced slightly, while the conditional mean of those who own financial assets increases. The latter points at the complementarity we have found in the estimates ($\lambda_2 < 0$). Decreasing the threshold for financial assets has an effect on financial wealth holdings, but the spill–over effect on home ownership is virtually zero

[31] Call the constants in the demand equation, threshold equation, and selection equation α_{0i}, δ_{0i}, and ζ_{0i}, respectively ($i = 1, 2$). Hence, $\zeta_{0i} = \alpha_{0i} - \delta_{0i}$. This implies that, keeping α_{0i} constant, a change in δ_{0i} changes ζ_{0i} by the same absolute amount but in the opposite direction. In the tables we show the effects of a percentage change in δ_{0i}. Note that all the variables refer to the specification in logs, and not in levels of the thresholds.

table 8 about here

Table 8 shows the analogous results for the model estimated on equity data. The effect of varying the housing threshold on home ownership rates is even more pronounced, since mortgages can be substantial. Cross effects from varying the housing threshold on the financial equity ownership rate and the conditional demand for financial assets have the same sign as in Table 7. The effects are stronger than for the gross asset case.

tables 9/10 about here

Table 9 displays ownership rates and conditional means for the impact of a change in house prices on gross assets. Table 10 shows corresponding results for equity. We consider house price changes from -20% to $+20\%$ which are well in line with the historical pattern documented in Section 2 and figure 1. As the results show, ownership rates and conditional means of both assets are affected. The impact of prices on homeownership rates is substantially negative, but is compensated by the positive impact on the conditional mean of gross housing wealth. As a consequence, the impact on the unconditional mean would be close to zero. Similarly, higher house prices reduce financial assets ownership rates while their effect on the conditional demand for financial assets is positive. The effects on the conditional demands are of opposite sign for the net variables compared to the gross variables. This can indicate that houseowners are able to overcompensate price changes by changes in mortgage contracts. As conditional financial equity decreases with house prices whereas conditional financial assets increase, the role of financial debts seems to increase with house prices.

The tables also show financial wealth holdings for renters, indicating that their financial resources are much lower than those of homeowners. As house prices rise, the conditional financial wealth holdings of renters is decreased (while the number of renters increases). Turning to equity we find a similar effect of the house price variation on renters' financial assets. These results are in contradiction with the findings of Sheiner (1995) who reports young renters to have more assets in cities and regions with high house prices. The low level of financial resources of renters is compatible with the view that renters do not have a desire for home owning and thus need not accumulate financial resources prior to ownership (cf. Haurin et al. (1996)). If down payment constraints were important, one would expect renters to have saved more with increased house prices, unless they are discouraged from home owning.

8 Conclusions

We have set up and estimated a bivariate censored regression model with endogenous switching for household investment in bequeathable wealth, distinguishing the two most important asset types households invest in. Avoiding selectivity problems we estimate the model on a representative sample of Dutch households, including both renters and owners and both financial asset holders and non–holders. The modeling of spill–over effects is derived from a LES demand system. The empirical model, however, is more general than LES, and avoids the implicit assumption of the LES that goods are substitutes. Our parameter estimates do not satisfy the LES constraints.

The main finding is that demand for financial wealth for home owners and for renters is systematically different, while housing wealth is not affected by whether or not financial wealth is held. Consistent with previous studies in this field is the finding that higher regional house prices reduce the likelihood of homeownership. At the same time, housing wealth of home owners responds positively to house price variation, whereas it does not affect their housing equity. Higher house prices also decrease the probability of holding financial wealth, whereas they increase the conditional demand for financial assets but reduces conditional demand for financial equity.

As has been widely discussed in the recent literature, down payment restrictions operate as liquidity constraints and influence households' saving behavior (cf. Engelhardt (1994, 1996), Haurin et al. (1996), and Sheiner (1995)): both in Canada and in the U.S. a down payment is specified as a percentage (usually in the range of 5–25%) of the purchase price of the house, such that an increase in house prices can lead to a higher down payment and thus can induce higher saving. On the other hand, if those increased down payments are too high, renter households might become discouraged from buying a house at all or be willing to only buy a smaller house to compensate for the increase in down payments, or even to delay the date of home buying. A higher down payment amount implies a greater intertemporal distortion of the consumption plan such that the discounted benefits of homeowning might fall short of the discounted costs of consumption distortion (cf. Artle and Varaiya (1978) for a theoretical exposition). Thus, both timing and extent of pre–ownership saving are affected. In the Netherlands however, the low homeownership rate and the effective absence of down payment constraints imply that liquidity constraints are not of major importance for Dutch households' saving behavior. This presumption is corroborated by our empirical findings.

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Table 1: Summary statistics of exogenous variables (3077 observations)[a]

Variable	mean	stddev.	min	max	median
log(income+1)	7.735	0.672	0	11.495	7.75
$\log^2$(income+1)	60.279	9.338	0	132.126	60.01
marg. tax rate	0.473	0.133	0	0.72	0.51
age of head	43.992	15.455	18	89	40
age squared / 1000	2.174	1.520	0.324	7.921	1.6
age cubed / 10000	11.880	12.295	0.583	70.497	6.4
interm. education	0.328	0.469	0	1	0
high education	0.161	0.368	0	1	0
self–employed	0.103	0.304	0	1	0
white collar	0.447	0.497	0	1	0
blue collar	0.247	0.431	0	1	0
other occupation	0.204	0.403	0	1	0
full–time	0.596	0.491	0	1	1
part–time	0.049	0.216	0	1	0
other status	0.355	0.478	0	1	0
female	0.207	0.405	0	1	0
couples	0.690	0.463	0	1	1
divorced / widowed	0.167	0.373	0	1	0
no. children	0.964	1.116	0	8	1
house price index	0.972	0.154	0.626	1.230	0.98

[a]Definition of variables:
`income`: sum of net labor income (Dfl/month) of head and partner; 7 households report zero income.
`marginal tax rate`: calculated from individual net earnings and family composition; the household rate is set equal to the maximum of the two individual rates.
`age`, the number of `children` are self–explanatory; the remaining variables are dummies:
`intermediate education`: technical and vocational training for 16+ years old, and pre–university education;
`high education`: university degree or higher vocational training.
Labor supply: `part-time` employment (10–35 hours per week); `other status:` disabled, unemployed, retired, students and housewives/men without alternative occupation. The reference group is `full-time` (36 hours per week or more).
Occupational status: `self-employed` (includes free lancers, directors or owners of firms, farmers or market gardeners), `whitecollar` employees and `other occupation` (people without paid employment and others); reference group are `bluecollar` workers; `couples:` married or living together. The `house price index` is based on average regional selling prices of houses, provided by the Dutch Association of Real Estate Agents. We differentiated according to the type of dwelling and divided the regional prices by national averages.

Table 2: Summary statistics of endogenous variables[a]

Variable	nobs.	mean	stddev.	min	max	median	skewn.
house value	3055	77.26E3	98.76E3	0	850.00E3	0	1.57
—, > 0	1469	160.67E3	82.95E3	10.00E3	850.00E3	145.00E3	2.36
logs	3055	5.707	5.942	0	13.653	0	0.09
—, > 0	1469	11.869	0.511	9.210	13.653	11.88	–1.08
fin. assets	2743	16.48E3	70.36E3	0	1.41E6	3.00E3	11.54
—, > 0	2244	20.14E3	77.32E3	1	1.41E6	4.74E3	10.49
logs	2743	6.795	3.619	0	14.163	8.01	–0.94
—, > 0	2244	8.306	1.859	0.693	14.163	8.46	–0.54
house equity	2786	38.68E3	71.53E3	–28.00E3	806.73E3	0	3.07
—, ≠ 0	1200	89.79E3	85.39E3	–28.00E3	806.73E3	70.00E3	2.31
logs	2786	4.326	5.725	–10.24	13.601	0	0.23
—, ≠ 0	1200	10.044	4.318	–10.24	13.601	11.16	–3.73
fin. equity	2697	14.64E3	71.77E3	–479.49E3	1.42E6	2.50E3	10.89
—, ≠ 0	2298	17.19E3	77.48E3	–479.49E3	1.42E6	3.90E3	10.07
logs	2697	5.041	6.166	–13.080	14.163	7.82	–1.23
—, ≠ 0	2298	5.917	6.281	–13.080	14.163	8.27	–1.70

[a]Definition of variables:
`house value`: gross housing wealth;
`house equity`: value of the house net of outstanding mortgage debt;
`fin. assets`: sum of the amounts held in saving account balances, time deposit accounts, saving certificates, certificates of deposit, shares in domestic and foreign companies, shares in investment funds, options, bonds and mortgage bonds;
`fin. equity`: financial assets net of liabilities;
'logs' means: $\log(x+1)$ for non–negative observations, $-\log(-x+1)$ for negative observations, cf. fn. 13;
skewness is measured as $\text{skewness}(x) \equiv \text{E}(x - \text{E}(x))^3/\sigma^3$, where σ^2 is the variance of x.

Table 3: number of observations per regime

a value of the home vs. financial assets

number of observations (%)	financial assets > 0 (observed)	financial assets > 0 (unobserved)	financial assets = 0	sum
value of the home > 0 (observed)	regime (a) 1136 (36.92)	209 (6.79)	regime (b) 124 (4.03)	1469 (47.74)
value of the home > 0 (unobserved)	12 (0.39)	7 (0.23)	3 (0.10)	22 (0.71)
value of the home = 0	regime (c) 1096 (35.62)	118 (3.83)	regime (d) 372 (12.09)	1586 (51.54)
sum	2244 (72.93)	334 (10.85)	499 (16.22)	3077 (100.00)

b housing equity (net of mortgages) vs. financial equity (net of liabilities)

number of observations (%)	financial equity $\neq 0$ (observed)	financial equity $\neq 0$ (unobserved)	financial equity = 0	sum
housing equity $\neq 0$ (observed)	regime (a) 949 (30.84)	182 (5.91)	regime (b) 69 (2.24)	1200 (39.00)
housing equity $\neq 0$ (unobserved)	209 (6.79)	50 (1.62)	32 (1.04)	291 (9.46)
housing equity = 0	regime (c) 1140 (37.05)	148 (4.81)	regime (d) 298 (9.68)	1586 (51.54)
sum	2298 (74.68)	380 (12.35)	399 (12.97)	3077 (100.00)

Table 4: ownership of asset types
(probit estimates)

nobs. 3077	short term savings	long term savings	life insurance	stocks or bonds	financial debt	number, inc. fin. debt	number, exc. fin. debt
home owner	−1.107	1.210	0.195	0.154	0.367	0.440	0.414
	(−6.18)	(10.29)	(2.17)	(1.14)	(3.40)	(6.03)	(5.52)
log(wealth+1)	1.019	0.595	−0.003	0.149	0.001	0.468	0.561
	(20.64)	(7.06)	(−0.11)	(1.98)	(0.05)	(21.50)	(23.73)
$\log^2$(wealth+1)	−0.055	−0.050	0.001	−0.005	−0.007	−0.031	−0.035
	(−14.99)	(−9.94)	(0.43)	(−1.00)	(−2.80)	(−16.74)	(−17.79)
marg.	0.380	1.969	0.710	1.893	1.419	1.547	1.330
tax rate	(0.87)	(4.53)	(2.64)	(4.19)	(4.44)	(6.90)	(5.72)
age	−0.013	0.043	0.070	−0.026	0.066	0.038	0.035
	(−0.66)	(2.19)	(5.48)	(−1.32)	(3.94)	(3.97)	(3.47)
age^2 / 1000	0.108	−0.251	−0.865	0.402	−0.883	−0.472	−0.388
	(0.55)	(−1.28)	(−6.48)	(2.00)	(−4.85)	(−4.79)	(−3.79)
selfemployed or	0.097	0.820	−0.147	0.405	−0.225	0.101	0.200
farmer	(0.61)	(5.51)	(−1.47)	(2.23)	(−1.93)	(1.23)	(2.33)
white collar	0.299	0.251	−0.149	0.316	0.103	0.065	0.015
	(2.40)	(2.00)	(−2.11)	(1.99)	(1.30)	(1.11)	(0.25)
other	0.215	0.305	−0.135	0.301	−0.149	−0.003	0.039
occupation	(1.49)	(2.09)	(−1.61)	(1.63)	(−1.43)	(−0.04)	(0.54)
intermediate	−0.122	0.109	−0.025	0.378	0.114	0.061	0.041
education	(−1.15)	(1.11)	(−0.40)	(3.39)	(1.62)	(1.19)	(0.76)
higher	−0.107	0.263	−0.065	0.662	0.113	0.176	0.176
education	(−0.79)	(2.23)	(−0.79)	(5.33)	(1.25)	(2.62)	(2.53)
couples	0.064	−0.045	0.776	−0.153	0.370	0.531	0.489
	(0.41)	(−0.29)	(8.38)	(−1.00)	(3.48)	(7.03)	(6.22)
divorced or	−0.077	−0.334	0.299	−0.258	0.268	0.184	0.095
widowed	(−0.43)	(−1.82)	(2.75)	(−1.32)	(2.10)	(2.11)	(1.05)
number of	0.185	0.053	0.061	−0.057	0.036	0.085	0.076
children	(4.17)	(1.32)	(2.38)	(−1.33)	(1.27)	(3.97)	(3.42)
intercept	−2.063	−5.505	−2.330	−3.704	−2.582		
	(−4.86)	(−9.85)	(−8.72)	(−7.01)	(−7.63)		
ordered probits:							
cut−off 1						1.571	1.946
cut−off 2						3.402	3.977
cut−off 3						4.690	5.625
cut−off 4						5.838	6.647
cut−off 5						6.715	
Log Likelihood	−560.3	−670.1	−1827.9	−592.0	−1365.6	−3360.5	−2844.5
Pseudo R^2	0.602	0.193	0.140	0.182	0.087	0.170	0.214
mean dep. var.	0.829	0.076	0.468	0.063	0.190	1.626	1.436

note: t−values in parentheses

Table 5a: Estimation results model (11), (12), (15), and (16)
data: housing wealth and financial wealth, logs

	housing wealth	selection equation	financial wealth	selection equation
constant	10.400	−3.866	8.712	0.646
	(9.30)	(−3.82)	(3.48)	(0.75)
log (income+1)	−0.237	−0.347	−0.586	0.073
	(−0.97)	(−2.36)	(−0.97)	(0.55)
$\log^2$ (income+1)	0.020	0.024	0.060	−0.004
	(1.37)	(2.03)	(1.61)	(−0.33)
marginal tax rate	0.678	3.050	1.881	1.545
	(3.08)	(7.61)	(3.16)	(3.10)
age of head	0.053	0.210	−0.072	−0.023
	(1.75)	(3.84)	(−0.97)	(−0.47)
age squared / 1000	−0.868	−3.812	1.625	0.662
	(−1.46)	(−3.44)	(1.03)	(0.66)
age cubed / 10000	0.047	0.228	−0.064	−0.050
	(1.27)	(3.24)	(−0.61)	(−0.77)
intermed. education	0.046	0.127	0.098	0.033
	(1.42)	(1.96)	(1.05)	(0.42)
high education	0.133	0.194	0.187	0.001
	(3.44)	(2.09)	(1.55)	(0.01)
selfemployed/farmer	0.262	0.314	0.341	−0.079
	(5.70)	(2.84)	(2.18)	(−0.64)
white collar	0.060	0.165	−0.076	0.248
	(1.60)	(2.29)	(−0.70)	(2.76)
other occ. status	0.036	0.124	0.262	0.282
	(0.64)	(1.21)	(1.84)	(2.77)
part–time work	0.110	−0.273	−0.373	−0.131
	(1.81)	(−2.10)	(−2.28)	(−0.95)
other status	−0.030	−0.324	−0.423	−0.281
	(−0.63)	(−3.28)	(−3.43)	(−2.77)
female	0.038	−0.119	−0.141	0.217
	(0.81)	(−1.11)	(−1.01)	(2.20)
couple	0.252	0.412	0.056	0.198
	(4.65)	(3.81)	(0.37)	(1.80)
divorced / widowed	0.206	0.024	−0.234	−0.345
	(3.49)	(0.20)	(−1.41)	(−2.99)
number of children	0.024	0.041	−0.067	0.152
	(1.76)	(1.40)	(−1.57)	(4.88)
house price index	0.334	−0.453	0.397	−0.829
	(3.85)	(−2.76)	(1.67)	(−4.34)

note: t–values in parentheses;
see table 1 for the reference groups for the dummy variables:
low education, blue collar worker, full time employed, male, and single

continued on next page

Table 5a: *continued*

	housing wealth	selection equation	financial wealth	selection equation
σ	0.446	1.0	1.679	1.0
	(98.64)	(fixed)	(86.16)	(fixed)
$\rho_{\epsilon_1\epsilon_2}$	0.067			
	(1.87)			
$\rho_{\nu_1\nu_2}$	0.230			
	(5.17)			
other ρ's*	0			
	(—)			
λ_1	0.0004			
	(0.09)			
λ_2	−0.0326			
	(−4.37)			
loglikelihood	−44199.6			
number of obs.	3077			

note: t–values in parentheses

*LM test: $H_0 : \rho_{\epsilon_1\nu_1} = \rho_{\epsilon_2\nu_2} = \rho_{\epsilon_1\nu_2} = \rho_{\epsilon_2\nu_1} = 0 : 5.61; \qquad \chi^2_4(0.95) = 9.49$

Table 5b: Model performance
selection model (16)
data: housing wealth and financial wealth, logs

	no. obs.		housing		fin. assets	
reg.	data	model	data	model	data	model
(a)	1364	1360	11.87	11.87	8.73	8.77
			(0.50)	(0.51)	(1.74)	(1.81)
(b)	127	127	11.83	11.81	0	0
			(0.65)	(0.52)	(0)	(0)
(c)	1214	1221	0	0	7.86	7.90
			(0)	(0)	(1.87)	(1.82)
(d)	372	369	0	0	0	0
			(0)	(0)	(0)	(0)

note: means and standard deviations (in parentheses);

note for tables **5b, 5c, 6b, 6c, 7–10:** simulations based on 100 random draws

Table 5c: Model performance by income quintile
selection model (16)
data: housing wealth and financial wealth, logs

		data			model		
income quintile		nobs	cond. mean	cond. stddv	nobs	cond. mean	cond. stddv
1st	h	87	11.52	0.58	102	11.54	0.48
	f	443	7.36	2.13	471	7.56	1.84
2nd	h	200	11.69	0.54	196	11.63	0.47
	f	470	8.15	1.76	455	8.03	1.79
3rd	h	321	11.71	0.47	330	11.77	0.47
	f	533	8.29	1.54	540	8.28	1.76
4th	h	382	11.86	0.41	373	11.88	0.47
	f	558	8.54	1.69	535	8.56	1.76
5th	h	501	12.11	0.47	486	12.09	0.49
	f	574	9.03	1.81	580	9.15	1.80

rows labeled h: housing wealth for houseowners
rows labeled f: financial wealth for fin. asset holders

Table 6a: Estimation results model (11), (12), (15), and (16)
data: housing equity and financial equity, logs

	housing equity	selection equation	financial equity	selection equation
constant	14.148	–3.930	18.685	–0.224
	(0.79)	(–3.80)	(1.25)	(–0.24)
log (income+1)	–1.110	–0.343	–0.626	0.049
	(–0.26)	(–2.30)	(–0.18)	(0.36)
$\log^2$ (income+1)	0.118	0.024	0.015	0.005
	(0.46)	(1.98)	(0.07)	(0.34)
marginal tax rate	–2.484	3.056	1.646	1.265
	(–1.12)	(7.65)	(0.74)	(2.35)
age of head	–0.302	0.213	–0.613	0.024
	(–0.66)	(3.80)	(–1.86)	(0.46)
age squared / 1000	8.443	–3.865	13.366	–0.340
	(0.85)	(–3.42)	(1.84)	(–0.32)
age cubed / 10000	–0.585	0.231	–0.766	0.011
	(–0.84)	(3.22)	(–1.51)	(0.16)
intermed. education	0.056	0.123	0.006	–0.031
	(0.17)	(1.88)	(0.02)	(–0.38)
high education	0.524	0.189	0.107	–0.079
	(1.16)	(2.05)	(0.25)	(–0.70)
selfemployed/farmer	0.020	0.315	0.480	–0.037
	(0.04)	(2.86)	(0.84)	(–0.28)
white collar	–0.815	0.167	–0.658	0.342
	(–1.95)	(2.30)	(–1.64)	(3.55)
other occ. status	0.254	0.120	0.314	0.270
	(0.19)	(1.18)	(0.50)	(2.50)
part–time work	0.776	–0.271	–1.765	–0.152
	(0.61)	(–2.07)	(–3.14)	(–1.06)
other status	–0.343	–0.322	–1.322	–0.182
	(–0.47)	(–3.24)	(–2.44)	(–1.70)
female	–0.346	–0.116	1.705	0.087
	(–0.51)	(–1.08)	(2.84)	(0.83)
couple	1.327	0.418	0.305	0.143
	(2.61)	(3.79)	(0.54)	(1.22)
divorced / widowed	1.376	0.026	–1.740	–0.319
	(1.71)	(0.22)	(–2.52)	(–2.63)
number of children	0.130	0.041	–0.174	0.183
	(0.69)	(1.36)	(–1.20)	(5.71)
house price index	–0.705	–0.454	–1.443	–0.656
	(–0.77)	(–2.72)	(–1.65)	(–3.28)

note: t–values in parentheses

continued on next page

Table 6a: *continued*

	housing equity	selection equation	financial equity	selection equation
σ	4.124	1.0	6.096	1.0
	(39.56)	(fixed)	(35.90)	(fixed)
$\rho_{\epsilon_1\epsilon_2}$	0.159			
	(5.77)			
$\rho_{\nu_1\nu_2}$	0.237			
	(3.16)			
other ρ's*	0			
	(—)			
λ_1	–0.0110			
	(–0.06)			
λ_2	–0.0928			
	(–2.80)			
loglikelihood	–45899.6			
number of obs.	3077			

note: t–values in parentheses

*LM test: $H_0 : \rho_{\epsilon_1\nu_1} = \rho_{\epsilon_2\nu_2} = \rho_{\epsilon_1\nu_2} = \rho_{\epsilon_2\nu_1} = 0 : 8.21;$ $\chi^2_4(0.95) = 9.49$

Table 6b: Model performance
selection model (16)
data: housing equity and financial equity, logged

	no. obs.		housing		fin. equity	
reg.	data	model	data	model	data	model
(a)	1381	1386	10.04	10.01	6.34	6.40
			(4.34)	(4.31)	(6.38)	(6.28)
(b)	100	101	10.16	10.33	0	0
			(3.94)	(4.39)	(0)	(0)
(c)	1295	1293	0	0	5.49	5.55
			(0)	(0)	(6.15)	(6.26)
(d)	301	297	0	0	0	0
			(0)	(0)	(0)	(0)

note: means and standard deviations (in parentheses);

Table 6c: Model performance by income quintile
selection model (16)
data: housing equity and financial equity, logs

income quintile		data nobs	data cond. mean	data cond. stddv	model nobs	model cond. mean	model cond. stddv
1st	h	87	11.30	0.74	102	10.37	4.39
	f	475	5.71	5.29	500	6.01	6.36
2nd	h	200	10.40	3.66	196	10.10	4.36
	f	488	6.28	5.63	474	6.16	6.31
3rd	h	321	9.18	5.19	330	9.70	4.32
	f	557	5.66	6.45	558	5.80	6.26
4th	h	382	9.83	4.49	373	9.82	4.27
	f	566	6.47	6.05	551	5.88	6.24
5th	h	501	10.37	4.12	486	10.32	4.30
	f	592	5.49	7.55	595	6.12	6.25

rows labeled h: housing equity for houseowners
rows labeled f: financial equity for fin. asset holders

Table 7: impact of threshold variation
data: housing wealth and financial wealth, logs

			housing wealth ownersh.	housing wealth cond. mean	financial wealth ownersh.	financial wealth cond. mean
data			48.46	11.87	83.78	8.31
model simulation	no change		48.31	11.87	83.88	8.36
	change of housing threshold by	−1%	52.65	11.86	83.81	8.38
		−2%	56.99	11.85	83.74	8.39
		−5%	69.21	11.82	83.58	8.44
	change of fin. wealth threshold by	−1%	48.31	11.87	85.63	8.35
		−2%	48.31	11.87	87.26	8.35
		−5%	48.31	11.87	91.30	8.34

Table 8: impact of threshold variation
data: housing equity and financial equity, logs

			housing equity		financial equity	
			ownersh.	cond. mean	ownersh.	cond. mean
data			48.46	10.04	87.03	5.92
model simulation	no change		48.31	10.03	87.07	5.99
	change of housing threshold by	−1%	53.82	10.02	86.84	6.04
		−2%	59.30	10.01	86.65	6.09
		−5%	74.15	9.97	86.17	6.22
	change of fin. equity threshold by	−1%	48.30	10.04	90.35	6.00
		−2%	48.30	10.04	93.03	6.00
		−5%	48.29	10.04	97.66	6.01

Table 9: impact of price variation
data: housing wealth and financial wealth, logs

			housing wealth		financial wealth		
			ownersh.	cond. mean	ownersh.	cond. mean	renters
data			48.46	11.87	83.78	8.31	5.87
model simulation	no change		48.31	11.87	83.88	8.36	6.06
	house price change of	−20%	51.00	11.80	87.24	8.29	6.31
		−15%	50.34	11.81	86.46	8.30	6.25
		−10%	49.67	11.83	85.64	8.32	6.19
		+10%	46.95	11.90	82.02	8.40	5.93
		+15%	46.28	11.92	81.02	8.41	5.85
		+20%	45.64	11.94	79.99	8.43	5.77

Table 10: impact of price variation
data: housing equity and financial equity, logs

			housing equity		financial equity		
			ownersh.	cond. mean	ownersh.	cond. mean	renters
data			48.46	10.04	87.03	5.92	4.35
model simulation	no change		48.31	10.03	87.07	5.99	4.51
	house price change of	−20%	51.01	10.17	89.29	6.29	4.90
		−15%	50.32	10.13	88.77	6.22	4.80
		−10%	49.68	10.10	88.21	6.14	4.71
		+10%	46.96	9.97	85.83	5.84	4.32
		+15%	46.29	9.94	85.20	5.76	4.22
		+20%	45.65	9.90	84.54	5.69	4.12

Appendix

In this appendix we address coherency of the empirical model. To simplify notation, we set p_1 and p_2 equal to one. For ease of exposition, we first assume that the thresholds are zero, i.e. the case of non–negativity constraints. The model we consider is thus given by

$$
\begin{array}{ll}
(a) & q_1^* > 0, q_2^* > 0: \\
 & q_1 = q_1^*, q_2 = q_2^* \\
 & \\
(b) & \tilde{q}_1 > 0, q_2^* < 0: \\
 & q_1 = \tilde{q}_1 = q_1^* + \lambda_1 q_2^*; \qquad q_2 = 0 \\
 & \\
(c) & q_1^* < 0, \tilde{q}_2 > 0: \\
 & q_1 = 0; \qquad q_2 = \tilde{q}_2 = q_2^* + \lambda_2 q_1^* \\
 & \\
(d) & \tilde{q}_1 < 0, \tilde{q}_2 < 0: \\
 & q_1 = 0, q_2 = 0.
\end{array}
\tag{17}
$$

(12) implies that the (q_1^*, q_2^*) follows a continuous distribution with support $\mathbf{R}^2$. Coherency therefore means that the set of (q_1^*, q_2^*) which yield zero or more than one solutions of (17) should have measure zero. Sixteen cases can be distinguished, according to whether q_1^*, q_2^*, $\tilde{q}_1$, and $\tilde{q}_2$ are positive or negative. Twelve cases lead to exactly one solution, for one of the four regimes $(a) - (d)$. In four cases, the solution is either non–unique or non–existent:

- If $q_1^* > 0$, $q_2^* > 0$, $\tilde{q}_1 < 0$, and $\tilde{q}_2 < 0$, regimes (a) as well as (d) would yield a solution.
- If $q_1^* < 0$, $q_2^* < 0$, $\tilde{q}_1 > 0$, and $\tilde{q}_2 > 0$, (b) as well as (c) yield a solution.
- If $q_1^* > 0$, $q_2^* < 0$, $\tilde{q}_1 < 0$, and $\tilde{q}_2 > 0$ or
- if $q_1^* < 0$, $q_2^* > 0$, $\tilde{q}_1 > 0$, and $\tilde{q}_2 < 0$, none of the regimes leads to a solution.

Coherency thus means that λ_1 and λ_2 must be such that these four cases do not occur. These four cases are those for which both q_1^* and $\tilde{q}_1$ and q_2^* and $\tilde{q}_2$ have different signs.

Proposition: Model (17) is coherent if and only if $\lambda_1 \lambda_2 \leq 1$.

Proof: Suppose the model is not coherent. Then the argument given above implies that there are q_1^*, q_2^*, $\tilde{q}_1$ and $\tilde{q}_2$ such that

$$q_1^*(q_1^* + \lambda_1 q_2^*) < 0 \quad \text{and} \quad q_2^*(q_2^* + \lambda_2 q_1^*) < 0$$

This implies

$$\lambda_1 q_1^* q_2^* < -q_1^{*2} < 0 \quad \text{and} \quad \lambda_2 q_1^* q_2^* < -q_2^{*2} < 0$$

and multiplying these inequalities yields

$$\lambda_1 \lambda_2 q_1^{*2} q_2^{*2} > q_1^{*2} q_2^{*2}$$

This implies

$$\lambda_1 \lambda_2 > 1.$$

For the reverse implication, assume that $\lambda_1 \lambda_2 > 1$. Distinguish two cases: $\lambda_1 > 0$ and $\lambda_2 > 0$ and $\lambda_1 < 0$ and $\lambda_2 < 0$. Consider the first case. In this case,

$$-\lambda_2 < -\frac{1}{\lambda_1},$$

so that the set of (q_1^*, q_2^*) with $q_1^* > 0$ and $-\lambda_2 q_1^* < q_2^* - \frac{1}{\lambda_1} q_1^*$ has nonzero measure. This is the set for which $q_1^* > 0$, $q_2^* < 0$, $\tilde{q}_1 < 0$, and $\tilde{q}_2 > 0$. Thus the model is incoherent. Similarly, for the other case ($\lambda_1 < 0$ and $\lambda_2 < 0$), the set with $q_1^* > 0$, $q_2^* > 0$, $\tilde{q}_1 < 0$, and $\tilde{q}_2 < 0$ has nonzero measure. Thus $\lambda_1 \lambda_2 > 1$ implies incoherency. This completes the proof. •

Now consider the case with thresholds. If we use (14) and rewrite the model as (15) and (16), the coherency requirement remains exactly the same as above. Just replace q_i^* by $S_i^* (i = 1, 2)$. It is not intuitively clear, however, why (14) would be appropriate. A more general specification would be

$$\begin{aligned} \tilde{T}_1 &= T_1^* + \mu_1 T_2^* \\ \tilde{T}_2 &= T_2^* + \mu_2 T_1^* \end{aligned} \tag{18}$$

for arbitrary μ_1 and μ_2. With $S_i^* = q_i^* - T_i^*$ and $\tilde{S}_i$ as in (15), the regime allocation equations for this model are given by

$$\begin{aligned} &(a) \quad S_1^* > 0, S_2^* > 0 \\ &(b) \quad \tilde{S}_1 + (\lambda_1 - \mu_1) T_2^* > 0, S_2^* < 0 \\ &(c) \quad S_1^* < 0, \tilde{S}_2 + (\lambda_2 - \mu_2) T_1^* > 0 \\ &(d) \quad \tilde{S}_1 + (\lambda_1 - \mu_1) T_2^* < 0, \tilde{S}_2 + (\lambda_2 - \mu_2) T_1^* < 0 \end{aligned} \tag{19}$$

As before, we can distinguish 16 cases, according to the signs of S_1^*, S_2^*, $\tilde{S}_1 + (\lambda_1 - \mu_1) T_2^*$, and $\tilde{S}_2 + (\lambda_2 - \mu_2) T_1^*$. To guarantee a unique solution, λ_1, λ_2, μ_1 and μ_2 should be such that the four cases are excluded for which the signs of S_1^* and $\tilde{S}_1 + (\lambda_1 - \mu_1) T_2^*$, as well as the signs of S_2^* and $\tilde{S}_2 + (\lambda_2 - \mu_2) T_1^*$ are different. The main difference with the situation we had before, however, is that these quantities are not determined by two but by four latent variables. It seems reasonable to assume that the support of $(S_1^*, S_2^*, T_1^*, T_2^*)$ equals $\mathbf{R}^4$. Then coherency can only be obtained if $\lambda_1 = \mu_1$ or $\lambda_2 = \mu_2$. This shows that a substantially more general model than the one defined by (14) cannot be obtained. For example, the intuitively attractive model with $\mu_1 = \mu_2 = 0$ (thresholds not affected by the regime switch) is only coherent if $\lambda_1 = 0$ or $\lambda_2 = 0$.

Figure 1:

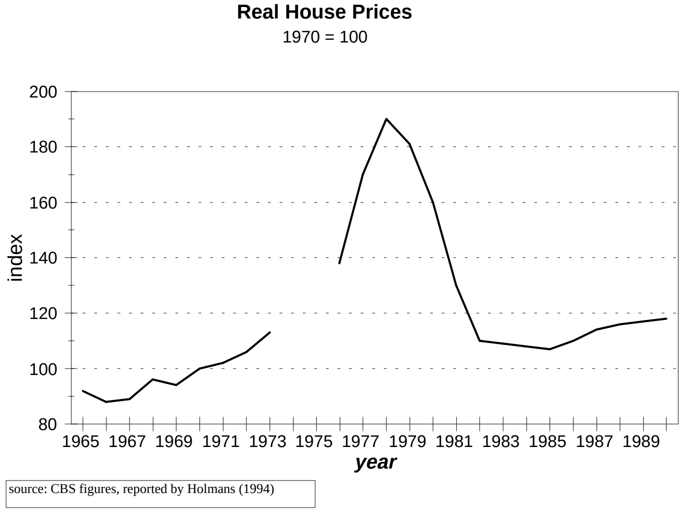
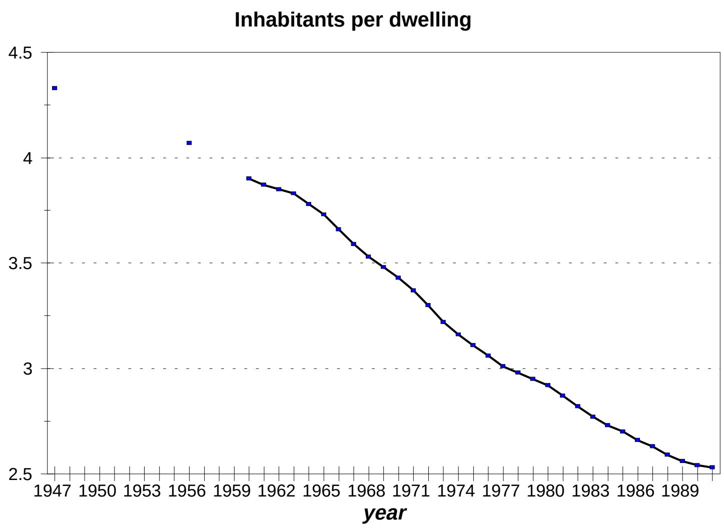


Figure 2:



source: CBS (1995)

Figure 3: marginal distributions

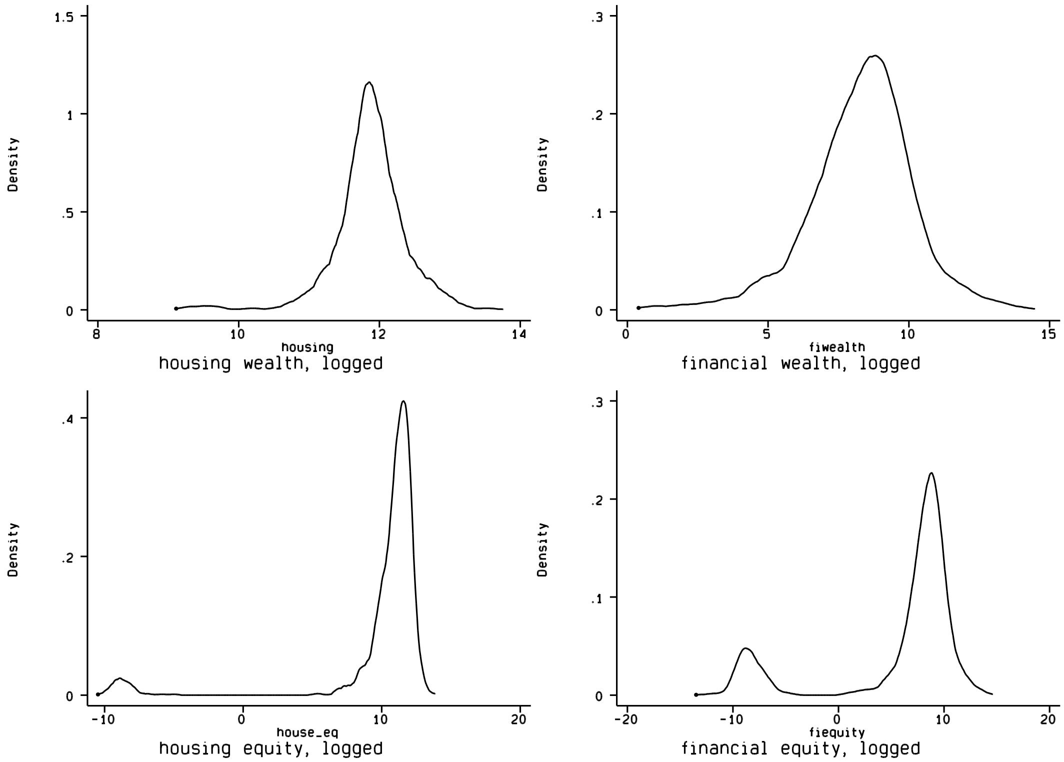


Figure 4: asset ownership by age

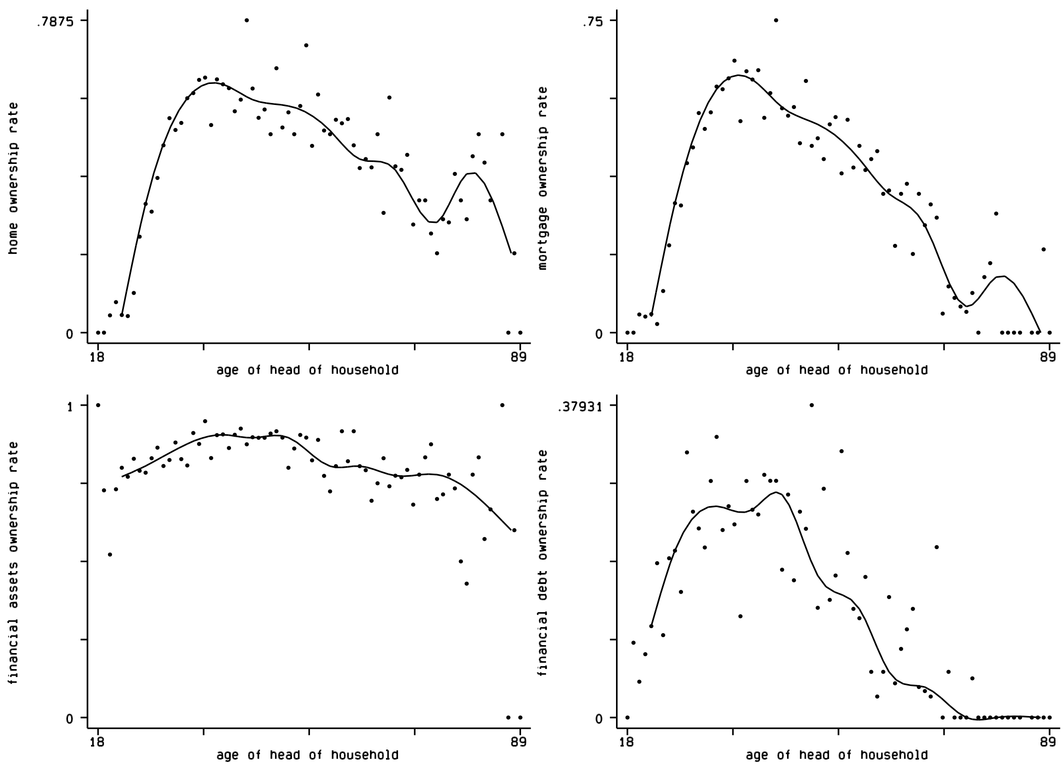
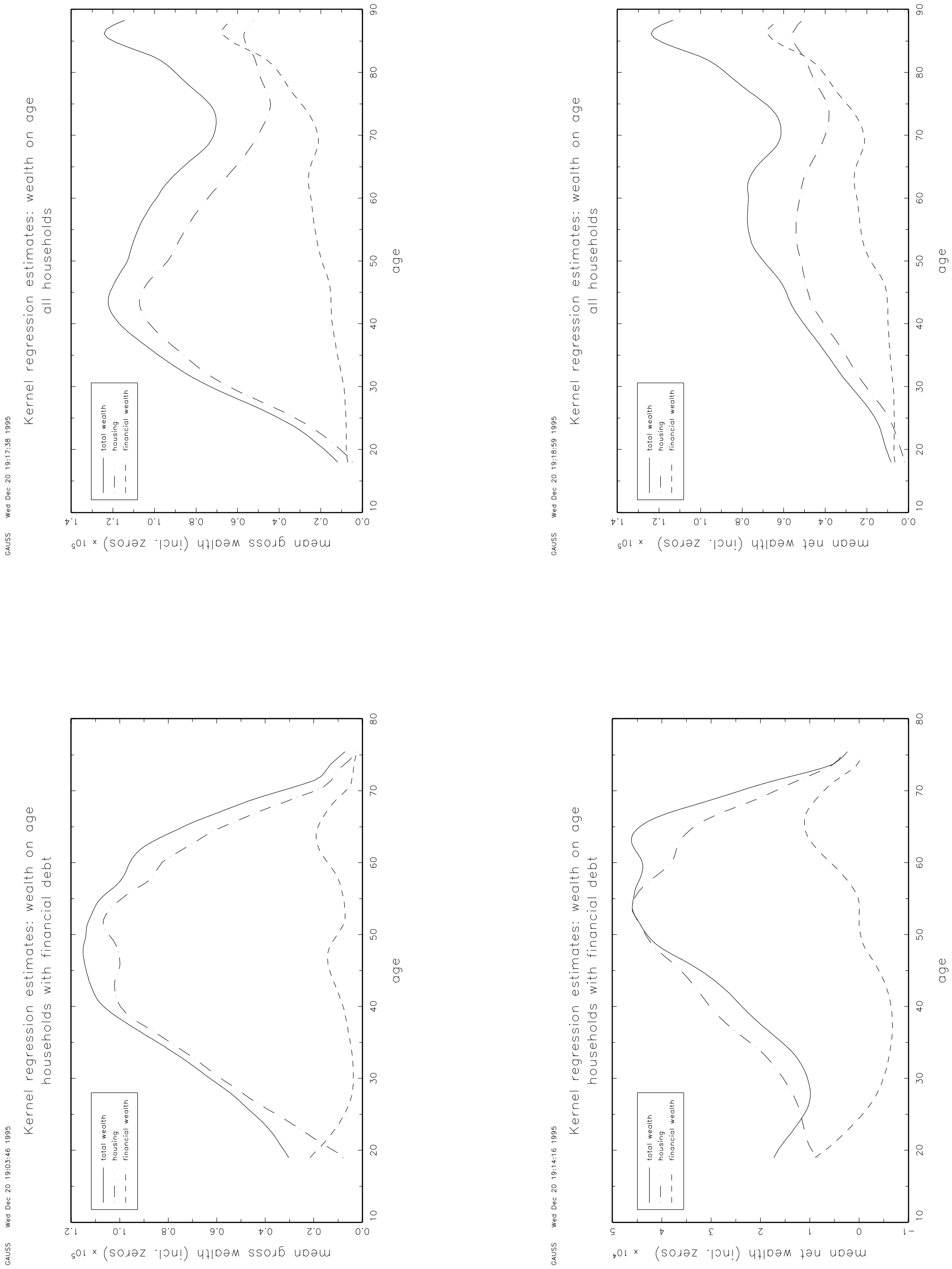
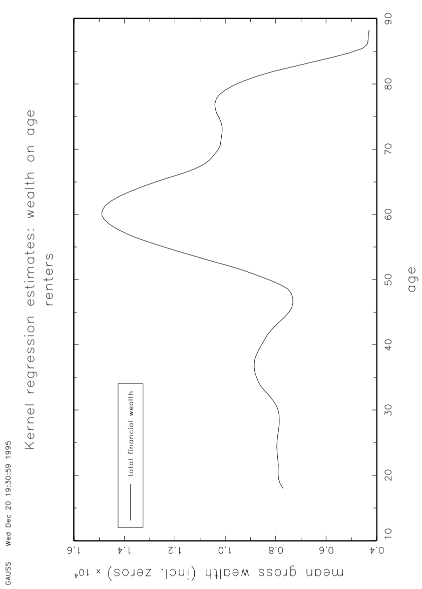


Figure 5: wealth holding by age

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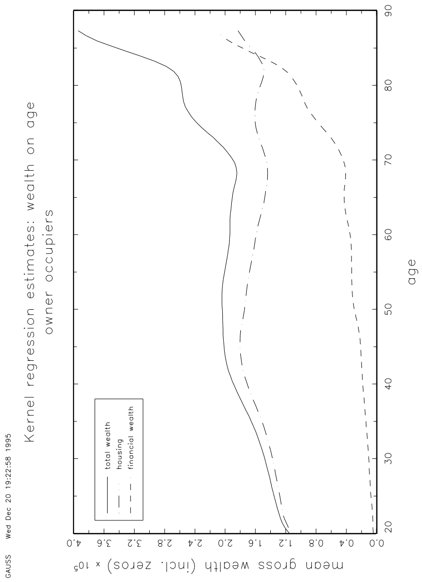
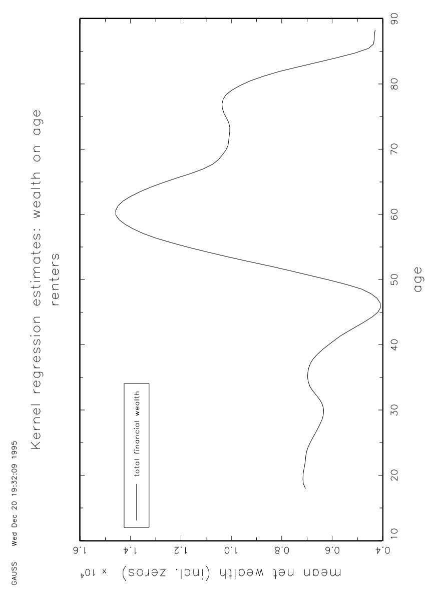
Kernel regression estimates: wealth on age
renters
total financial wealth
mean gross wealth (incl. zeros) x 10⁴
age


GAUSS Wed Dec 20 19:22:58 1995
Kernel regression estimates: wealth on age
owner occupiers
total wealth
housing
financial wealth
mean gross wealth (incl. zeros) x 10⁵
age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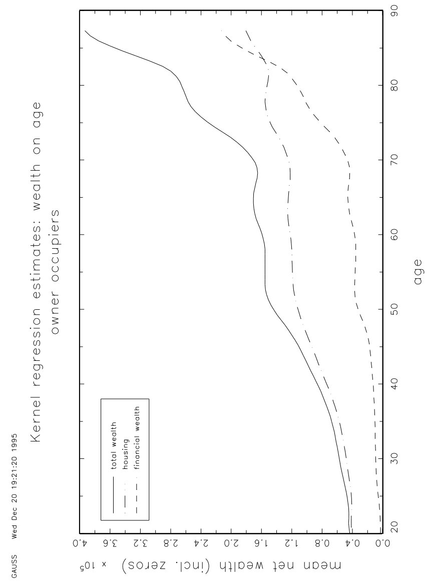
Kernel regression estimates: wealth on age
renters
total financial wealth
mean net wealth (incl. zeros) x 10⁴
age


GAUSS Wed Dec 20 19:21:20 1995
Kernel regression estimates: wealth on age
owner occupiers
total wealth
housing
financial wealth
mean net wealth (incl. zeros) x 10⁵
age