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Consumption and Savings of First Time House Owners: How Do They Deal with Adverse Income Shocks?

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Abstract: We characterize savings behavior around the point of the first house purchase. Using a panel data set with income and wealth information on Danish first-time house owners we document that households save for the down payment, mortgage to the limit, run down liquid assets at purchase, and adjust to adverse income shocks occurring just after the purchase by reducing consumption. We build a model that replicates these observations, show that the preference parameters are identified from the data, and estimate them. Based on the estimated model house buying significantly reduces the ability to smooth adverse income shocks.

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1. Introduction

The canonical life cycle models of consumption and savings describe households as buffer-stocks savers, i.e. they save or run down assets to maintain a target level of wealth to permanent income, in the first half of the working life, after which they start to accumulate funds for retirement. Buffer-stock savers expect to have increasing income; they are moderately impatient, risk-averse and keep a buffer-stock large enough to protect consumption against medium-sized adverse income shocks, but not sufficient to smooth large adverse shocks completely. The leading example of an empirically based model is Gourinchas and Parker (2002) whose work follows from Carroll (1997), and Deaton (1991). Recently, the empirical validity of this description of household savings behavior has been questioned. Jappelli, Padula, and Pistaferri (2006) find that households do not generally save to target what they think themselves is needed for future emergencies, as buffer-stock savers would be expected to do. One reason for this can be that the standard buffer-stock model gives a description on nondurable consumption only. It is, however, an empirical fact that people accumulate durables, in particular housing, in the early part of their life cycle, and this is likely to be important for the description of consumption and savings decisions over a considerable range of the life cycle.

Housing is of special interest because it consumes a significant fraction of the household budget for those entering the owner market. The transition to owner-occupied housing is characterized by requiring a down payment. Moreover, selling the house is associated with considerable transaction costs, and this imposes a commitment on housing expenditure. These features change the consumption and savings path around the time of the house purchase relative to the reference case without housing.

The purpose of this paper is to characterize savings behavior around and in particular just after the point of first house purchase. We do this by exploring a unique panel data set with annual information about income, wealth and imputed non-housing expenditures for a large number of first time house owners in Denmark. The data show that households mortgage to the limit and run down liquid assets when buying their first house. Adjustments to small/medium sized shocks appearing just after the house purchase are concentrated on non-housing consumption. Just after the purchase a 1% reduction in disposable income leads to a 0.7% reduction in non housing expenditure.

We show that these observations can be rationalized with a standard life cycle model extended with housing. The transaction costs associated with selling the house, together with being close to the borrowing limit just after the house purchase, imply that adjustments to medium sized shocks appearing just after the house purchase are concentrated on non-housing consumption. In effect households trade off the desire to own a house with the ability to smooth non housing consumption in the event of facing small/medium sized adverse income shocks just after the house purchase. We also show that the savings path around the point of the house purchase and the consumption response to adverse income shocks just after the house purchase identify the central preference parameters of the model, i.e. the discount factor and the risk aversion parameter. Finally, we estimate these parameters and simulate counterfactual outcomes. We find that house buyers are willing to reduce the ability to smooth small/medium sized income shocks appearing soon after the purchase by 18-32% points.

This paper extends the standard buffer-stock framework, but is also related to three other branches of the literature on consumption and savings behaviour. First, the results presented in this paper are related to the work by Grossman and Laroque (1990) and recent work on consumption commitments by Chetty and Szeidl (2007). In the latter study it is shown that the committed expenditure following from the presence of transactions costs implies that people are more risk averse towards medium sized adverse income shocks than large shocks, since for small and medium sized shocks it is not optimal to incur the transaction costs in order to equate marginal utility of housing and non housing consumption. Our analysis extends the analysis of Chetty and Szeidl (2007) by detailing the savings path around the house purchase, and the response to adverse income shocks. We present a full model of tenure choice and non housing consumption showing how people optimally run down liquid asset and get close to the credit limit leaving them vulnerable to drops in income just after the purchase. We show that this behaviour is consistent with micro data. These features are merely assumed by Chetty and Szeidl (2007).

Second, this paper links to a recent literature on partial consumption insurance. Blundell et al. (2008) shows that households are able to perfectly self-insure against temporary adverse income shocks, but not against permanent shocks. We show that households rationally/intentionally trade away insurance capacity against temporary income shocks when they enter the owner housing market.

Third, the analysis presented here is also related to a literature on the use of housing equity as implicit insurance against adverse income shocks. Hurst and Stafford (2003), Lustig and Nieuwerburgh (2005), and Leth-Petersen (2008) show evidence consistent with behavior where households access housing equity in order to smooth consumption in periods where they face adverse shocks. We show that by borrowing extensively households optimally choose not to have access to this type of self insurance just after the house purchase.

In the next section we present empirical evidence on the savings path around the house purchase and on responses to income shocks just after the house purchase. In section 3 a model of housing and consumption is developed, and section 4 is devoted to calibrating the model. In section 5 the model is simulated in order to establish a set of moments that identify the parameters of the model and that can be calculated from the data. Section 6 goes through the estimation methodology, and section 7 presents the estimation results. Finally, section 8 concludes.

2. Evidence on consumption and savings of first time house owners in Denmark

The data used in this study are merged Danish public administrative registers giving annual longitudinal information on wealth, income, transfers, tax payments, household composition, and characteristics of the dwelling and of the household living in it for a 10% random sample of the population in the period 1987 to 1996. For each person in the sample we obtain information for any partner that he or she cohabits with. The income and wealth information exist because Denmark had a wealth tax in this period, and this part of the data comes from the income-tax register. The income-tax register variables are measured on 31st December each year. An important feature of the wealth data is that it can be divided into a number of categories[1]. In particular, assets and liabilities are possible to separate, and assets can be split into housing assets and liquid assets. This feature enables us to follow how household saving develops around the time of entering the owners market. Because we have access to

[1] The data does not contain information about pension wealth. Pension contributions are not taxable before they are paid out, and so pension funds do not appear on the tax form.

longitudinal information about total income and transfers as well as total wealth it is possible to impute total non-housing expenditure for house owners, cf. Browning and Leth-Petersen (2003). We give more details on this below where we present an event analysis of the effects of an adverse income shock just after the house purchase.

For the purpose of this analysis we focus on a sample of first time house owners where the oldest member is aged 45 or less. We select couples moving into owner occupied housing in 1989-1993. We exclude couples that have not been observed as non-cohabiting at least one year at some point before they buy their dwelling. This selection is introduced to be able to follow the savings path of the couple leading up the purchase. For the same reason we deselect observations where the partner is not the same person with whom our randomly selected person buys a dwelling together with. Some 200 observations where liquid assets are extreme are deselected; specifically, observations where liquid assets have a larger value than the house purchased or where liquid assets are observed as being negative of numerical value corresponding to half the value of the house purchased. Such observations are deselected because they are considered erroneous or because they are considered atypical to an extent that our model would not give a relevant description of their behavior. Finally, conditional on the above selection criteria we include only consecutive observations that span the point of transition from rented accommodation to owner occupied accommodation. This leaves us with a sample of 5,914 households that are observed two to 10 times. In total our data set includes 43,438 observations.

During the period covered by our sample house owners in Denmark can mortgage up to 80% of the house value in mortgage banks. Mortgage banks are specialized banks offering mortgage loans based on underlying mortgage bonds. Mortgage loans use the house as collateral and they are typically cheaper than conventional bank loans. On top of the mortgage loan households are allowed to borrow 15% of the house value for the purpose of buying a house in conventional banks. Also these loans are offered using the house as collateral. House buyers are thus required to provide financing for the remaining 5% of the house value themselves. This is the effective down payment requirement.

The buildup of liquid funds, defined as the sum of all non-housing assets, for the down payment comes out very clearly in the data.[2] Figure 1 plots the savings profile around the time of the house purchase for the observations in our sample. This savings profile is constructed from coefficients obtained from a regression of one period changes in liquid assets relative to the value of the house purchased on a set of dummies indicating the distance in time from the point where the house is purchased and a set of controls for changes in the number of children in the family.

[Figure 1 about here; see end of paper]

Figure 1 shows a clear build-up of liquid assets up to the time of the house purchase. Liquid assets peak the year before entering the house, where average liquid assets relative to the value of the house to be purchased are 4%-points higher than in the year of the house purchase. The households in the sample keep de-accumulating liquid assets after the house purchase, presumably due to initial repairs. Only in the third year after the purchase are liquid assets starting to build up again. Not until period seven after the purchase are liquid assets built up to a level higher than in the year of the purchase. Figure 1 gives a description of the *changes* in the level of liquid assets across time where the reference is the point where the house is purchased. The average value of the house to disposable income is 2.8. In period 2 after purchase, where liquid assets are at its minimum, the mean *level* of liquid assets is 20% of disposable income[3].

One important feature in our data is that house purchases are financed by mortgages, and the mean mortgage to house value is 85%. By law it is only possible to mortgage up to 80%, and the likely reason that we find a larger number is because of the fact that house values are tax assessed, and tax assessed house values are typically lower than the market price. In any case, these numbers do suggest that households in the sample mortgage to the

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[2] We focus on savings rather than imputed non-housing consumption because we do not observed housing expenditures for renters. This implies we cannot separate housing and non-housing expenditure for the households in our sample before they have moved into owner housing.

[3] This, however, covers the fact that median assets to disposable income is 13%, and that 25% of the households hold less than 5% and that 10% of households hold less than 1% liquid assets relative to disposable income.

limit when buying their first house. Many households hold bank debt on top of the mortgage. Mean total debt is 115% of the tax assessed house value in the year of the house purchase.

We now turn to investigate the effect of adverse income shocks for first time house owners. Owner housing imposes a commitment, and this influences the way households smooth marginal utility. Commitments imply that people will respond differently to small/medium sized income shocks than to large shocks, because only when shocks are large will the household find it optimal to incur the transaction costs and adjust the level of housing expenditure, so that the marginal utility of non housing consumption equals that of consumption of housing. We illustrate this in the data by presenting a series of nonparametric regressions of adjustments of liquid assets, debt, and non-housing expenditure on changes in disposable income in period two after the house purchase, the year where the level of liquid assets attain its lowest level. This part of the analysis is based on a subsample of households observed with non-positive adjustment to their income from period 1 to 2, and it will reveal how responses differ depending on the size of the adverse income shock. We interpret negative adjustments in disposable income as an indicator of the size of an unemployment shock.

Figure 2 shows that households reduce liquid assets drastically even for medium sized income shocks. A drop in disposable income of 25% leads to a drop in liquid assets of approximately 30%, and the response tend to be more dramatic the larger the drop in income. This follows from the fact that liquid asset were run down when the house was purchased.

[Figure 2 about here; see end of paper]

Many households mortgage to the limit, hold additional debt, and have limited liquid assets. It is therefore likely that they are close to their borrowing limit. If this is the case then households experiencing an adverse income shock cannot increase debt in order to smooth consumption when the income shock kicks in. Figure 3 shows that negative income shocks are not significantly associated with accumulation of new debt. This suggests that households experiencing adverse income shocks just after they bought a house cannot accumulate more debt, and that once liquid assets have been run down they are left only with the option to reduce non-housing expenditure or to get rid of the commitment by selling the house.

[Figure 3 about here; see end of paper]

We therefore turn to considering adjustments in non-housing expenditure. The data set that we use is based on information available in public administrative registers. Specifically, the wealth and income information is obtained from income and wealth tax registers. We therefore do not have direct information on expenditures. We do, however, have information on total wealth, capital income, transfers, earnings and tax payments. It is therefore possible to impute non housing expenditure according to $\hat{c} = y - \Delta W$, where $\hat{c}$ is imputed expenditure, y is gross income and transfers net of taxes and payments on mortgage loans, and ΔW is the change in wealth from the previous to the current year. The quality of this imputation has been investigated by Browning and Leth-Petersen (2003) who found that imputed expenditure is able to match the level of expenditure obtained by survey for the households in the Danish Family expenditure survey.

Figure 4 shows a regression of the change in log non housing expenditure on changes in the log of disposable income two periods after the house purchase. This graph shows that negative adjustments in disposable income are correlated with negative adjustments in total non housing expenditure. Figure 4 shows that small and medium sized income shocks generate sharp drops in non housing consumption.

[Figure 4 about here; see end of paper]

Cutting back on non housing expenditure is not the only option left. It is also an option to sell the house and get rid of the commitment in response to the unemployment shock, i.e. to sell the house and to adjust to a lower level of commitment. We see few of these responses in our data, but among those where we observe a large adverse income shocks and a move, we find weak evidence of downsizing the commitment. Our analysis focuses on the consumption/savings response to transitory adverse income shocks, and we shall therefore not go further in to this.[4]

3. Model

In this section we propose a finite horizon (life cycle) model of the consumption and savings decision of a household that also engages in the purchase of a large indivisible durable good (a house). The purpose is to show that the data patterns presented in the section 2 are consistent with optimizing behavior in a life cycle framework.

The agent in our model is the couple/household. One of the decisions the agent takes is that of whether to rent or own a house. There is only one type of rented or owned accommodation, and they are identical[5]. The key feature of housing here is its discreteness: it is big and it is not possible to consume just a fraction of it. The agent prefers owning to renting purely for demographic motives. However, given that he buys, the house provides also financial services which we describe below. There are many motives for buying rather than renting. We choose to include all factors that affect the desire to own, such as when you meet your partner or when you have children, in a reduced form utility shock.[6] There is no divorce in our model, so this is a permanent shock. This permanent shock has the role of increasing the utility of owning relative to renting.

When the agent buys a house he establishes a mortgage with fixed payment, X, and duration, M. The fixed payment starts immediately and is defined by:

$$\begin{aligned} &\left(H-D\right)=X(1+\theta+\theta^2+\theta^3+...+\theta^{M-1}), \\ &\text{where } \theta=\frac{1}{1+r}, \\ &X=(H-D)\frac{\left(1-\theta\right)}{\left(1-\theta^M\right)} \end{aligned} \tag{1.1}$$

[4] Results are available on request.
[5] This is a simplifying assumption. Housing could be a continuous choice, cf. Luengo Prado (2006), thereby allowing households to pick the optimal house size. The optimal size of the house is not treated in this paper because the interest is in the consumption and savings behaviour conditional on having bought a house.
[6] Houses with enough space for families may be unavailable on the rental market as in Fisher and Gervais (2007). In our data when couples buy their house, they acquire on average about forty squared meters more than when renting the year before.

where r is the fixed mortgage interest rate, H is the value of the house, and D is the required down payment.

In the model there is only one type of mortgage. Therefore we effectively condition on house buyers mortgaging to the limit. This is a convenient shortcut, but it is a good description of the actual behavior described in section 2. We assume also a perfect real estate market. Since houses do not depreciate, the market rent, R, is determined by an infinite horizon mortgage at the same rate,

$$H = R(1+\theta+\theta^2+\theta^3+...+\theta^{+\infty}) = \frac{R}{r\theta} \quad (1.2)$$

Regarding the savings decision, the interest rate on positive assets is the same as the mortgage rate, r. The interest rate on negative assets is higher at r+Δ, with Δ>0. Finally, our agent is credit constrained and we impose that assets must exceed a lower bound, $\underline{A} \leq 0$.

The problem has two branches, depending on whether or not the agent owns the house at the start of the period. Apart from the decision of whether to buy or sell the house, each period the agent also decides how much to consume given his liquid assets and random income realization. The problem for agents that start the period not owning the house, with n periods left to live, with a stock of liquid assets A, and with a realization y of the exogenous random process for income is

$$V(A,y,z,n) = \max \begin{cases} \max_{A'} U(c) + \beta E_{(y',z')} V(A',y',z',n-1) & if \quad rent \\ s.t.\ (1.4) & \\ \max_{A'} U(c) + z\pi + \beta E_{(y',z')} W(A',y',z',n-1,M-1) & if \quad buy \\ s.t.\ (1.5) & \end{cases} \quad (1.3)$$

$$A' = (1+\tilde{r})\left(A+y-c-R\right) \quad (1.4)$$

$$A' = (1+\tilde{r})\left(A + y - c - D - k^b - X - \tau_1\right) \qquad (1.5)$$

where $\tilde{r}$ depends on A' being positive or negative.

The agent may have received his one-time binary utility shock, in which case $z = 1$ now and forever, increasing by π his utility of owning. Importantly, this extra utility only accrues if he owns the house. If he has incurred his permanent shock but does not own the house he does not get the extra utility. Nevertheless his state has changed, because although he is not getting his extra utility yet, now he *can* get it if he buys a house. Future income and the arrival of the utility shock are uncertain.

If the agent decides not to buy, utility is maximized subject to the period-to-period budget constraint given in (1.4). The resources available to him are given by liquid assets at the beginning of the period, A, together with income realization, y. These resources are distributed on non housing consumption, c, rent, R, and liquid assets passed on to the future A'.

If he buys a house utility is maximized subject to constraint (1.5). The agent moves in immediately and saves the rent, but has to put a down payment, D, pay transaction costs, k^b, as well as the first mortgage installment. Owning a house introduces an additional state variable, m, the number of periods left until the mortgage ends, which starts at M-1 since the first installment of X is paid immediately at purchase. Finally, buying a house implies immediate additional expenses on refurbishing which are summarized in the parameter τ_1. Here their amount and time pattern are exogenous and we allow for a small number of periods where they can occur.

For the house owner the value function is labeled W. His current decisions are how much to consume, and whether or not to sell his house. The dynamic problem in this case includes the additional state variable, and is given by:

$$W(A,y,z,n,m) = \max \begin{cases} \max_{A'} U(c) + \beta E_{(y',z')} V(A',y',z',n-1) & \textit{if} \quad \textit{sell} \\ s.t.\ (1.7) & \\ \max_{A'} U(c) + z\pi + \beta E_{(y',z')} W(A',y',z',n-1,m-1) & \textit{if} \quad \textit{keep} \\ s.t.\ (1.8) & \end{cases} \qquad (1.6)$$

$$A' = (1+\tilde{r})\left(A + y - c - R - X - k^s + H - B(m-1) - \tau_j\right) \quad (1.7)$$

$$A' = (1+\tilde{r})\left(A + y - c - X - \tau_j\right) \quad (1.8)$$

If the agent sells the house he must liquidate his remaining mortgage debt, B(m-1), obtaining net equity H-B(m-1).[7] The current mortgage payment X is fully recovered in the equity realized by selling the house. Selling the house implies a transaction cost k^s. The agent moves out of the house immediately and so pays rent this period and loses the extra utility of owning the house if his utility shock has occurred. This is summarized in the budget constraint (1.7). If, on the other hand, the agent decides not to sell, he must pay the mortgage on top of his non-housing expenditure, cf. (1.8). In both problems there is an extra parameter τ_j which stands for exogenous refurbishing expenses which take place in the first j periods after owning the house. Note that if the agent starts the period owning the house he must have already paid at least one mortgage payment X and incurred at least the first refurbishing expense τ_1. Finally, the agent is restricted in his transactions. The period in the model is one year, and it is conceivable that agents will change house, sell the old and buy a new house, within a year. That is not allowed here. He can only make one house transaction per period. If he sells, he has to rent at least the current period.[8]

The principal added feature of the model presented here relative to the standard model is the house buying decision. In the model the motive for buying a house is summarized by the utility shock, which, given our data, we interpret as a demographic motive.[9] In a number of previous models of housing and consumption, households have been attracted to own because of a financial gain from owning.[10] In our model such motives are shut down. To see this compare the present value of the financial cost of renting a house for a number of periods, with the cost of buying, living in the house, and selling it. The agent buys a house, pays the

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[7] The evolution of m is censored from below at zero, so that if today m=0, we do not have next period m = -1. These details are self evident and we prefer not to write max (m-1,0) on the right hand side value function.

[8] This *is* a constraint for households with housing equity. It could be optimal to sell and buy in the same period in order to extract equity.

[9] This motive is also included in the model of Banks et al (2004).

[10] In Gervais (2002) there are tax benefits from owning (deductability of mortgage interest payments for tax purposes). In Chambers, Garriga, and Schlangenhauf (2005) the mortgage rate is 3% lower than the interest rate on other assets, making the return on owning a house better than on bonds. In Sheiner (1995) a owned house provides cheaper housing services than rental due to landlord/tenant moral hazard.

full mortgage without interruption for M periods, and lives in the house n more years before selling and moving back to renting. The two scenarios have the following net present values of the cost of renting (CR) and the cost of buying (CB):

$$CR = \left[R + \theta R + \theta^2 R + .. + \theta^{M-1} R \right] + \left[\theta^M R + ... + \theta^{M+n-1} R \right] + \theta^{M+n} R \quad (1.9)$$

$$CB = D + k + \left[X + \theta X + \theta^2 X + .. + \theta^{M-1} X \right] + \left[0 + ... + 0 \right] + \theta^{M+n} \left[R - H + k \right] \quad (1.10)$$

After some algebra, and using the definitions of R and X, we obtain the difference between the two present values at

$$CB - CR = k\left(1 + \theta^{M+n}\right) > 0 \quad (1.11)$$

so that buying a house carries a net positive financial loss as long as there are transaction costs.[11] This implies the agent will not buy the house for financial gain. Instead he does it because he has a utility gain which summarizes other motives external to the house itself.

In reality households do have a longer term financial advantage by owning rather than renting, since housing equity provides access to credit, as emphasized by Hurst and Stafford (2003), Lustig and Nieuwerburgh (2005), and Leth-Petersen (2008). This motive is, however, longer term in nature. Households mortgage to the limit and have no equity to access in the first years after the purchase.

In the model there is no feature allowing the household to establish second mortgages for consumption purposes. The only way to access the equity in the model is by selling the house. In fact, this is what happens towards the end of the life cycle: The house must eventually be consumed, and to do this the agent may buy and sell the house strategically several times in order to consume the equity trapped in it. Each time they sell and buy back the house, they release equity in the amount of the difference between, on one hand, current equity and, on the other hand, the down payment plus the transaction costs. If transaction

[11] We can have capital gains in this algebra without any change in the conclusion, as long as the market rent evolves in the exact same way as the capital gain on the house.

costs are very high, they will sell it only once, within a reasonable time distance of death.[12] If these costs are low the couple will sell and buy back to release equity, perhaps several times over the life cycle. The house therefore provides financial services, but that is because the agent must buy it in the first place. Alternatively, this feature could have been included by allowing for second mortgages where the proceeds can be used for consumption purposes. This is not crucial for our purpose since we focus on the few periods after initial purchase where no significant equity has yet been accumulated.

The model presented here extends the model studied by Gourinchas and Parker (2002), where they examine consumption and savings decisions over the life cycle. Their model comes out as a special case of our model by closing down the tenure choice and the associated financial decisions. This is the benchmark against which to measure the housing problem from the consumption and savings perspective. It is worth emphasizing also, that our model is a very parsimonious way of introducing housing in the life cycle framework.[13]

4. Calibration

In this section we set a benchmark parameterization of the model. We use this in section 6 to examine the impact of changes in key parameters to determine which moments provide identification for our estimation exercise. Some parameter values are chosen from the literature but, where appropriate, we also use our data for guidance. There are many parameters in this model but our simplifying assumptions pin down a good number of them. The mortgage interest rate is 4% and the interest rate penalty on negative assets is set to Δ=1.5%.

The value of H is set at 2.85, which is about three times average income, since average (normalized) income is never too far from 1.[14] Then, since the rent is defined by the infinite horizon mortgage, knowing H and r we know R. Transaction costs for the house are set at 3% of H for buying and 3% for selling. This is comparable to US measurements.[15] The mortgage

[12] Ortalo-Magne and Rady (2002) explore reverse implications of tenure lenght. Agents that plan to live in a house for a long period are more likely to buy. In our model tenure length depends on shocks and costs.

[13] Assumptions about the income process and borrowing constraints exist already in the consumption literature. All we add is the utility shock, the mortgage, and the fact that you can buy *and sell* the house. We do not model the optimal timing of purchase, but rather condition on it via the utility shock.

[14] H is calibrated from data on the distribution of house valuations relative to disposable income (see appendix).

[15] Chambers, Garriga, and Schlangenhauf (2005) have 3% costs for buying and 6% for selling for the US.

length is set at the unique value of M = 25 years. The down payment D is set at 5% of the value of the house. Since in our data agents borrow up to the limit of 15% of the value of the house at first purchase in a separate bank loan, in addition to the mortgage limit of 80% of the value of the house, we just set the down payment at 0.05×H and simplify the financing options.[16]

We need to specify the credit constraint. In Gourinchas and Parker (2002) the effective lower bound on assets is zero since their model has a positive probability of zero income at every period and so it is optimal never to have negative assets. In Laibson, Repetto and Tobacman (2007) the agent faces a constraint on liquid assets given by a fraction λ of *current* income $\underline{A}_t \geq -\lambda Y_t$, where $\lambda = 0.318$. In our model this translates roughly into having a fixed lower bound on liquid assets of 0.3 - or around 10% of the value of the house. We set the lower bound on assets at the time-independent negative number, $\underline{A} = -0.1H$.

The vector τ is calibrated to accommodate the average fall in liquid asset holdings in period 1 and 2 after the purchase that was observed in figure 1. It turns out that without this device, in the model assets drop for a single period at purchase and start increasing immediately. There is no information in the data informing us about the reasons for this protracted drop except that we know that it is not due to the arrival of children as this is corrected for in the construction of figure 1.[17] Bover and Estrada (1994), however, presents evidence that Spanish household's increase durable expenditure when buying a new house. Our vector τ has four elements for the first four periods of house ownership, respectively, 0, 0.1, 0.085, and 0.05.[18]

We still lack the value of π, the stochastic process for z, and the income process. The income process is assumed to follow

$$Y_{it} = Y_{it}^{P} U_{it} \tag{1.12}$$

[16] The extent of the mortgage is heterogeneous but 60% of agents have a mortgage to house value ratio bigger than or equal to 0.81. Allowing for a down payment *bigger* than the minimum of 5% does not change the outcome of the model since the interest rate earned on assets is the same as the mortgage rate, and so keeping that extra cash liquid is always a dominant decision. The agent always puts up the minimum down payment.

[17] In the data we control for the arrival of children, but not for how much children cost, nor for how these costs evolve as children get older.

[18] These values are chosen such that for the benchmark parameterization where β=1/(1+r) the asset path after purchase resembles the data. The values are **not** chosen to target the values of A/H before purchase or the asset drop at purchase, which we use at the estimation stage.

where Y_{it}^{P} is a permanent component and U_{it} is a transitory component.

The permanent component Y_{it}^{P} is assumed to be deterministic and anticipated. Generally, permanent income is subject to shocks as well, and such shocks can trigger adjustments of the housing stock. Our focus is on the interplay between the committed housing expenditure, liquid assets and access to credit in the short run following the transition from renting to owning. Permanent revisions to income would introduce additional variation making our inference harder without obvious gains, and so we exclude them. The permanent component is calibrated to match the average life cycle profile from the data.

The calibration of the permanent component uses two pieces of information from our data, the average profile of disposable income for our sample of households where the oldest member is below 46 years of age, and the average profile of disposable income based on a gross sample without any de-selections. [19] We use both these pieces of information to construct our lifetime profile. The model starts at age 17.[20] In our data average income at 20 equals 73% of income at age 25. Our agents live to the age of 75, with 10 years of retirement. We do not model retirement in any particular way, except by making the income profile flat at 80% of their income at age 65. This is in a rough ballpark for our sample**.** Our profile has the value 0.73 at age 20, rises to 1 at age 25, then rises to 1.2 at age 45 and to 1.22 at age 50, and then falls to 1.18 by age 65, with a retirement period of 10 years at 0.944.[21] The overall profile is a smoothed curve fitted around these points.

The transitory component U_{it} is more complicated to construct. We have information on gross income, disposable income, earnings, and on length of unemployment.[22] We first measure three properties of this data, the standard deviation, the mean and the first order serial correlation. The unconditional standard deviation of the log of disposable income is 0.26 while that of unemployment is 0.15. The unconditional mean of unemployment is

[19] The numbers are presented in appendix 2.

[20] In our data we have *one* household where the oldest member is 19 years old at point of purchase, and 13 households with 20 years of age. We start the model at age 17 to try to generate the age profile we see in the data. We set income of 17 years olds at about 40% of income at age 25.

[21] This life cycle profile is – consistently with a more progressive tax system - flatter than the one constructed by Gourinchas and Parker, where from the age of 25 to the age of 45-50 income increases by 40%.

[22] Unemployment is a measure of time in the unit interval. If the variable has a value of 0.7 this means that the couple was unemployed for a combined 30% of the time during the year. This can be divided asymmetrically, with one spouse working full time and the other being unemployed 60% of the time.

0.0892. The serial correlation is 0.47 for unemployment, 0.47 for disposable income, 0.51 for gross income, and 0.40 for earnings. We look at the correlation between gross income (and disposable income) and unemployment and reassuringly find that these measures are significantly negatively correlated.[23]

We construct the U_{it} process to have a first order serial correlation around 0.5. As in Gourinchas and Parker this transitory part is the product of two components. Both are discrete first order Markov processes. The first one generates small variations around the lifetime profile, and is a seven point discretization of a log normal AR1 process with serial correlation of 0.5 and standard deviation of 0.02. This results in a support vector with a lower value of 0.933 and an upper value of 1.072.

The second part is constructed to produce larger unemployment shocks. Because in our data unemployment is measured as a percentage of time, it is bounded below by zero and above by one, and so it cannot be defined as a log normal shock.[24] We therefore break the unit interval in discrete subintervals and directly measure Markov transition matrices for unemployment from data values for adjacent periods.[25] We pick as our matrix the transition between periods one and two after the house purchase.[26] The resulting process has unconditional expectation equal to 0.9067, and a support vector with a lower bound at 0.45 and an upper bound at 1.

The final process is the Kronecker product of these two transition matrices and support vectors. Our income variable never drops down to zero, but given the commitment in housing (both in rent and in mortgage) it is the lower of these values that plays the role of zero by boosting risk aversion. Nevertheless, with our process, even at the lowest value of income we are still strictly above commitments. The final step in the specification of the income process is to renormalize it by shifting the entire path such that it has unconditional expectation equal to one at age thirty, which is the average age of house purchase in the sample, to be consistent with the average ratio of the house value to disposable income at purchase which is 2.85.

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[23] Regressing log of gross income on the unemployment measure yields a coeffcient of -0.57, and regressing the log of disposable income on unemployment yields a coeffcient of -0.33, both strongly significant.

[24] Gourinchas and Parker have a log normal shock times a binary process taking the value zero with probability q and value one with (1-q). This binary variable is here replaced by our more detailed unemployment process.

[25] The unemployment process is not necessarily independent of the house purchase decision. Home owners have less flexibility in choosing jobs and their unemployment spells are longer. It is not hard to add this feature to our model, although for our purposes it is not necessary.

[26] We pick period 2 after the house purchase because in the data it is at this point that assets are at their lowest.

We now need to define a stochastic process for z, and a value for π. The value for π is selected for its usefulness. If we set it to zero, the house is never bought. If we set it very high agents will save in anticipation of the utility shock so that they can buy immediately and do not lose any period of this extra utility from housing. This, however, seems unrealistic. There is a range which has the property of making the decision dependent on the path of income and on the timing of the utility shock, and we experiment until we have a value that is in this range. After some experimentation we set $\pi = 6*(\log(0.5+k^b)-\log(0.5))*(r/(1+r))$.

In the appendix we show the data distribution of households by the age of their oldest element at the moment the house is bought. The highest density is at age 27, and 50% of households in our sample have bought by the age of 29, and 80% have done so by the age of 34. Our stochastic process for z is a smoothed curve fitted using a fourth order polynomial on the conditional density generated by the age distribution in the data.

5. Estimation

Conditional on the calibration presented in the previous section we estimate the discount rate and the curvature of the utility function. These two parameters are estimated by the method of simulated moments (MSM), i.e. the parameters are chosen to minimize a quadratic form in the vector of moments:

$$J = (m(\eta,\beta) - m) \times V^{-1} \times (m(\eta,\beta) - m)',$$

where $m(\eta,\beta)$ are the moments simulated from the model and m are moments measured from the data. The simulated moments are calculated by simulating 11 time series observations for 15,000 artificial agents, and then calculating the moments from here. The weighting matrix, $V = \left(1+\frac{1}{n}\right)W$, where W is the covariance matrix of the data moments obtained by bootstrapping. The bootstrap method picks individuals rather than observations. It creates one thousand random samples constructed with replacement from our panel of 5914 households, where each sample contains the same number of households as in the original sample. Finally, the number n equals 15,000/6,000 which is approximately the ratio of the number of agents in the artificial data to the number of agents in actual data. This factor corrects for the simulation error.

In order to estimate (η, β) we match three moments. In the following section we will show that these three moments identify the two preference parameters. Given that we use three moments for estimating two parameters the model is over-identified. If the model is incorrect some of the simulated moments will not match the corresponding moments calculated from the actual data. Therefore *J* can be evaluated as test statistic for over-identifying restrictions that are chi-square distributed with 3-2=1 degree of freedom. If the moments calculated from the simulated data match the data moments, minimization of *J* will provide consistent and efficient estimates of the parameters.

6. Moments identifying the parameters of the model

The purpose of this section is to show that the central preference parameters of the model, the discount factor and the curvature parameter of the utility function, are identified from three moments that we can measure in the data. The three moments are: the average level of liquid assets at the beginning of the period of the house purchase, the average drop in liquid assets relative the house value at the point of the house purchase, and finally the response of total expenditure to a change in income in period 2 after the house purchase. We consider the response in period two since this is the year when liquid assets are at their lowest. The response is measured as the slope coefficient from a regression of total expenditure growth on income growth and the moment that we match is the slope coefficient α_1.

$$\frac{\left(C_{i,t} - C_{i,t-1}\right)}{C_{i,t-1}} = \alpha_0 + \alpha_1 \left(\frac{\left(Y_{i,t} - Y_{i,t-1}\right)}{Y_{i,t-1}} \right) + \varepsilon_{i,t}$$

To show that these moments provide identification we simulate the model for different values of the discount factor, β, and the curvature parameter, η, and calculate the value of the three moments for each of these cases. For doing this the dynamic programming problem is solved for the selected parameter values. Then an 11-period panel of 15,000 individuals is generated, and the moments are calculated from this simulated panel. Each experiment contains the exact same realization of the income and unemployment shocks and all individuals are initialized with zero assets at the youngest age in the model. Results are presented in figure 5.

[figure 5 about here]

Each panel in figure 5 shows the association between each of the three moments (on the vertical axis) and η (on the horizontal axis), for three different values of a parameter that we denote by $\beta-\text{factor}$, or β_F.[27] β_F multiplies the reference case where the discount factor balances the interest rate, i.e. $\beta=1/(1+r)$. If β_F is one, then $\beta=1/(1+r)$, and if the $\beta-\text{factor} > 1$ then $\beta>1/(1+r)$. The values of η and β_F for which simulations are shown are chosen strategically in the neighborhood of where the MSM criterion is minimized.

The top panel in figure 5 shows how the first moment, the level of assets one period before the purchase relative to the house value at purchase, varies with η and $\beta-\text{factor}$, and shows that the value of the moment changes as both η and $\beta-\text{factor}$ change. The level of liquid assets one period before the house purchase brings information that is relevant for both parameters. In economic terms, the level of liquid assets is a result of both risk aversion and discounting. Being more patient increases the level of liquid assets, because the households are willing to postpone consumption in order to build up liquid assets. There is a nonlinear association between the curvature parameter and the level of liquid assets. This reflects that as households become less risk averse and approach linear utility (η=0), marginal utility of housing becomes larger relative to the marginal utility of non-housing consumption. This means that households are more willing to postpone non-housing consumption in order to satisfy their current housing needs. The asset level initially declines with η and then starts to increase again. Assets initially drop as η grows towards 1.4. At this range the household becomes increasingly less willing to postpone non-housing consumption in order to be able to purchase the house. As η grows even bigger the level of assets increases again, but now the precautionary motive dominates. Non-housing consumption now has high value relative to housing, and assets are accumulated to buffer adverse income shocks so as to avoid drops in

[27] $\beta_F=(1.0025,\ 1.0035,\ 1.0045)$

non housing consumption in the event that income drops. This is done by postponing the house purchase.

The second panel in figure 5 shows the corresponding simulations for the second moment, the drop in assets around the period of the house purchase. The main part of the asset drop reflects the down payment, which is set exogenously at 5% of the house value. The size of the drop deviates from 5% because the decision time-unit of the model is discrete. This implies that the measured asset drop around the purchase also captures some part of the accumulation immediately before and immediately after the purchase. Also, this moment varies with both η and β although it tends to be constant over most of the considered range of η. This means that the magnitude of the drop is primarily related to the discount factor. The lines in this second panel are non monotonic. The absolute value of the asset drop gets smaller as the agent of the model becomes more patient, because patient individuals build up more liquid assets before the purchase. At high values of η the absolute value of the drop is smaller because more assets are accumulated prior to the purchase to accommodate the precautionary motive getting more important.[28] At the lower end of the η range the absolute value of the asset drop increases as η gets smaller. This reflects that as the agent gets less risk averse she is more willing to decrease liquid assets holding and be left with a smaller buffer to cushion adverse income shocks after the house purchase on the one hand, but on the other hand (and a dominating factor) she is more willing to intertemporally substitute consumption which makes her save more in order to buy the house earlier.

The third panel shows simulations for the third moment, the consumption adjustment to income drops. This moment is highly responsive to movements in η but is relatively unaffected by variations in the discount factor. This moment captures the risk trade-off that the agents of the model are engaging in: the risk of having to decrease consumption in the event of an adverse income shock against the possibility to lower marginal utility of housing. The fact that this moment mostly varies with η but not with β means that there is

[28] With a high value of η, consumption is depressed before purchase which increases assets. In addition, the agent tends to buy later which also contribute to increasing both the level of assets and income. All of these factors increase the right hand side of the balance sheet, see (1.5), and therefore increase $A_{t+1} - A_t$, or, equivalently, reduce the absolute value of the drop.

clear identification of the two parameters of the model. Having identified η from this moment the remaining two moments are left for identifying β.

7. Results.

This section reports the results from estimating the model. The principal benefit of estimating the structural model is that it facilitates calculating counterfactuals, and this enables us to calculate the counterfactual consumption response to an adverse income shock in period 2 after the house purchase. This moment is the focus of our interest because it quantifies the risk trade off that households engage in when entering the owners market: To be able to purchase the house liquid funds are first accumulated to meet the down payment requirement and then run down aggressively at purchase and two periods further on. This ~~is~~ entails a risk that non-housing consumption must be adjusted if adverse income shocks appear shortly after the house has been bought because little consumption insurance capacity is left.

The model is estimated by SMS. The SMS-criterion is minimized at the following parameter values: $\beta = 1.0035 * 1/(1+r) = 0.9952$, and $\eta = 1.25$. Standard errors of the parameter estimates are $s.e.(\beta, \eta) = (0.0014,\ 0.7477)$. At this combination of parameter values $J = 3.03$. The estimated consumption response is $[\partial c/\partial y]_{\text{Estimated}} = 0.4331$. In this case we are interested in finding out the counterfactual consumption response for the case where the household has not and will not buy a house.[29] This moment, $[\partial c/\partial y]_{\text{CF}} = 0.3546$, is lower than the estimated response by about 18%. The difference between the estimated moment and the counterfactual quantifies the value that households attach to the risk trade off that is the focus of our analysis.

The difference between the estimated response and the counterfactual appears relatively small, and seems to suggest that households do not attach much value to the risk of having to decrease non-housing consumption if income drops shortly after the house purchase. Note, however, that the estimated response $[\partial c/\partial y]_{\text{Estimated}} = 0.4331$ is quite different

[29] This is done by simulating the model with a negative value of π, keeping everything else constant. We first run the model with the house and extract the distribution of ages at which agents buy. Then we run the model with $\pi<0$ and pick each agent at the same age at which he bought the house in the unrestricted model.

from the response estimated from on actual data which is $\left[\partial c/\partial y\right]_{\text{Data}} = 0.7262$, yet the test for the overidentifying restriction is passed. This has to do with the measurement of our total expenditure measure. $\left[\partial c/\partial y\right]_{\text{Data}}$ is based on the imputed measure of c implying that this moment is measured imprecisely in the data. The consequence is that this moment is given little weight in the estimation procedure. This is unfortunate since this moment is important for identifying η. At the same time, while the SMS-criterion is minimized at the particular parameter set listed above, the SMS-criterion is very close to its minimum at a small range of parameter values in the vicinity of the minimum.

Table 1 shows a range of combinations of (η, β_F), including the actual minimizing set, that is close to minimizing the SMS-criterion. This table gives a sense of the region of optimality.

[table 1 about here]

Table 1 shows that for the set of parameter values $\beta = 1.0020 * 1/(1+r)$ and $\eta = 0.8$ $J = 4.29$, which is very close to the minimum. This parameter set yields an estimated consumption response $\left[\partial c/\partial y\right]_{\text{Estimated}} = 0.6538$ which is much closer to the corresponding data moment. Picking this estimated parameter set corresponds to putting more weight to the consumption response moment in the estimation procedure, and in this setting the counterfactual differs significantly, $\left[\partial c/\partial y\right]_{\text{CF}} = 0.4425$, corresponding to a 32% drop in the self-insurance capacity. The difference between the two cases illustrates the housing/consumption-risk trade off: when agents become less risk averse they take bigger risks in terms of having to reduce non-housing consumption in the event of an adverse income shock soon after the house purchase.

8. Conclusion

We present a stochastic life cycle model of consumption and tenure choice and estimate the central preference parameters on a rich data set with almost 6,000 first time house owners in

Denmark. Introducing housing changes the optimal savings path for a considerable period surrounding the time of the purchase. Households save for the down payment, optimally mortgage to the limit, and run down liquid assets to a relatively low level when purchasing the house. Because housing transactions entail transaction costs the ability to smooth adverse income shocks just after the house purchase is affected. Buying a house reduces the ability to smooth medium sized income shocks by 18-32% points for a period following the transition into the owners market. This suggests that first time house owners get close to their borrowing limit, but in this context it is an anticipated and self-imposed constraint reflecting a housing/consumption risk trade off that households' make when they buy their house.

The results from this paper add to the existing consumption and savings literature in at least two dimensions. First, we develop the standard life cycle model to incorporate tenure choice, and this yields a more realistic description of consumption and savings behavior in the first half of the life cycle. The model is estimated using a unique Danish data set with panel information on wealth, income and tenure choice for about 6000 first time house buyers. We show that a particular set of consumption and savings moments associated with the house purchase identify the central preference parameters of the model. Second, we identify a new risk trade off where households trade off the desire to own a house with the risk of not being able to smooth non housing consumption in the event of facing medium sized adverse income shocks soon after the house purchase. This suggests that first time house owners are left with limited ability to self insure even transitory adverse income shocks for some periods after the house purchase.

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Appendix 1: Parameter estimates used for constructing figure 1.

Table A1. Parameter estimates from the regression of changes in liquid assets relative to house value at time of purchase on time from purchase dummies and controls for children.

Dependent variable: $\Delta(\text{liquid assets/house value})$	Parameter estimate		Standard error
Dum, 4 years before purchase	0.0049		0.0052
Dum, 3 years before purchase	0.0108	**	0.0038
Dum, 2 years before purchase	0.0111	**	0.0024
Dum, 1 year before purchase	0.0111	**	0.0020
Dum, year of purchase	-0.0340	**	0.0025
Dum, 1 year after purchase	-0.0105	**	0.0018
Dum, 2 years after purchase	-0.0052	**	0.0017
Dum, 3 years after purchase	0.0031	*	0.0017
Dum, 4 years after purchase	0.0076	**	0.0021
Dum, 5 years after purchase	0.0013		0.0027
Dum, 6 years after purchase	0.0054	*	0.0032
Dum, 7 years after purchase	0.0049		0.0050
Dum, child 4 years before	-0.0094		0.0138
Dum, child 3 years before	-0.0187	*	0.0104
Dum, child 2 years before	0.0021		0.0052
Dum, child 1 year before	-0.0063		0.0051
Dum, child in year of purchase	-0.0053		0.0057
Dum, child 1 year after	-0.0046		0.0037
Dum, child 2 years after	-0.0013		0.0039
Dum, child 3 years after	-0.0088	**	0.0038
Dum, child 4 years after	-0.0006		0.0049
Dum, child 5 years after	-0.0023		0.0062
Dum, child 6 years after	0.0082		0.0080
Dum, child 7 years after	-0.0221	*	0.0133

Appendix 2: Moments from The Data Used for Calibration

In this appendix moments from the data that we use for calibrating the model are described

Item 1: Distribution (percentiles) of House Valuations relative to Disposable Income.

Table A2.1. Distribution of house values to disposable income at time of purchase

Dens	10	20	30	40	50	60	70	80	90
X=HV/Y	1.63	2.02	2.30	2.55	2.79	3.03	3.31	3.69	4.27
ΔX	0	0.39	0.28	0.25	0.24	0.24	0.28	0.38	0.58

Item 2: Distribution of the house buyers by the age of the oldest person in the house at the moment when they buy their house. The utility shock is calibrated to match the distribution of age of the oldest person in the house at the moment when the house is bought.

Table A2.2. Distribution of age of house buyer at time of purchase

Dens	10	20	30	40	50	60	70	80	90
Age	24	26	27	28	29	31	32	34	37

Item 3: Average Income profile

For calibrating the permanent component of income in the model we need information on the average income profile over the life cycle. The data set analyzed in the paper covers only households aged less than 46. The income profile for this sample is given in table A2.3.

Table A2.3. Average disposable income for sample <46 years

Age	25	30	35	40	45
1000 DKK	166	183	192	194	~200
%	1	1.10	1.16	1.17	1.20

To get information covering the entire working life we calculate average disposable income before making any deselections. Average disposable incomes across the life cycle for this gross sample are presented in table A2.4.

Table A2.4. Average disposable income for sample <46 years

Age	20	25	30	35	40	45	50	55	60	65
1000 DKK	114	157	176	189	197	200	193	189	200	196
%	0,73	1	1.12	1.20	1.25	1.27	1.23	1.20	1.27	1.25

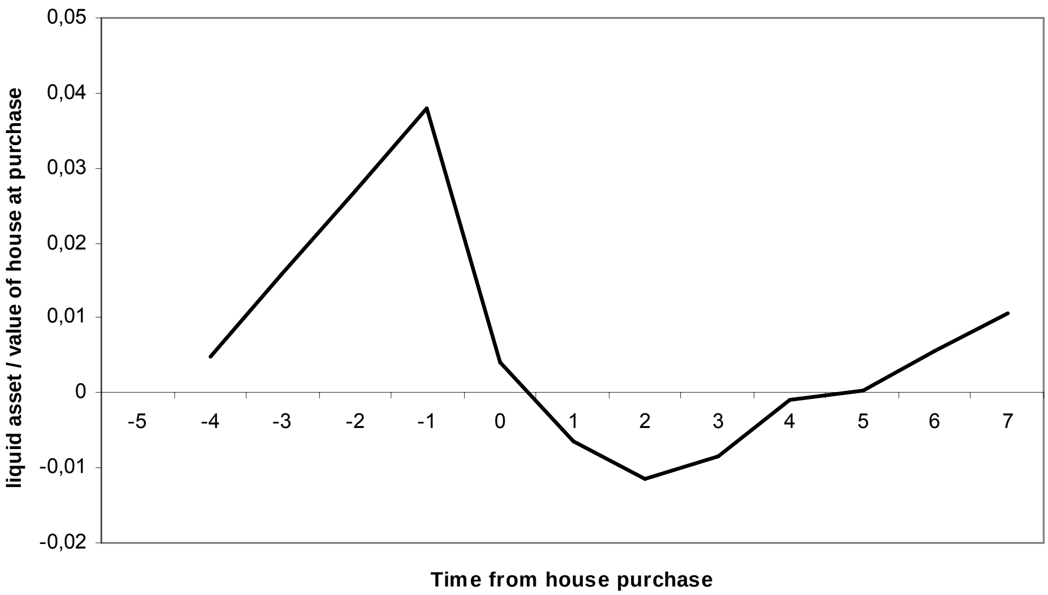
Item 4: Unconditional standard deviations of unemployment, earnings, gross income, and disposable income. This information is used for calibrating the transitory component of the income process.

Table A2.5. Unconditional standard deviations of unemployment, earnings, gross income, and disposable income.

	Unempl. degree	log(earn.)	log(gross inc.)	log(disp. inc.)
Standard deviation	0.15	0.61	0.32	0.26

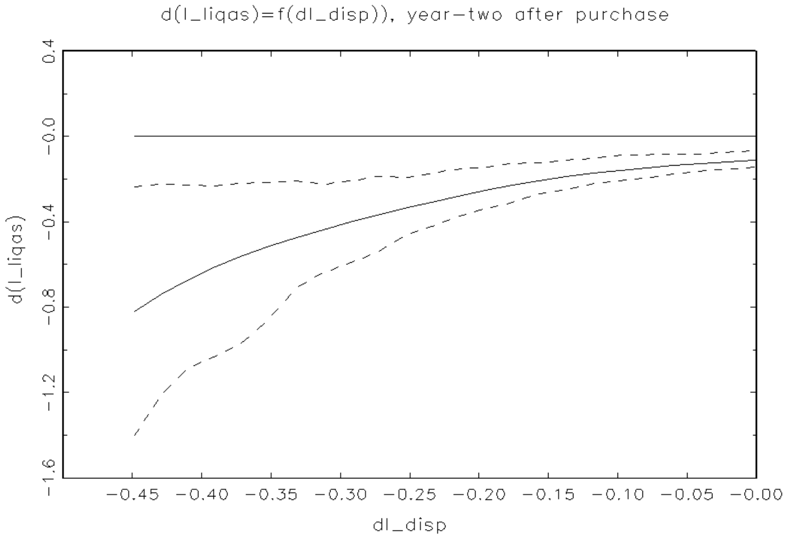
Figures to be inserted in the text

Figure 1. Liquid assets relative to the house value against time from house purchase.



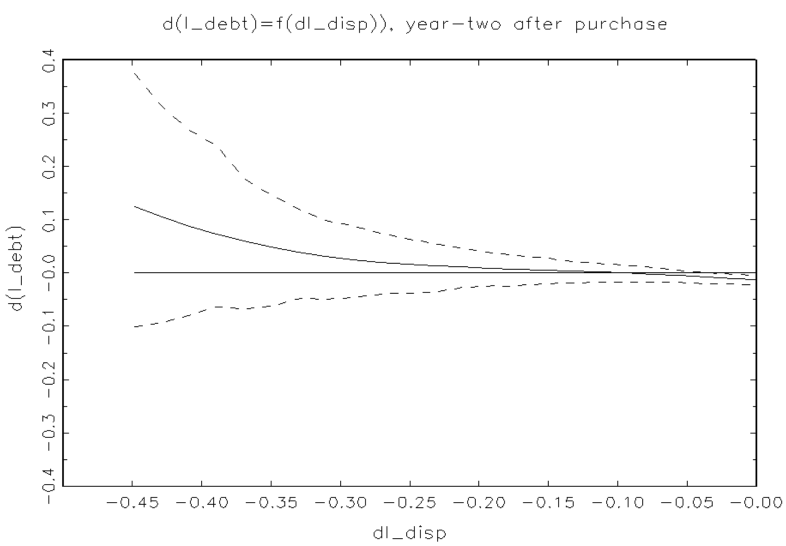
Note: Parameter estimates used to construct this figure are presented in table A1 in the appendix.

Figure 2 Nonparametric regression: $\Delta \ln(\text{liquid assets}) = f\left(\Delta\ln(\text{disposable income}\right)$



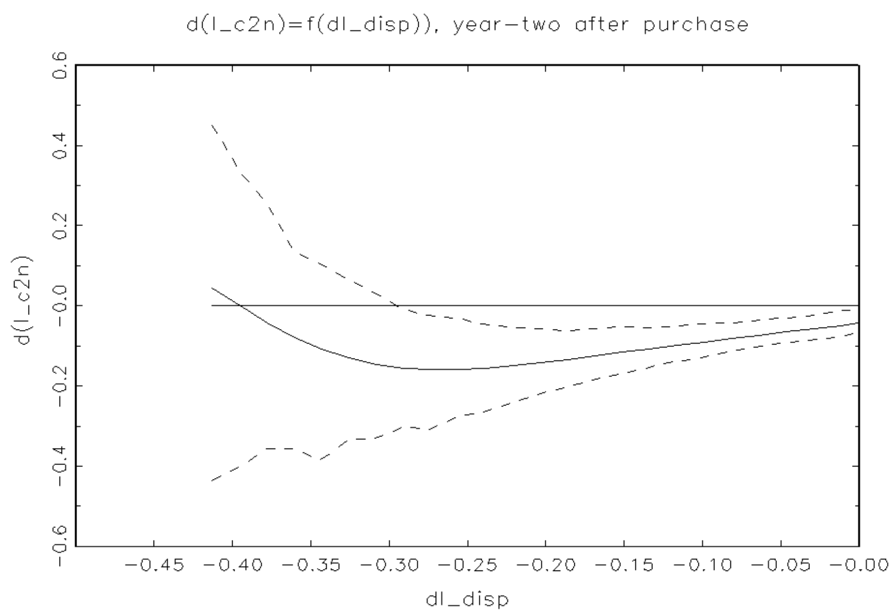
Note: The graph presents a weighted local linear regression estimated using Fan's (1992) estimator. Confidence intervals are 2.5 and 97.5 percentiles of the bootstrap distribution based on 1000 re-samples.

Figure 3. Nonparametric regression: $\Delta \ln(\text{debt}) = f\left(\Delta\ln(\text{disposable income}\right)$



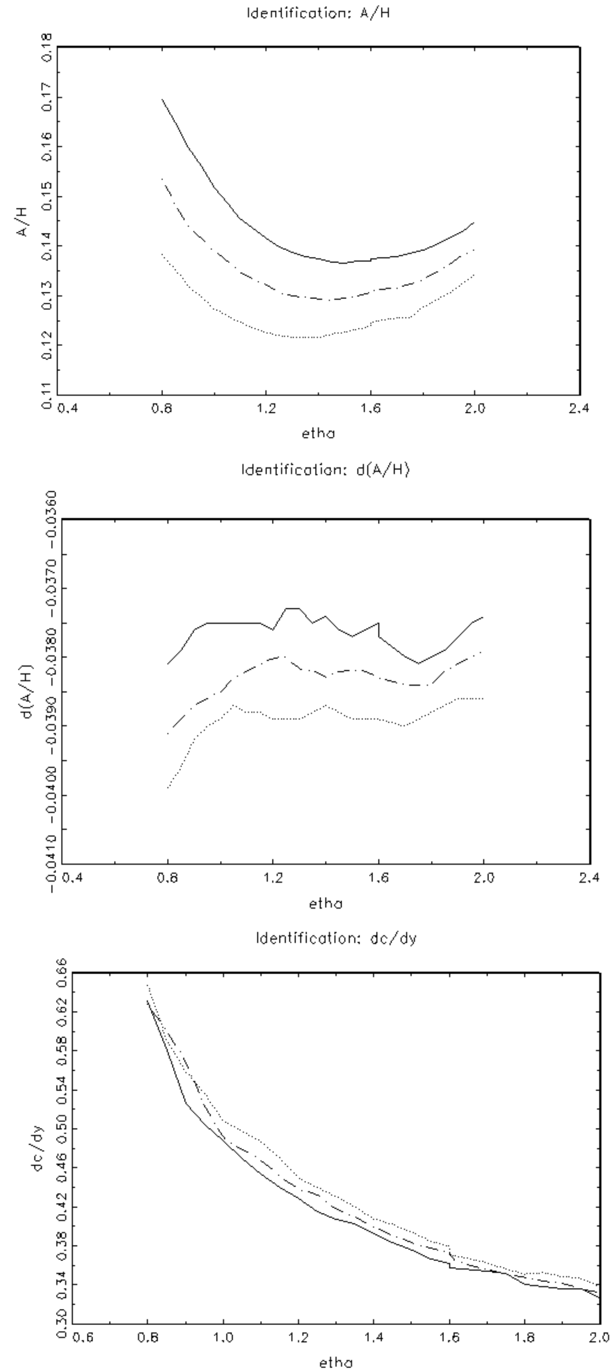
Note: The graph presents a weighted local linear regression estimated using Fan's (1992) estimator. Confidence intervals are 2.5 and 97.5 percentiles of the bootstrap distribution based on 1000 re-samples.

Figure 4: Nonparametric regression: $\Delta \ln(\text{expenditure}) = f\left(\Delta\ln(\text{disposable income}\right)$



Note: The graph presents a weighted local linear regression estimated using Fan's (1992) estimator. Confidence intervals are 2.5 and 97.5 percentiles of the bootstrap distribution based on 1000 re-samples.

Figure 5. Simulation of moments for different values of β and η.



Note: Dotted line: $\beta_F = 1.0025$. Dashed line: $\beta_F = 1.0035$. Solid line: $\beta_F = 1.0045$

Tables to be inserted in the text

Table 1. combinations of (β,η) minimizing the J-criterion and the associated moments.

β	η	A/H	ΔA/H	∂c/∂y	J	[∂c/∂y]$_{CF}$
1.0015	0.70	0.1296	-0.0412	0.7970	6.055	0.4767
1.0020	0.80	0.1308	-0.0400	0.6538	4.291	0.4425
1.0025	0.95	0.1298	-0.0390	0.5368	3.313	0.4069
1.0030	1.10	0.1296	-0.0385	0.4770	3.099	0.3776
1.0035	1.25	0.1306	-0.0380	0.4331	3.037	0.3546
1.0040	1.40	0.1329	-0.0378	0.3963	4.348	0.3351
1.0045	1.50	0.1366	-0.0377	0.3557	8.931	0.3227

Note: [∂c/∂y]$_{CF}$ is the counterfactual consumption response (model without a house)