

# **Intertemporal Consumption and Credit Constraints: Does Total Expenditure Respond to an Exogenous Shock to Credit?**

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*There is continuing controversy over the importance of credit constraints. This paper investigates whether total household expenditure and debt is affected by an exogenous increase in access to credit provided by a credit market reform that enabled Danish house owners to use housing equity as collateral for consumption loans. We find that the magnitude of the response is correlated with the amount of equity released by the reform and that the effect is strongest for younger households. Even for this group, the response was moderate. The aggregate effect of the reform was significant but small. (JEL D11, D12, D91)*

There is continuing attention paid to the significance of credit constraints<sup>1</sup> but controversy over their importance. Testing for the presence of credit constraints is notoriously difficult because the key variable, the shadow value of the constraint, is unobserved. Empirical tests are always based on indirect measures and in many cases they are known to have low power because they conflate credit demand and supply, Martin Browning and Annamaria Lusardi

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<sup>1</sup> For example, a series of recent papers have found that consumers react to anticipated changes in income following tax rebates and refunds, (see Sumit Agarwal, Chunlin Liu, and Souleles, 2007; David S. Johnson, Jonathan A. Parker, and Souleles, 2006; Souleles, 1999), paycheck receipts, (see Melvin Stephens Jr., 2006), and following the final payment of vehicle loans, (see Stephens, 2008). This behavior is not consistent with the unconstrained Life-Cycle/Permanent-Income model, and all the studies mentioned refer to the alternative hypothesis that consumers have been credit constrained.

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(1996). As a response to this, a recent study by David E. Gross and Nicholas S. Souleles (2002) focuses on credit supply and investigates the debt response to exogenous changes in the credit limit for credit cards, i.e. unsecured debt. They find that people respond to an expansion of the credit limit by spending more. Along similar lines, Robertus Alessie, Stefan Hochguertel, and Guglielmo Weber (2005) use data from a credit company and exploit the introduction of a usury law in Italy limiting permitted interest rates charged on consumer credit to identify how consumers react to changing interest rates on credit. They find that the new law influenced credit demand.

This paper studies the importance of collateralized credit constraints by investigating whether total household expenditure and debt are affected by an exogenous increase in the supply of credit provided by a credit market reform that gave Danish house owners access to housing equity as collateral for consumption loans. An extraordinary panel data set with annual information on income, assets and liabilities for the period 1987-1996 is used to analyse the effect of the reform. Introduced in 1992, the reform, for the first time, enabled Danish house owners to use housing equity as collateral for establishing mortgage loans where the proceeds could be used for financing nonhousing expenditure. The reform is crucial because it was unanticipated, thereby providing an opportunity to distinguish the effect of constraints on the propensity to access the housing equity from the effects of omitted variables related to preferences. The unique combination of the reform and the panel data, with detailed information on wealth and income, makes it possible to estimate the causal effect of having access to housing equity as collateral for consumption loans on (imputed) total expenditure and debt, and to evaluate whether collateralized loan constraints are important in practice. Collateralized debt is quantitatively very important. The median share of secured debt out of total debt among house owners in the sample analyzed in this paper was 80 percent in 1991. Moreover, much of household wealth is held as housing equity.

Collateralized loans based on housing equity are thus potentially important as an instrument for households to use in smoothing consumption, which could imply less variability in the aggregate.

Two recent studies using the Panel Study of Income Dynamics investigate the extent to which households extract housing equity. Eric Hurst and Frank P. Stafford (2004) find that, when experiencing a spell of unemployment, households with a low level of liquid assets are more likely to refinance and extract equity. Takashi Yamashita (2007) finds that households with a low wealth to income ratio respond strongly to house price appreciation and that households with a high wealth to income ratio do not. This finding is interpreted as evidence that house price appreciation has lifted collateral constraints. These studies are, however, subject to the criticism that households with low levels of liquid assets in their data have possibly anticipated having access to their housing equity, and this would have lead them to hold lower levels of liquid assets. Such a situation could, for example, arise if households observed with low levels of liquid assets are relatively more impatient than households observed with high levels of liquid assets. Therefore, simply observing households with low levels of liquid assets accessing housing equity, and households with high levels of liquid assets not accessing housing equity can reflect both the effect of constraints and preference heterogeneity, i.e. supply and demand for credit.

The effect of the Danish reform is estimated using a differences-in-differences estimator comparing the growth rate of total expenditure and debt from before to after the reform for two groups of households; one that was likely to be constrained prior to the reform and another that was not. The results show that the magnitude of the response is correlated with the amount of equity released by the reform and that younger households, in particular, have been affected by constraints. For this group the response was moderate.

The findings suggest that the credit elements of the reform had a limited aggregate impact. Using a random sample of the Danish population and applying the preferred set of estimates from the analysis, 12.5 percent of the total population of house owners was likely to have been affected by constraints at the point of the reform. This group had housing equity corresponding to 37 percent of the value of their housing stock released for credit purposes as a result of the reform. The aggregate impact of the credit elements of the reform was to raise total expenditure by 0.3 percent and to increase aggregate total household debt by 1 percent. This tentative estimate does not include multiplier effects, does not take into account that house prices are likely to increase as a consequence of the reform, and is, of course, highly dependent on the assumption about the size of the group affected by the reform. Nevertheless, the estimate does suggest that the credit elements of the reform did not have a major direct impact on the national economy.

The next section outlines the framework for testing for collateralized loan constraints, and details of the credit market reform and aggregate descriptive evidence are also presented. Section 3 presents the data and the approach to imputing total expenditure. Section 4 gives details of the econometric approach. Section 5 presents the results, and the final section sums up the analysis.

## **I. The Framework**

### *A. Collateralized Loans Constraints*

According to the canonical Life-Cycle/Permanent-Income model an exogenous increase in the access to credit has no real effects on consumption. Alternatively, if credit constraints play a role, the propensity to consume out of an expansion in credit supply should be positive. This suggests a direct test for the importance of credit constraints, where consumption or debt

expansion is measured following an exogenous increase in access to credit<sup>2</sup>. This is the essential idea behind the test for the importance of credit constraints used here. Making use of collateralized credit is usually associated with costs. The presence of transaction costs implies that households having experienced one or more successive adverse income/consumption shocks will run down liquid assets before accessing the housing equity.<sup>3</sup> This implies that households with low levels of liquid asset holdings are more likely to be affected by a binding constraint when liquid assets have been exhausted, and this feature is central to the test implemented here. To test for the importance of collateralized loan constraints, the sample is split according to the level of liquid assets in 1991, the year before the credit market reform, and the growth in expenditure and liabilities from before to after the reform is compared.<sup>4</sup>

The reform is crucial for the test because it unexpectedly expands the access to collateralized credit for house owners with housing equity. The life cycle framework emphasizes that agents plan. Short of an unanticipated expansion of credit, the propensity to access housing equity will be influenced not only by the constraint but also by the preference parameters. For example, relatively impatient / less risk-averse agents would be more likely to run down liquid assets in anticipation that housing equity can be accessed in the future than would relatively patient and/or risk-averse agents. Therefore, simply observing one group of

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<sup>2</sup> The credit market reform should increase demand for housing because the reform makes housing serve a double purpose as both housing and collateral, and potentially more people should upgrade or move from rental to owner-occupied housing. Along similar lines, Daniela Del Boca and Lusardi (2003) find that the choice of mortgage influences womens participation in the labor market.

<sup>3</sup> As pointed out by Hurst and Stafford (2004) the propensity to access housing equity is greater if the low liquid asset state is a result of a permanent shock, and a permanent shock will be more likely to generate an adjustment in the housing stock. Here only non-movers are considered, and the types of shocks having led to low liquid asset holdings are therefore likely to be more temporary in nature.

<sup>4</sup> The framework presented here assumes that people do not have access to credit before the reform, i.e. the focus is on quantitative constraints. In reality, people may have had access to other types of credit not based on housing equity as collateral, and such loans would be likely to be supplied at higher interest rates, so that borrowing rates exceed lending rates by more before the reform than after. Analytically, the case where borrowing rates exceed lending rates is similar to the one developed here, see for example Browning and Lusardi (1996), in the sense that the wedge between borrowing and lending rates creates a positive shadow value of liquidity

households accessing and another group not accessing the housing equity would likely reflect both the effects of constraints and preference heterogeneity. If, on the other hand, the reform is unanticipated and low liquid asset holdings just before the reform are the result of random adverse consumption/income shocks, then the low liquid asset status is not related to preference parameters. In other words, the reform provides an opportunity to distinguish the effect of constraints on the propensity to access housing equity from the effect of omitted variables related to preferences.

### *B. The Credit Market Reform*

The Danish credit market reform took effect on 21 May 1992. The crucial elements of the reform for the purpose of this paper are that it was unanticipated<sup>5</sup> and that it introduced the possibility for house owners to establish mortgage loans for financing nonhousing expenditure. The financing of real property in Denmark takes place via mortgage banks offering loans where the borrower's real property is used as collateral for the loan. It is possible to mortgage up to 80 percent of the property value. Real credit loans are typically associated with lower costs than loans established in commercial banks. The house owner needs to provide other financing for the remaining 20 percent of the value of the house. Loans through the mortgage banks are funded by the issue of callable mortgage credit bonds with fixed coupon rates. The principal of the loan depends on the price of the underlying bond. When the bond price is below par, a higher number of bonds must be sold to meet the funding requirements. This typically makes the principal of the loan larger than the loan proceeds paid out. Before the reform mortgage loans based on bonds had a maximum maturity of up to 20 years and they could only to be used to finance real property.

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<sup>5</sup> To check when the reform became public knowledge I have gone through all issues of a popular monthly magazine on personal finance (Penge og Privatøkonomi) for the period 1990-1993. This is the first place one would expect to find mention of such plans. The first time the reform is mentioned is in the June 1992 issue. This supports the notion that the introduction of the possibility of accessing housing equity for consumption really was a surprise to households.

The reform changed the rules about mortgaging in three ways. The most important here is that the reform introduced the possibility of using the proceeds from a mortgage loan for purposes other than financing real property, i.e. the reform introduced the possibility to using housing equity as collateral for consumer loans established through mortgage banks. The May 1992 bill introduced a limit of 60 percent of the house value for loans for nonhousing purposes. This limit was extended to 80 percent in December 1992. In the sample used in this paper, this part of the reform provided an increase in access to credit comparable to at least one year of disposable income for more than 50 percent of the households in the sample. Another feature of the reform is that the maximum maturity of real credit loans was expanded from 20 to 30 years. For people who were already mortgaged to the limit prior to the reform, and who therefore could not establish additional mortgage loans for nonhousing consumption, this option provided the possibility of acquiring more liquidity.

The final element of the reform gave the option to re finance. Refinancing makes it possible for borrowers to lower the cost of the loan when the market interest rate falls. A borrower is entitled to redeem a real credit bond *at par* at any time prior to maturity by prepayment. This enables the borrower to exploit changes in the market rate of interest in order to reduce the costs of funding. If the interest rate falls, the borrower may prepay his loan, and raise a new mortgage loan at the lower coupon rate. This may lower his monthly payment, but may also imply a larger principal of the new loan relative to the old loan if the price of the bond underlying the new loan is below par. While the first two parts of the reform influence the access to credit, this part of the reform provides house owners with the option to lock in low market interest rates in order to obtain lower monthly payments on their mortgages and an overall gain in wealth.

In this paper the interest is in the first two elements of the reform providing access to extra credit. These two elements should only be exploited by households who are credit

constrained in order to smooth consumption. All households, whether affected by constraints or not, are likely to benefit from the third element of the reform, the re financing option. This suggests a differences-in-differences empirical specification. The details of this will be taken up in section 4.

### *C. The Economic Environment*

The credit reform was introduced following a recession in the economy. In figure 1 private sector total expenditure and net disposable income from the National Accounts are illustrated along with net volume of mortgage loan issues and house prices. Disposable income is increasing, except for 1993, after which there is a pronounced increase in 1995. Total expenditure decreases up to 1989, and then starts to increase again. In 1994-1996 the level of total expenditure is considerably higher than in the previous years. The net volume of mortgage loan issues starts to increase slightly in 1991 and keeps increasing for the rest of the period. The mortgage loan volume reflects both variations in the number of houses traded and loans established to finance consumption after the reform. House prices increase rapidly from 1994.

[Figure 1 about here; see end of paper]

Clearly, many things are at play here. Income and house prices are increasing after 1992 and this should promote consumption increases to the extent that these increases are perceived as permanent. On the other hand increasing house prices generate more collateral and the movements of total expenditure are also consistent with some households being constrained. Households that are affected by credit constraints and experience a sudden access to extra credit following the reform are expected to increase total expenditure.

## **II. Data**

The data used in this study are merged Danish public administrative registers giving annual longitudinal information on wealth, income, household composition, and characteristics of the dwelling for a 10 percent random sample of the population over the period 1987 to 1996. The income and wealth information exists because Denmark had a wealth tax during this period. This information is used to impute total expenditure at the individual household level. The income tax registers contain information about total taxable income and transfers, taxable wealth, and total final tax payments. One notable feature is that the data on assets and liabilities can be divided into a number of categories. Unfortunately, the definitions of these categories are not stable across the observation period, and the level of detail decreases in the latest years of the sample period, particularly after the reform, for both assets and liabilities.

Up to 1992 assets are divided into six different categories: housing assets, shares, deposited mortgage deeds, cash holdings, bonds, and other assets. Housing assets are defined as the cash value of property as set by the tax authorities. Tax assessed house values are, in practice, a bit different from market values, and for the present purpose they are scaled with the aggregate ratio of actual house prices to tax assessed values. Shares, bonds, and deposited mortgage deeds contain the market value of each of these, respectively. Cash is cash in the bank. The last category contains self-reported information about nondeposited bonds, a particular type of unquoted shares (in ships), as well as the value of investment objects and high value objects such as cars, and boats. No information is held about accumulated pension funds. Many wage earners are enrolled in employer organized pension schemes where pension contributions are deducted before the salary is paid out. As pension contributions are not taxable before they are paid out, pension funds do not appear on the tax form. One exception is if the scheme is privately organized, in which case contributions are included in the total expenditure measure.

Liabilities are available under four different categories up to 1992: mortgage debt, bank debt, secured debt and other debt. Importantly, the size of the mortgage is known up to 1993. After this point definitions of the available variables are changed. A measure of liabilities that is consistent across the entire observation period can only be obtained for the total size of the liability stock.

House value, cash holdings, mortgage debt and bank debt are reported automatically by banks and other financial intermediaries to the tax authorities for all Danish tax payers and are therefore considered to be very reliable. The remaining components are self-reported, but subject to auditing by the tax authorities.

The income and wealth information is used to impute total expenditure at the household level according to a simple accounting identity where total expenditure in a period is linked to income and the change in wealth across the period<sup>6</sup>. Let  $c_t$  be total expenditure,  $y_t$  be disposable income, and  $W_t$  be total wealth at the end of period  $t$ . Total expenditure is then imputed according to (1)

$$(1) \quad c_t = y_t - \Delta W_t$$

where  $\Delta W_t$  defines saving. This implies that if a household adjusts its portfolio by purchasing, say, one share (holding other assets and liabilities constant), this will appear as a savings decision. If, however, the portfolio is held constant, but the price of one share in the portfolio goes up, i.e., there is a capital gain on the share, then this will erroneously appear as

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<sup>6</sup> The quality of the imputation is investigated by Browning and Søren Leth-Petersen (2003) using data drawn from the Danish Family Expenditure Survey (DES) for the years 1994-1996. The DES gives diary and interview based information on expenditure on all goods and services, which can then be aggregated to give total expenditure in a sub-period within the calendar year for each household in the survey. The households in the DES can be linked to their administrative income/wealth tax records for the years around their survey year, making it possible to directly check the reliability of the imputation against the self-reported total expenditure measure at the household level. Browning and Leth-Petersen (2003) find that the imputation provides a measure that performs quite well in terms of matching individual households' self-reported total expenditure.

savings as well. It is only possible to correct for this if the quantity of assets is observed along with the value. For all asset and liability categories only the total value is observed. One exception is housing assets where adjustments in the number of units are observed. When implementing the imputation, the capital gains on housing assets will be controlled for by considering only nonmovers and leaving the changes in the housing value out of the imputation. The remaining asset/liability variables available are composed of quite diverse assets/liabilities which have very different returns; for example, after 1992 one asset group includes both cash-in-hand and interest bearing bonds. Consequently, no attempt is made to control for capital gains within the remaining asset/liability categories. In the results section some consistency checks will be performed to make sure that capital gains are not the driving force behind the results.

The gross sample is restricted for the present purposes. First, sampled individuals who are living with their parents and those living in a communal or common household are omitted. This is necessary in order to identify the income and wealth variables of all individuals within a household. The sample is also restricted to individuals aged between 25 and 65 in 1991. Persons aged 66 or over are omitted to avoid interference from retirement decisions. Households that cannot be unequivocally identified as either renters or owners are also omitted, as are households that move during the sample period. A few observations are omitted because they are obviously defective. Finally, conditional on meeting these selection criteria, only households that are observed in all years over the period 1987-1996 are included. A balanced panel is constructed to make sure that the results are not driven by changes in the sample composition across the sample period.

This leaves a sample of 63,613 households, of which 49,597 live in owner-occupied housing. The latter is the group of interest in this paper, because it contains the households

that have the potential to gain access to extra credit because of the reform. The sample of renters will be used to perform a consistency check of the results for owners.

A crucial part of the analysis is to separate out a group that is more likely to be constrained. In order to do this the sample is split into two groups according to the levels of liquid asset in 1991, the year before the reform, where liquid assets are defined as the value of nonhousing assets. This is similar to the approach taken by Stephen P. Zeldes (1989), David E. Runkle (1991), James Ziliak (1998), and Johnson, Parker, and Souleles (2006). This approach follows naturally from the framework presented in section 2, suggesting that, prior to the reform, households will run down liquid assets if they experience an adverse income/consumption shock and will face a binding constraint when liquid assets have been exhausted. The low liquid asset group is restricted to having liquid assets worth less than one month of disposable income. 12,091 out of 49,597 house owners satisfy this criterion. Most people in Denmark are paid their December salary a few days before the end of the year, and asset holdings are summarized for tax purposes at the end of the year. For many households liquid asset holdings corresponding to one month's disposable household income thus amount to having virtually no liquid assets as a buffer.<sup>7</sup>

Figure 2 presents graphs of average imputed total expenditure and average disposable income, along with average total debt for households with low and high liquid asset holdings in 1991. The graphs show that disposable income is increasing over the period. Income is increasing more strongly for the low liquid asset group in 1993 and 1994 than for the high liquid asset group. At the same time households are generally reducing debt. Total liabilities, however, increase in 1995 and 1996, and the increase is most pronounced for the low liquid asset group. Total imputed expenditure is increasing in this period as well. Total expenditure

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<sup>7</sup> Liquid asset holding is not a perfect indicator of constrained status, Tullio Jappelli (1990). For the test implemented here a sufficient requirement is that the high liquid asset group is not constrained. It is not required that households with low liquid assets are all restricted, only that some households in the low liquid asset group are affected by constraints. Alternative sample splits are explored in section 5.3.

starts increasing from 1994, but initially the increase is lowest for the low liquid asset group. Total expenditure appears to take off in 1995, and now the increase is stronger for the low liquid asset group<sup>8</sup>. A final observation is that the graphs indicate that total expenditure is quite volatile. This is likely to reflect, at least in part, the noisiness of the imputation<sup>9</sup>.

[Figure 2 about here; see end of paper]

The graphs suggest that the low liquid asset households expanded total expenditure by more than the high liquid asset households after the reform, and that the excess expansion was financed by building up debt. This is consistent with the hypothesis that some movements in total expenditure are related to the credit market reform. It is still necessary, however, to look into the household level decision in more detail to verify that movements in total expenditure are really due to the credit market reform. This is the subject of the next two sections.

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<sup>8</sup> The micro data share some of the features of the aggregate data. Income is increasing, particularly towards the end of the period. Total expenditure is increasing across most of the sample period, and particularly towards the end. Both micro and aggregate data indicate that households are saving in the first part of the observation period. The exact timing of the changes is, however, not closely synchronized between the national account data and the micro data. In the aggregate data there is a rapid expansion of total expenditure in 1994. The micro data also displays an overall increase in 1994, but the increase is larger for the high liquid asset group in this year. The larger overall increase appears in 1995. Likewise, income appears to be increasing particularly rapidly from 1994 to 1995 in the aggregate data. In the micro data income exhibits the most rapid increase from 1993 to 1994. There can be many reasons for aggregate numbers not matching the micro data. First, the aggregate definitions of income and wealth may not exactly match those at the micro level. Second, national accounts are based on different data sources than the micro data. Third, measurement error can certainly play a role. Fourth, the micro sample is a selected sample and potentially this could be a source of differences. To check for this figure 2 has been reproduced using a sample without restrictions. That graph (not reported) shares the features of figure 2, thus ruling out sample selection as a source of the differences between the micro data and the national accounts data.

<sup>9</sup> The imputation is noisy and it generates some negative values of total expenditure. 34 percent of the households in the sample have at least one observation with negative imputed total expenditure. Out of these, 61 percent only have one negative observation across the entire observation period. Cases with negative imputed total expenditure are disproportionately found among owners. There is a weak tendency for more negative imputed expenditures in the earlier part of the observation period. The distribution of negative observations between low and high liquid asset households is stable across the sample period.

### III. Econometric Methodology

#### A. Differences-in-Differences

For investigating the effect of the credit market reform on households with low liquid assets in 1991, the starting point is a simple differences-in-differences specification consistent with specifications used in other consumption studies modeling effects of policy changes (e.g. Parker, 1999; Souleles, 1999; Johnson, Parker, and Souleles, 2006).

$$(2) \quad Q_{iA} - Q_{iB} = \beta_0 + \beta_1 X_{iB} + \beta_2 D_i + \varepsilon_{iA}$$

Where  $Q_{iA}$  is either total imputed expenditure or liabilities for household  $i$  measured at some point after the reform;  $Q_{iB}$  is correspondingly either total imputed expenditure or liabilities measured before the reform.  $X_{iB}$  is a vector of control variables introduced to absorb differences in the growth rate of total expenditure that are related to preference heterogeneity.  $D_i$  is an indicator variable taking the value one if household  $i$  was observed holding low levels of liquid assets in 1991, the year before the reform.  $\beta_0$  measures the average effect of the reform under the null hypothesis of no credit constraints, but it also includes possible general trend effects. This term will capture the wealth effects relating to the possibility of refinance in order to lock in lower market interest rates.  $\beta_2$  measures the additional effect of the reform for the low liquid asset group, and this is the parameter of interest. Under the null hypothesis of no collateralized constraints,  $\beta_2$  should equal zero.

### B. Matching

The parameters of equation (2) could be estimated by OLS under the assumption that  $\varepsilon_{iA}$  is orthogonal to  $(X_{iB}, D_i)$ . This would undoubtedly be the simplest way to estimate the effect of the reform for the low liquid asset group. OLS is, however, known to be sensitive to differences in the covariate distribution, see Guido Imbens (2004), because regression estimators rely on extrapolation in areas with no overlap in the covariate distribution between low liquid asset households and high liquid asset households. Moreover, OLS requires arbitrary functional form assumptions. To avoid imposing these assumptions the differences-in-differences structure in (2) is mimicked by a matching framework. A matching estimator balances the covariates between the low and the high liquid asset groups and estimates the mean effect of the reform for low liquid asset households without imposing functional form assumptions. For this purpose consider

$$(3) \quad E\left[\left(Q_{iA}^1 - Q_{iB}^1\right) - \left(Q_{iA}^0 - Q_{iB}^0\right) \mid D_i = 1, X_{iB}\right] \\ = E\left[\left(Q_{iA}^1 - Q_{iB}^1\right) \mid D_i = 1, X_{iB}\right] - E\left[\left(Q_{iA}^0 - Q_{iB}^0\right) \mid D_i = 1, X_{iB}\right]$$

Where  $E(\ )$  is the cross sectional expectation operator,  $(Q_{iA}^j - Q_{iB}^j)$  is the change in total expenditure or liabilities for a household with liquid asset holding status  $j$  from before to after the reform. (3) measures the mean additional growth in  $Q$  from before to after the reform for the low liquid asset group conditional on  $X_{iB}$ , and this corresponds to  $\beta_2$  in (2).

It is not possible to construct a sample counterpart to the last term on the right hand side of (3), i.e. the change in  $Q$  for the low liquid asset households had they held high levels of liquid asset. This is a counterfactual. If, however, households with low liquid asset holdings

have ended up in this state due to a random event conditional on  $X_{iB}$ , e.g. a random adverse consumption or income shock, it is reasonable to assume unconfoundedness

$$(4) \quad (Q_{iA}^0 - Q_{iB}^0) \perp D_i | X_{iB}$$

where  $\perp$  indicates independence. (4) assumes that the level of liquid assets is not systematically related to differences in the growth rate of expenditure conditional on  $X_{iB}$ . Generally, differences in the level of liquid asset holdings can be the result of many different historical and contemporaneous factors, and low liquid asset holdings is not a perfect indicator of being constrained. Holding limited liquid assets could be a result of maximizing behavior making the expenditure growth rate of low liquid asset households systematically different to that of high liquid asset households for unobserved reasons. For example, households in the low liquid asset group could potentially be less patient than households in the high liquid asset group, have higher expenditure growth for this reason, and consequently hold fewer liquid assets. The fact that the reform was unanticipated is helpful because it makes it unlikely that households in the low liquid asset group were running down liquid assets in anticipation of having access to their housing equity. This does, however, not guarantee that differences in expenditure growth are not driven by unobserved factors. Therefore, a series of robustness checks will be performed to support that high/low levels of liquid asset holdings is not a result of preference heterogeneity over and above what can be controlled for by  $X_{iB}$ .

(4) implies that  $E[(Q_{iA}^0 - Q_{iB}^0) | D_i = 1, X_{iB}] = E[(Q_{iA}^0 - Q_{iB}^0) | D_i = 0, X_{iB}]$ , i.e. that the expected change in  $Q$  for the low liquid asset households had they had high liquid asset holdings is the same as the expected change in  $Q$  for the high liquid asset households, i.e.

those who are not affected by the credit components of the reform, but otherwise have similar characteristics.  $E\left[\left(Q_{iA}^0 - Q_{iB}^0\right) \mid D_i = 0, X_{iB}\right]$  has a sample counterpart if there is overlap in the distribution of  $X$  between the high and the low liquid asset group.<sup>10</sup> A problem associated with implementing matching estimators is to match on a multi dimensional covariate vector. One way to reduce the dimensionality of the problem is to estimate  $E\left(D_i \mid X_{iB}\right)$  by a parametric model, and substitute this for the unknown propensity score, cf. Paul R. Rosenbaum and Donald B. Rubin (1983). Here the propensity score is estimated using a probit specification.

The specific matching estimator applied here is the simplest possible. For each individual in the low liquid asset group a single match is found from the high liquid asset group that minimizes the difference in the propensity score. Matching each low liquid asset observation with one observation from the high liquid asset group minimizes the bias, but is generally inefficient, since many observations from the high liquid asset group are discarded. Matching is done with replacement, so that the same household from the high liquid asset group can act as a match for different low liquid asset households. Reusing observations minimizes the risk that matched high liquid asset households do not look like the observations in the low liquid asset group, i.e. it minimizes the risk of bias. The drawback is that reusing observations causes a loss of precision.

### *C. Choice of covariates*

The choice of covariates is crucial. So far the unconfoundedness assumption was based on the assumption that all relevant covariates are controlled for. In practice the covariate set has

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<sup>10</sup> This can be stated compactly as  $P\left(D_i = 1 \mid X_{iB}\right) < 1$ , for all  $x \in \text{supp}\left(X_{iB} \mid D_i = 1\right)$  where  $P\left(D_i = 1 \mid X_{iB}\right)$  is the probability of having low levels of liquid assets just before the reform conditional on  $X_{iB}$ . This requires that being in the state with low levels of liquid assets just before the reform conditional on  $X_{iB}$  must not be given with certainty, since otherwise it is not possible to find a control with the same  $X_{iB}$ .

to be selected. Unfortunately, there is no formal guide for choosing the covariates.<sup>11</sup> For choosing the covariate set I refer to the life cycle framework with collateralized constraints outlined in section 2; see for example Alessie, Michael Devereux and Weber (1997) or Hurst and Stafford (2004) for explicit models. The idea is to compare low liquid asset households with high liquid asset households that face an identical expansion of credit through the reform and that are otherwise identical in terms of their life cycle characteristics, i.e. in terms of family composition, permanent income, discount rates, and attitude to risk. A central feature of the life cycle framework is that agents plan. Hence, all variables measured after the reform was announced and introduced would violate the unconfoundedness assumption since they would themselves potentially be a result of the reform. Therefore, households are compared in terms of their characteristics measured in 1991, i.e. before the reform was announced. Not all variables measured before the reform should be included in the covariate set, though. The life cycle framework with collateralized constraints says that while agents face binding constraints, consumption is depressed below, and noncollateralized debt is inflated above, the desirable level determined by the level of permanent income. In the present case households with low levels of liquid assets are potentially constrained before the reform. Hence, pre-1992 values of total expenditure and noncollateralized debt are not included in the covariate set. Not all financial variables are affected by binding constraints. Before the reform households did not have access to their housing equity, and the size of the mortgage and the house value<sup>12</sup> are therefore unaffected by the type of constraints considered here. The

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<sup>11</sup> In particular there is no justification for selecting variables based on a goodness-of-fit criterion, James J. Heckman and Salvador Navarro-Lozano (2004).

<sup>12</sup> If the constraint leads people to maintain their house less, the house value could be affected by the constraint, Joseph Gyourko and Joseph Tracy (2006). The types of shocks leading to lower levels of liquid asset holdings are mostly temporary in nature though, and the impact on the house value would be small. Moreover, house values are measured by the tax assessed house values, and these are independent of the maintenance standard of the house. Therefore, matching on the observed house value will potentially match low liquid asset households to high liquid asset households with more valuable houses, and this will bias the estimate of the effect of the reform on the low liquid asset households downwards.

expansion of the credit limit, which is the amount of housing equity, is directly determined by these variables.

Besides variables used to determine the amount of housing equity released by the reform the data offer detailed information on age and family composition. These are all indicators of the life stage position. Moreover, the size of the house is included as a proxy for expected future household size. Future changes of the size of the household may influence consumption and saving decisions. House size may also control for some parts of expenditure that are likely to be nonseparable from housing, e.g. the use of energy.

Permanent income, the discount rate, and attitude to risk are all theoretical concepts that are not observed and need to be approximated by observed variables. Permanent income is approximated by the value of the house, level of education, labor supply, and by gross income measured in 1991. Income has a transitory as well as a permanent component. Using income to control for permanent income could be problematic because the reason for being in the low liquid asset group could be that the household has faced an adverse income shock. This situation will violate the unconfoundedness assumption. The discount rate will be approximated by age, and education. These have been suggested as indicators of discount heterogeneity, Emily C. Lawrance (1991).

The validity of the unconfoundedness assumption depends on all relevant variables being included in the control set. This assumption is particularly sensitive with respect to the unobserved variables that are approximated. A series of robustness checks will be performed to check that these factors are controlled for appropriately.

## **VI. Results**

This section presents results from estimating the average effect of the credit market reform on households with low liquid asset holdings immediately prior to the reform. First, results from

estimating the propensity score are presented, along with an assessment of the ability of the matching estimator to balance the covariates. Next, the main results are presented, and finally a series of robustness checks are performed to confirm that the effects found are likely to be related to constraints.

*A. Estimating the propensity score and assessing the quality of the matches*

The propensity score is estimated using a probit model giving the probability of holding low levels of liquid assets in 1991 as a function of the share of housing equity out of the house value, house value, income, age, an indicator for single adult households, membership of unemployment insurance, size of the house, labor supply, education, and the number of children. All these variables are measured in 1991. The index of the probit model is the only parametric part of the estimator. This leaves a potential for misspecification. To address this concern squares of continuous variables are also entered. Estimates of the probit model are given in table 1.

[Table 1 about here; see end of paper]

The estimation results in table 1 indicate that the probability of holding low levels of liquid assets is negatively correlated with the share of housing equity. Households with more valuable houses are less likely to hold low levels of liquid assets, and the probability of holding low levels of liquid assets decreases with the income level. The probability of holding low levels of liquid assets is increasing up to 37 years, and decreasing thereafter. Singles are less likely, and households with children are more likely, to hold low levels of liquid assets. Generally, the chance of having few liquid assets is larger when adult household

members are participating in the labor market and if they are self-employed. Finally, more education lowers the probability of holding low levels of liquid assets.

The probit estimates are used to calculate the propensity score for all households in the sample. It is crucial for the validity of the matching estimator that there is common support for the low and the high liquid asset groups. Figure 3 depicts the kernel densities of the estimated propensity scores for the low and the high liquid asset groups, and shows that there is common support.

[figure 3 about here; see end of paper]

If the probit index is misspecified, the matching estimator may be inconsistent. In order to check whether the probit index is misspecified, the nonparametric specification test suggested by Azeem M. Shaikh et al. (2006) is performed<sup>13</sup>. The null of no misspecification is not rejected.

The purpose of the matching procedure is to balance the covariates between the high and low liquid asset groups. To assess this, two-sample t-tests for all explanatory variables included in the probit model are calculated. Each t-statistic tests for the variable in question if the mean for the low liquid asset group is different to the mean for the matched high liquid asset group. If such a test is rejected it indicates that, on average, the low liquid asset households do not have characteristics similar to the matched high liquid asset households, so that the functional form of the probit index plays a role in matching. The t-tests are reported in table A1 in the appendix, and they show no evidence of differences in the characteristics between the low and the matched high liquid asset groups.

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<sup>13</sup> Shaikh et al. (2006) derive a restriction between the density of the propensity score for low liquid asset households (in this context) and the density for high liquid asset households. Based on this restriction they derive a formal test of no misspecification  $E(D_i|P_i) = P_i$ , where  $P_i$  is the estimated propensity score.

The assumption that matched high and low liquid asset households are comparable can be tested indirectly by comparing expenditure and liability growth rates before the reform. For example, if households in the low liquid asset group are less patient than households in the matched high liquid asset group then the two groups should not have similar expenditure and liability growth before the reform if households with low levels of liquid assets were not constrained prior to 1991. The test is in the spirit of Heckman and V. Joseph Hotz (1989) and is implemented by estimating the relative growth rate of total expenditure, debt, and income from 1988 to 1991 for the low liquid asset group relative to the matched high liquid asset group. The test is implemented for income as well to check that differences in the development of income are not driving the results. Growth rates are calculated as annualized changes in total expenditure, liabilities, and gross income measured relative to the average income across the entire observation period.<sup>14</sup>

[table 2 about here; see end of paper]

The results reported in table 2 show that the expenditure, liability, and income growth for the group of households holding low liquid assets in 1991 is not different from that of the matched group of households with high levels of liquid assets<sup>15</sup>. These findings do not reject the hypothesis that the matched high and low liquid asset households are comparable. We

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<sup>14</sup> Usually the log of total expenditure is considered in consumption studies, so that one models the growth rate of total expenditure; see for example Johnson, Parker, and Souleles. (2006). In the present case this is not possible since, for some observations, total expenditure is imputed negatively. Instead, to get a relative measure the outcome variables are normalized by the average gross income over the observation period. This leaves the possibility that the estimated effect gets inflated if the low liquid asset households have suffered larger income shocks over the observation period than the matched high liquid asset households. For all calculations, average gross income across the sample period has been compared between low liquid asset households and matched high liquid asset households and there were never any significant differences.

<sup>15</sup> To explore whether the apparent lack of an average effect could be covering heterogeneous responses, the estimated responses have been regressed on the amount of equity relative to the value of the house (ETV) released for credit purposes by the reform. If the matching procedure is able to make high and low liquid asset households comparable, there should be no correlation between the estimated effect and ETV since the households did not yet have access to the equity. This analysis did not reveal any deviations. Results are reported in the online appendix.

now turn to the analysis of the effect of the reform.

### *B. Main Results*

Estimates of the average effect of the credit reform on low liquid asset household are presented in table 3.<sup>16</sup> As before estimation results are based on the annualized change in total expenditure, liabilities, and gross income measured relative to the average income across the entire observation period. The imputed measure of total expenditure is noisy because it inherits the noise from all the components used to construct it, and this may conceal the effect of the reform. Therefore, the estimated average growth rate of total liabilities is reported as well. If low liquid asset households have been affected by constraints, it is to be expected that they accumulate more debt than otherwise similar but unconstrained households. Ideally, this check should be done for the mortgage itself, but due to changes in variable definitions across the period it is only possible to do it for total liabilities. Estimates for the growth rate of gross income are reported to check that the estimated total expenditure and liability effects are not driven by different developments in income between the low and the matched high liquid asset groups<sup>17</sup>. Estimates for all three outcome measures are calculated over four different periods: 1993-1996 relative to 1988-1991, 1993-1995 relative to 1989-1991, 1993-1994 relative to 1990-1991, 1993 relative to 1991 to follow when the effect kicks in, if it does so.

[Table 3 about here; see end of paper]

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<sup>16</sup> The corresponding results obtained by OLS estimation of equation (2) are presented in table A2 in the appendix. OLS estimates are very similar to the matching estimates in table 2. This is not entirely unexpected given that the distribution of estimated propensity scores is fairly balanced between the low and high liquid asset groups, cf. figure 2. We continue with the matching estimator, though, because it provides nonparametric estimates of the effect of the reform, which is convenient when exploring the heterogeneity in responses.

<sup>17</sup> To this end it is important to consider gross income as opposed to disposable income, i.e. gross income net of interest payments and taxes, since disposable income is affected when households extract housing equity because higher tax deductions for mortgage interest payments are incurred

The results in table 3 indicate that, on average, there appears to have been no positive expenditure effect for the low liquid asset households of the reform until 1995, cf. column 1, where total expenditure has grown 0.0077 more than for the high liquid asset group. Column 2, however, shows that the low liquid asset group has been accumulating more debt than the high liquid asset group since 1993. Column 3 reassuringly shows that across all periods the average growth rate of income for the low liquid asset households is always the same except for 1993 and 1994 where the low liquid asset group has experienced a slightly higher income growth. The average results for total expenditure appear, on the face of it, to provide limited evidence that low liquid asset households have been constrained, since there was no excess expenditure growth for low liquid asset households until 1995. The estimates listed in column 2, however, give firm indications that the low liquid asset households have accumulated more liabilities over the period than the matched high liquid asset households.

The lack of an average expenditure effect could conceal heterogeneous responses that balance out. The matching estimator produces individual estimates for the effect of the reform for all low liquid asset households, and this makes it possible to explore whether there are systematic differences in the responses across different groups in the data. To provide further evidence that the effects found are related to gaining access to housing equity, the estimated effect for total expenditure and liabilities is regressed nonparametrically against the equity to house value (ETV) in 1991. Regressions are shown in figure 4 for the periods 1989-1995 and 1990-1994.

[Figure 4 about here; see end of paper]

The graphs show a clear positive association between ETV in 1991 and the estimated expenditure and liability effects of the reform for the low liquid asset households for both

periods. Considering first the graph for total expenditure for the 1990-1994 period, there is a positive expenditure effect of the reform for low liquid asset households but only for ETV greater than 0.5. The effect for this group is in the interval 1-3 percent. For low liquid asset households with ETV less than 0.5, the effect is negative. This suggests that the reform has not brought access to extra credit for these households. Considering now the effects for the period 1989-1995, the point where the graph intersects the zero effect line has shifted to the left on the ETV axis, i.e. households that in 1991 had ETV in the interval 0.1 to 0.5 now exhibit excess expenditure growth<sup>18</sup>. This suggests that households with ETV in this interval have accessed their equity in 1995. This is likely to be due to the fact that house prices have been increasing, cf. figure 1, thereby effectively generating collateral.

The picture is similar when considering the estimated effects for liabilities against ETV in 1991. Considering first the relationship for the 1990-1994 period, results indicate that only low liquid asset households with ETV larger than 0.2 have built up more debt than the high liquid asset households. In fact households with ETV less than 0.2 have accumulated fewer liabilities than their matched high liquid asset households. Again, this suggests that credit constraints were not effectively lifted for this group. Also, in the case of liabilities, the intersection point shifts to the left when considering the 1989-1995 period, but the slope remains unaltered<sup>19</sup>. The fact that the curve shifts to the left suggests that some households with ETV in the interval 0.1 to 0.2 in 1991 have accessed their equity in 1995. Corresponding regressions have been run using the estimated income effect as the dependent variable (not reported). They showed no differences in the income development for high and low liquid asset households across the ETV range. The relationships shown in figure 4 are thus not related to differences in the development of income between low and high liquid asset households across the ETV range. Corresponding regressions were also run for the 1991-

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<sup>18</sup> The slopes of these regressions give the marginal propensity to spend out of credit released by the reform. Fitting this relationship by OLS yields an estimate of the propensity to spend out of ETV of 0.026.

<sup>19</sup> Fitting this relationship by OLS yields a propensity to accumulate liabilities out of ETV of 0.236.

1993 period (not reported). They showed no significant expenditure effects but significant liability effects for ETV greater than 0.5.

In the sample the average equity to house value (ETV) in 1991 is linearly related to age of the oldest member of the household (not reported). Among households whose oldest member is aged 40 or less, the average housing equity was 20 percent in 1991<sup>20</sup>, and only 16 percent of the households with ETV larger than 0.5 are aged less than 40. This suggests that the group of households responding in 1995 but not in 1994 is to be found among the younger households in the low liquid asset group. To explore this issue figure 5 presents nonparametric regressions of the estimated expenditure and liability effect for the period 1989-1995 by age of the oldest member of the household. The graphs show that low liquid asset households aged up to approximately 45 have, on average, increased total expenditure by 1-4 percent more than households with high levels of liquid assets but otherwise similar characteristics. There appears to have been no positive expenditure effects for households aged over 45. In the same period there has also been an excess accumulation of liabilities of 5-6 percent for households aged less than 55. The corresponding graph for income (not reported) shows that households aged less than 40 have had excess income growth but of a much smaller magnitude than for total expenditure and liabilities. This suggests that households aged less than 45 have extracted equity for consumption purposes, and financed it partly by extracting equity and partly by excess income growth<sup>21</sup>. Considering the periods 1990-1994 and 1991-1993 (not reported) there is no evidence of excess expenditure growth, but low liquid asset households aged less than 55 still appear to have been accumulating liabilities faster than their matched high liquid asset households, although at a slower rate than over the period 1989-1995 period.

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<sup>20</sup> Due to changes in variable definitions it is only possible to identify the housing equity up to 1991.

<sup>21</sup> Excess income growth is less pronounced or nonexistent when the other periods are considered suggesting that this is not the driving force. Moreover, this feature does not appear consistently across a set of different sample splits that are examined in the robustness section.

[Figure 5 about here; see end of paper]

The estimates presented so far provide the main set of results from this study. They are consistent with the hypothesis that some households in the low liquid asset group have been affected by collateralized loans constraints. The response is found primarily among the younger households and it is found to be moderate. The magnitude of the response is correlated with the amount of housing equity released by the reform. Because many younger households had not accumulated enough housing equity at the point of the reform but achieved that as house prices increased, the response is delayed for this group.

### *C. Robustness*

The results presented are potentially sensitive to the design of the analysis. To confirm that the effects found are in fact related to the reform, a number of consistency checks are carried out. First, the imputation used is sensitive to capital gains on the portfolio, and this could have influenced the results. Second, the conclusion rests upon the sample split being indicative of some households in the low liquid asset group being constrained. Third, the signal could be a wealth effect following from the low liquid asset group having experienced a more rapid growth in wealth than the high liquid asset group, for example due to increasing house prices.

Before turning to these issues, the estimation exercise will be performed for renters. If the access to housing equity provided by the reform is really the reason for the effects on total expenditure that were found for house owners, then no positive expenditure or liability effects should be found for renters. The sample of renters is split into renters with liquid assets corresponding to less/more than one month's disposable income. Matching is done on the

same variables as for owners, except that it is of course not possible to include housing equity and the value of the house among the covariates. The estimated total expenditure and liability effects are regressed nonparametrically against age in figure 6.

[figure 6 about here]

Young renters with low levels of liquid assets exhibit excess growth in total expenditure. This is not accompanied by excess accumulation of liabilities. The corresponding graph for income (not reported) shows excess income growth for young low liquid asset renters and this explains the excess growth of total expenditure. The evidence for renters therefore does not contradict the basic result. These results rest on the auxiliary assumption that renters are similar to owners except that they do not hold housing equity. This is potentially a restrictive assumption, if housing tenure is correlated with unobserved variables governing consumption and savings decisions.

The imputation of total expenditure is sensitive to capital gains on assets such as bonds and shares, and this could have influenced the results. If matched high liquid asset households have different portfolios than low liquid asset households, then concern could justly be invoked that the effects on total expenditure found here could be due to differences in capital gains between the low and the matched high liquid asset households. To investigate this, a sub-sample is created that includes only households that do not hold shares or bonds at any point in the observation period<sup>22</sup>, and the estimation exercise is repeated for this sample. The results show the same pattern as for the whole sample<sup>23</sup>: low liquid asset households have lower expenditure growth up to 1994, and expenditure growth increases thereafter to the same level as that of the high liquid asset group. There is excess debt accumulation from

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<sup>22</sup> Because of changes in variable definitions it is only possible to identify bond holdings up to 1992.

<sup>23</sup> Detailed results for this analysis are reported in the online appendix.

1993 as in the original sample. Responses in this sub-sample are heterogeneous with respect to the amount of equity (ETV) and age in the same fashion as for the full sample.

A crucial element in the analysis is the sample split, since this does not uniquely identify constrained households. Households can be in a state with low levels of liquid asset holdings for reasons other than an adverse consumption/income shock. The leading alternative explanation is that households with low liquid assets are more impatient than high liquid asset households, cf. Christopher Carroll (1997) and Angus Deaton (1991). If this is the main explanation for observing some households with low levels of liquid assets then the findings do not represent the result of constraints but rather preference heterogeneity.

The level of education has been suggested as an indicator for discount heterogeneity, Lawrance (1991). To investigate whether there is heterogeneity in the response across educational levels, the nonparametric regressions in figure 6 have been extended by splitting according to the educational level.<sup>24</sup> The regression curves generally lie close to each other, and do not suggest different responses across educational levels. For liabilities, however, households with a low level of education exhibit excess accumulation of liabilities relative to households with a high level of education at the age interval 40 to 50.

Impatient consumers of the type described in Carroll (1997) and Deaton (1991) persistently keep low levels of liquid assets. To assess the extent to which the households holding low liquid assets in 1991 do that, liquid asset holdings over the period 1988 to 1996 are plotted in figure 7.

[Figure 7 about here; see end of paper]

The figure clearly shows that 1991 is the year where the average liquid asset holding is lowest, and that liquid assets are consistently de-cumulated up to 1991 and consistently

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<sup>24</sup> Graphs of these nonparametric regressions are reported in the online appendix.

accumulated after 1991. This suggests that low liquid asset households held undesirably low levels of liquid assets in 1991.

Another reason for low levels of liquid asset holdings not being a perfect indicator of a need to access housing equity due to constraints is that some households will have access to other types of credit with lower transaction costs than mortgage loans, and they will not access the housing equity. To counter such objections the robustness of the findings has been tested by trying out three alternative sample splits. In the first alternative split households in the low liquid asset group are restricted to having liquid assets corresponding to two months of disposable income or less. As mentioned in Section 3, most people in Denmark are paid their salary for December a few days before the end of the year. Because asset holdings are summarized on 31 December for tax purposes, for many people who are observed as having liquid assets corresponding to one month's disposable income, this amounts to having virtually no liquid assets. What's more, the definition of liquid assets may include assets that are in fact not very liquid. In a second alternative split it is required that households hold liquid assets comparable to less than one month's disposable income in both 1990 and 1991. This split allows for a larger degree of permanency of the shock leading to low levels of liquid asset holdings.<sup>25</sup> As noted by Hurst and Stafford (2004) households will benefit more by gaining access to housing equity if the shocks leading to low levels of liquid assets are permanent. Finally, a third alternative split is attempted where the group of potentially constrained households are restricted to those holding liquid assets comparable to less than one month's disposable income and to subsequently experiencing an unemployment shock. This split is introduced by Hurst and Stafford (2004). It is based on the idea that if liquid assets are already run down, and the household experiences an adverse income shock, then the need to access housing equity is even more urgent. In all cases the basic results are

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<sup>25</sup> Potentially, one could define a split where households in the low liquid asset state are observed with low liquid assets for many years. This would, however, likely represent the consequence of households being relatively impatient, i.e. preference heterogeneity.

similar, although for the second and third alternative split the effects are less precisely estimated because fewer households qualify to be in the low liquid asset group<sup>26</sup>.

It is argued that the expenditure effect found is due to the lifting of the collateral constraint. If the low liquid asset group experiences a more rapid expansion in wealth than the matched high liquid asset group, then the effect measured could just be a wealth effect<sup>27</sup>. Figure 1 shows that house prices increased dramatically in 1994 and subsequent years. This could have created differential wealth effects if the house values of the low liquid asset group developed differently to the house values of the matched high liquid asset group. Alternatively, house values may have developed similarly across the two groups, but if the low liquid asset households have lower permanent income than the matched high liquid asset households, the relative increase in wealth following from the house price increase has been higher for the low liquid asset households.

Results show that the average house value relative to average income across the observation period in the low liquid asset group has developed slower than the average house value in the matched high liquid asset group in all periods considered (not reported). At the same time, as shown earlier, debt to average income across the observation period has developed more rapidly for low liquid asset households over the period. This suggests that the expenditure effect found is not a housing wealth effect. On the contrary, these results

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<sup>26</sup> Detailed results are relegated to the online appendix.

<sup>27</sup> A number of papers have investigated the effect of changes in asset prices on consumption using micro data. One branch deals with the impact of stock prices on consumption; see Orazio P. Attanasio, James Banks, and Sarah Tanner (2002), Annette Vissing-Jørgensen (2002), F. Thomas Juster et al. (2006), and James M. Poterba (2000) for a survey of earlier studies. These studies find that consumption of stock holders co-vary more strongly with stock market returns than the expenditures of non-stock holders or that capital gains influence savings. This supports the existence of a direct wealth effect. Another branch deals with the effect of housing capital gains on consumption. Housing is different to stocks, since housing is held by a much larger fraction of the population and because an increase in house prices not only increases wealth, but also increases the price of future housing. Therefore direct wealth effects should be smaller for younger house owners than older house owners. John Y. Campbell and Joao Cocco (2006) find evidence of a direct effect that is larger for older house owners than for young house owners. Other studies also find evidence pointing towards the existence of a direct wealth effect, Jonathan Skinner (1996), but the evidence is not unequivocal. Gary V. Engelhardt (1996), using the PSID, does not find any effect of capital gains on consumption, and Hillary W. Hoynes and Daniel McFadden (1997) are not able to find any link between saving and capital gains on housing. Juster et al. (2006) find no evidence that capital gains in housing influence savings decisions.

suggest that low liquid asset households have accumulated more debt even though housing wealth has developed less favorably than for the high liquid asset group. Moreover, the evidence presented here points out that the accumulation of debt and expansion of expenditure is most predominant among low liquid asset households aged less than 50, and this does not support the idea of a direct wealth effect. If, on the other hand, house prices were an indicator of future earnings prospect as argued by Attanasio and Weber (1994), then it would be expected that younger households respond more to increasing house prices, since they have longer remaining working lives. But it would not be expected that low liquid asset households experiencing smaller increases in housing wealth would accumulate more debt than high liquid asset households. In summary, there is no evidence that wealth effects, either direct or indirect, are driving the results.

## **V. Summary and Conclusion**

In this study the importance of collateralized credit constraints is investigated by exploiting a Danish reform introduced in 1992 that unexpectedly gave house owners access to housing equity as collateral for consumption loans. The reform is used to identify whether collateralized credit constraints have influenced (imputed) total expenditure and debt accumulation.

The analysis is based on an extraordinary panel data set with household level information about income and wealth covering the years surrounding the reform. The effect of the reform is estimated using a differences-in-differences estimator comparing the growth rate of total expenditure and debt from before to after the reform for two groups of households; ones that were likely to be constrained prior to the reform and others that were not constrained. We find that the magnitude of the response is correlated with the amount of equity released by the reform and that younger households were particularly affected by

constraints. Many younger households did not have housing equity at the point of the reform but did so later as house prices increased. For this group the response was moderate; total expenditure is estimated to have increased 1-4 percent and total debt to have increased by about 5 percent.

The findings suggest that the credit elements of the reform had a limited aggregate impact. Assuming that the group of households with liquid assets worth less than one month's disposable income is the group of households who have benefitted from the credit components of the reform, it is possible to calculate the aggregate impact. According to the data set used in the present analysis, this group constitutes 12.5 percent of the total population of house owners<sup>28</sup>. They had 26 billion DKK of housing equity, corresponding to 37 percent of the value of their housing stock, released for credit purposes as a result of the reform. Based on the estimated propensity to consume out of equity for the period 1988-1995 (see footnote 17 and 18), the aggregate impact of the credit elements of the reform was to raise total expenditure by 0.3 percent and to increase aggregate total household debt by 1 percent. As already mentioned this tentative estimate does not include multiplier effects and does not take into account that house prices are likely to increase as a consequence of the reform. Such calculations are highly dependent on the assumption about the size of the group affected by the reform, but they do suggest that the credit elements of the reform did not have a major direct impact on the national economy.

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<sup>28</sup> These calculations are based on the 10 percent random sample of adult individuals from the population without restrictions.

## References

- Abadie, Alberto and Guido Imbens.** 2006. "Large Sample Properties of Matching Estimators for Average Treatment Effects." *Econometrica*, 74(1): 235-67.
- Alessie, Robertus, Michael Devereux, and Guglielmo Weber.** 1997. "Intertemporal Consumption, Durables and Liquidity Constraints: A Cohort Analysis." *European Economic Review*, 41: 37-59.
- Alessie, Robertus, Stephan Hochguertel, and Guglielmo Weber.** 2005. "Consumer Credit: Evidence from Italian Micro Data." *Journal of the European Economic Association*, 3(1): 144-178.
- Agarwal, Sumit, Chunlin Liu, and Nicholas S. Souleles.** 2007. "The Reaction of Consumer Spending and Debt to Tax Rebates - Evidence from Consumer Credit Data." *Journal of Political Economy*, 115(6): 986-1019.
- Attanasio, Orazio P., James Banks, and Sarah Tanner.** 2002. "Asset Holding and Consumption Volatility." *Journal of Political Economy*, 110(4): 771-791.
- Attanasio, Orazio P., and Guglielmo Weber.** 1994. "The UK Consumption Boom of the Late 1980s: Aggregate Implications of Microeconomic Evidence." *Economic Journal*, 104(427): 1269-1302.
- Browning, Martin, and Søren Leth-Petersen.** 2003. "Imputing Consumption from Income and Wealth Information"; *Economic Journal*, 113(488): F282-F301.
- Browning, Martin, and Annamaria Lusardi.** 1996. "Household Saving: Micro Theories and Micro Facts." *Journal of Economic Literature*, 34: 1797-1855.
- Campbell, John Y., and Joao Cocco.** 2006. "How do House Prices Affect Consumption? Evidence from Micro Data." *Journal of Monetary Economics*, 54(3): 591-621.
- Carroll, Christopher.** 1997. "Buffer-Stock Saving and the Life Cycle/Permanent Income Hypothesis." *Quarterly Journal of Economics*, 112(1): 1-55.
- Deaton, Angus.** 1991. "Saving and Liquidity Constraints." *Econometrica*, 59(2): 1221-1248.
- Del Boca, Daniela, and Annamaria Lusardi.** 2003. "Credit Market Constraints and Labor

Market Decisions.” *Labour Economics*, 10: 681-703.

**Engelhardt, Gary. V.** 1996. “House prices and home owner saving behavior.” *Regional Science and Urban Economics*, 26: 313-336.

**Gross, David B., and Nicholas S. Souleles.** 2002. “Do Liquidity Constraints and Interest Rates Matter for Consumer Behavior? Evidence from Credit Card Data.” *Quarterly Journal of Economics*, 117(1): 149-185.

**Gyourko, Joseph, and Joseph Tracy.** 2006. “Using Home Maintenance and Repairs to Smooth Variable Earnings.” *The Review of Economics and Statistics*, 88(4): 736-747.

**Härdle, Wolfgang.** 1990. *Applied Nonparametric Analysis*. Econometric Society Monographs, no. 19, Cambridge University Press.

**Heckman, James J., and V. Joseph Hotz.** 1989. “Choosing among Alternative Nonexperimental Methods for Estimating the Impact of Social Programs: The Case of Manpower Training.” *Journal of the American Statistical Association*, 84(408): 862-74.

**Heckman, James J., and Salvador Navarro-Lozano.** 2004. “Using Matching, Instrumental Variables, and Control Functions to Estimate Economic Choice Models.” *Review of Economics and Statistics*, 86(1): 30-57.

**Hoynes, Hillary W., and Daniel McFadden.** 1997. “The Impact of Demographics on Housing and Nonhousing Wealth in the United States”; in *The economic effects of aging in the United States and Japan*, eds. Michael Hurd, and Naohiro Yashiro, 153-94. National Bureau of Economic Research Conference Report Series. Chicago and London: University of Chicago Press, 1997;

**Hurst, Eric, and Frank P. Stafford.** 2004. “Home is Where the Equity Is: Liquidity Constraints, Refinancing and Consumption.” *Journal of Money, Credit and Banking*, 36(6), 985-1014.

**Imbens, Guido.** 2004. “Nonparametric Estimation of Average Treatment Effects under Exogeneity: A Review.” *Review of Economics and Statistics*; 86(1): 4-29.

**Jappelli, Tullio.** 1990. “Who is Credit Constrained in the U.S. Economy?” *Quarterly Journal of Economics*, 104: 219-234.

**Johnson, David S., and Jonathan A. Parker, and Nicholas S. Souleles.** 2006. "Household Expenditure and the Income Tax Rebates of 2001." *American Economic Review*, 96(5): 1589-1610.

**Juster, F. Thomas, and Joseph P. Lupton, and James P. Smith, and Frank P. Stafford.** 2006; "The Decline in Household Saving and the Wealth Effect." *Review of Economics and Statistics*, 88(1): 20-27.

**Lawrance, Emily C.** 1991. "Poverty and the Rate of Time Preference: Evidence from Panel Data." *Journal of Political Economy*, 99(1): 54-77.

**Parker, Jonthan A.** 1999. "The Reaction of Household Consumption to Predictable Changes in Social Security Taxes." *American Economic Review*, 89(4): 959-73.

**Poterba, James M.** 2000; "Stock Market Wealth and Consumption." *Journal of Economic Perspectives*, 14(2): 99-118.

**Rosenbaum, Paul R., and Donald B. Rubin.** 1983. "The Central Role of the Propensity Score in Observational Studies for Causal Effects", *Biometrika*, 70: 41-55.

**Runkle, David. E.** 1991. "Liquidity Constraints and the Permanent-Income Hypothesis: Evidence from Panel Data." *Journal of Monetary Economics*, 27: 73-98.

**Skinner, Jonathan.** 1996. "Is Housing Wealth a Sideshow?"; in *Advances in the economics of aging*, ed. Wise, D. A., 241-68. National Bureau of Economic Research Project Report series. Chicago and London: University of Chicago Press.

**Shaikh, Azeem M., and Marianne Simonsen, and Nese Yildiz, and Edward J. Vytlacil.** Forthcoming. "A specification test for the propensity score using its distribution conditional on participation" *Journal of Econometrics*.

**Souleles, Nicholas S.** 1999. "The Response of Household Consumption to Income Tax Refunds." *American Economic Review*, 89(4): 947-958.

**Stephens, Melvin Jr.** 2006. "Paycheque Receipt and the Timing of Consumption." *Economic Journal*, 116(513): 680-701.

**Stephens, Melvin Jr.** 2008. "The Consumption Response to Predictable Changes in

Discretionary Income: Evidence from the Repayment of Vehicle Loans” *Review of Economics and Statistics*, 90(2): 241-252.

**Vissing-Jørgensen, Annette.** 2002. “Limited Asset Market Participation and the Elasticity of Intertemporal Substitution.” *Journal of Political Economy*, 110(4): 825-853.

**Yamashita, Takashi.** 2007. “House price appreciation, liquidity constraints, and second mortgages.” *Journal of Urban Economics*, 62: 424–440.

**Zeldes, Stephen P.** 1989. “Consumption and Liquidity Constraints: An Empirical Investigation.” *Journal of Political Economy*, 97(2), 305-346.

**Ziliak, James.** 1998. “Does the Choice of Consumption Measure Matter? An Application to the Permanent-Income Hypothesis.” *Journal of Monetary Economics*, 41: 201-16.

## Appendix

**Table A1. Balance of individual characteristics. Two-sample t-test.**

Variable	E( $X_{Low}$ )	E( $X_{High}$ )	t
Housing equity/House value	0.3222	0.3293	-0.0807
ln(House value)	12.9395	12.9355	0.0465
ln(Gross income)	12.8712	12.8686	0.0301
Age	44.6993	44.8309	-0.3361
Single	0.0602	0.0624	-0.0326
UI membership	0.8726	0.8687	0.0508
Size of house	138.1897	138.4460	-0.2968
Labour supply, male	0.7858	0.7805	0.0611
Labour supply, female	0.7994	0.7966	0.0319
Self-employed, male	0.1516	0.1556	-0.0490
Self-employed, female	0.0777	0.0818	-0.0589
Education, short	0.4900	0.4897	0.0026
Education, medium	0.1734	0.1725	0.0110
Education, long	0.0539	0.0544	-0.0077
1 child	0.2368	0.2340	0.0320
2 children	0.3938	0.3882	0.0588
3 children	0.1050	0.1098	-0.0639
4 children	0.0176	0.0171	0.0102

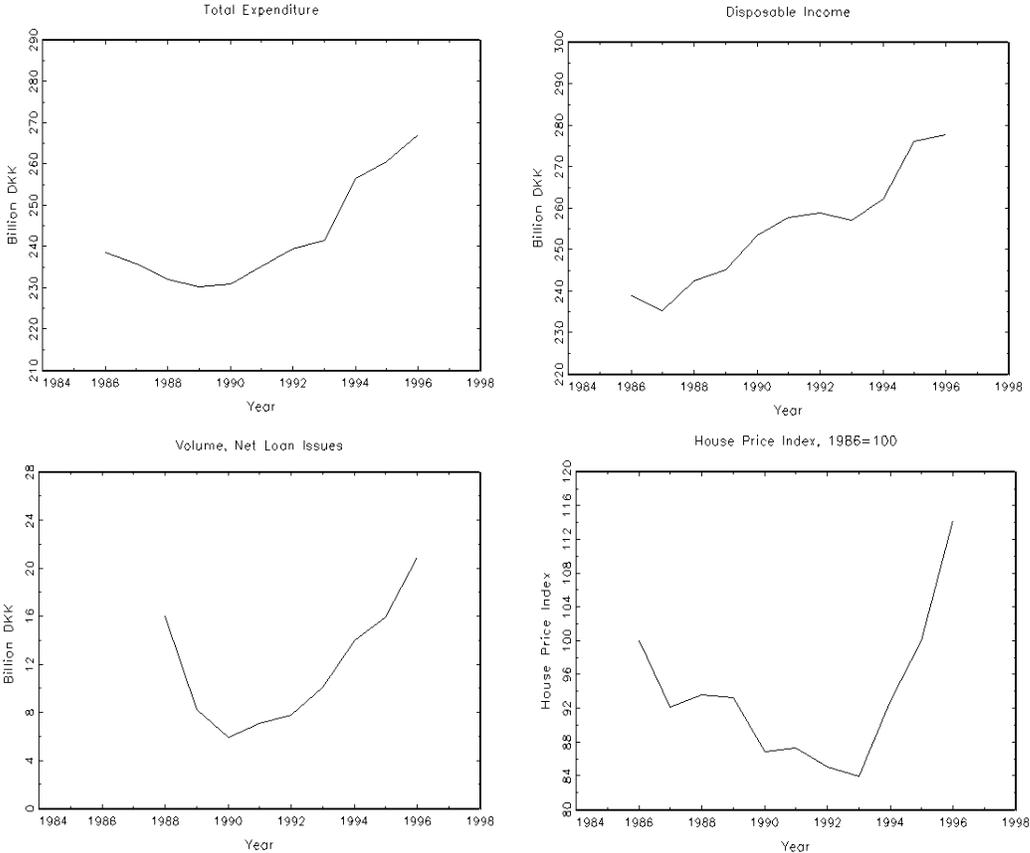
**Table A.2 OLS estimates of the average effect of the reform on owners holding low levels of liquid assets in 1991, for total expenditure, disposable income and liabilities**

Average effect of the reform for low liquid asset households			
Dependent variable	(1) Q=Expenditure	(2) Q=Liabilities	(3) Q=Income
1 $[(Q_{96}+Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89}+Q_{88})]/4$	0.0106*	0.0544*	0.0007
Standard Error	0.0029	0.0050	0.0020
2 $[(Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89})]/3$	0.0075*	0.0416*	0.0010
Standard Error	0.0034	0.0052	0.0020
3 $[(Q_{94}+Q_{93})-(Q_{91}+Q_{90})]/2$	-0.0097*	0.0275*	0.0047
Standard Error	0.0047	0.0055	0.0019
4 $(Q_{93})-(Q_{91})$	-0.0064	0.0247*	0.0073*
Standard Error	0.0068	0.0066	0.0022

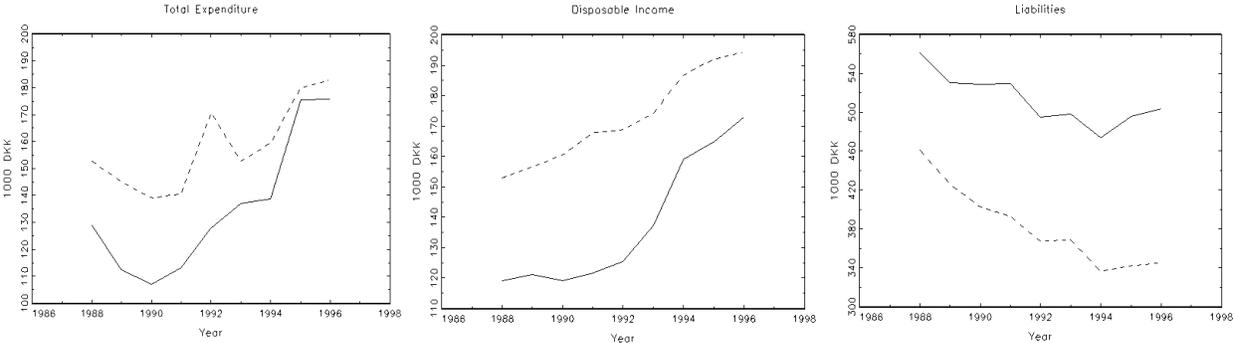
Note: All variables are measured in DKK at 1990 price levels. \* significant at the 5 percent level. Standard errors are robust to arbitrary forms of heteroscedasticity. Parameter estimates presented in this table are estimates of  $\beta_2$  in equation (2) from 12 regressions run independently. All regressions also include the covariate vector used in the probit models reported in table 2. Parameter estimates for these covariates are not reported.

# Figures to be inserted in the text

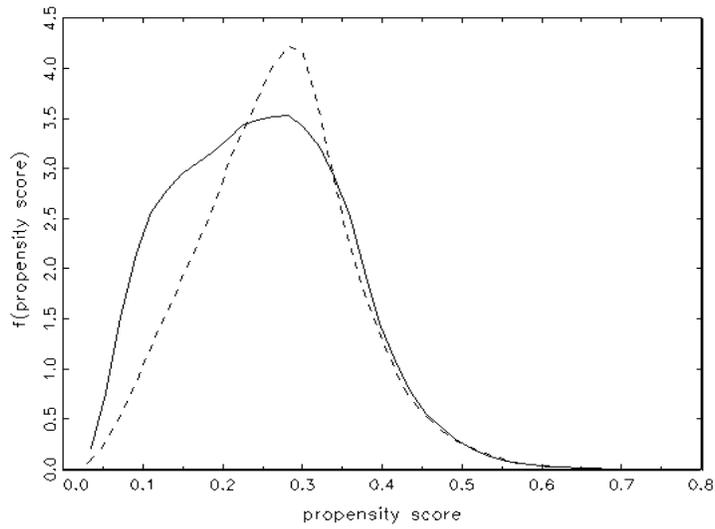
**Figure 1. Private sector total expenditure, net disposable income from the National Accounts, net mortgage loan issues, and the index for house prices.**



**Figure 2. Average imputed total expenditure, disposable income, and total debt for households holding high (broken line) and low levels of liquid assets in 1991.**

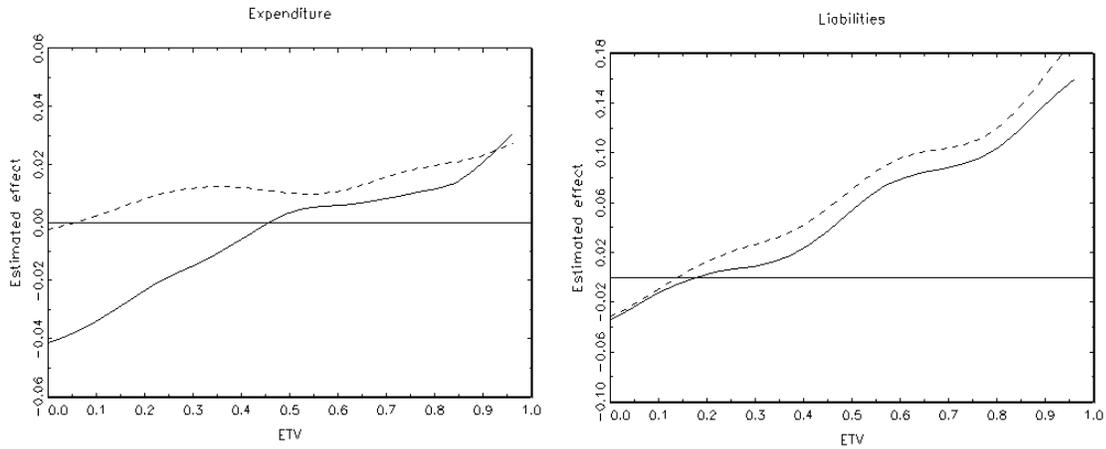


**Figure 3. Kernel densities of propensity scores for low and unmatched high (broken line) liquid asset house owners.**



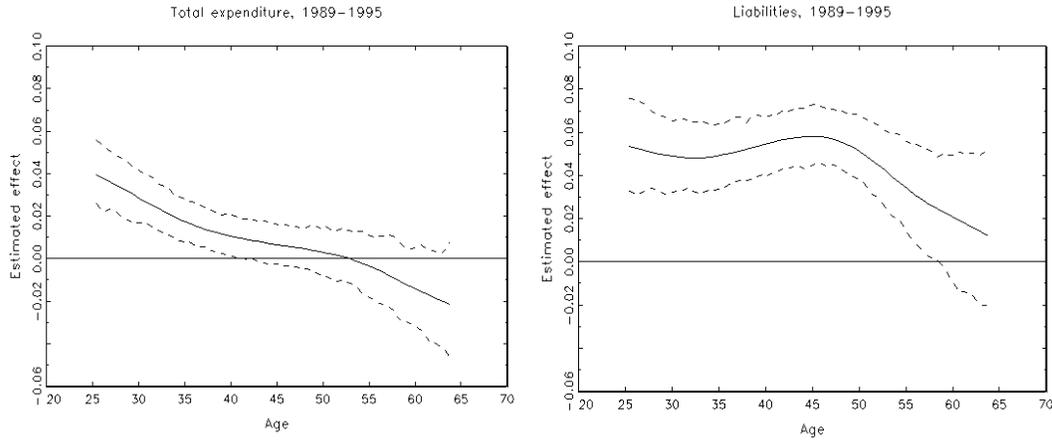
Note: Bandwidth set to  $1.06\sigma n^{-(1/5)}$ .

**Figure 4. Kernel regressions of the estimated expenditure and liability effect of the reform for the low liquid asset house owners on equity to value (ETV) in 1991. Estimates based on the period 1993-1994 relative to 1990-1991 (solid line) and 1993-1995 relative to 1989-1991 (broken line).**



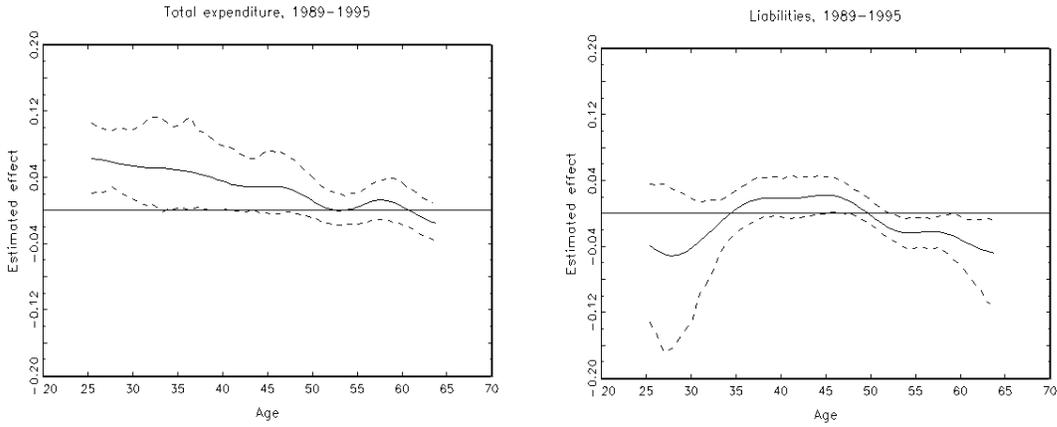
Note: Bandwidths have initially been chosen by generalized cross validation. The kernel regressions presented in both panels are over-smoothed relative to the cross validated level. This is only of presentational importance.

**Figure 5. Kernel regressions of estimated total expenditure and liability effect of the reform for the low liquid asset house owners on age. Estimates based on the period 1993-1995 relative to 1989-1991.**



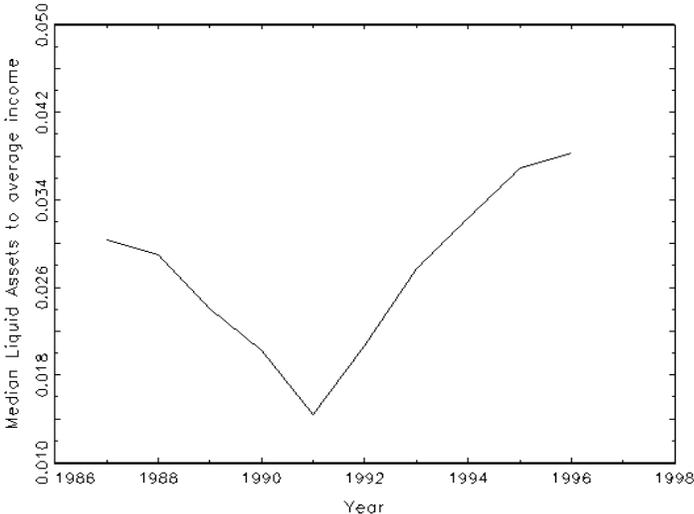
Note: Bandwidths have initially been chosen by generalized cross validation. The kernel regressions presented in both panels are over-smoothed relative to the cross validated level. This is only of presentational importance. Confidence intervals are bootstrap point wise confidence intervals based on 500 replications, cf. Wolfgang Härdle (1990).

**Figure 6. Kernel regression of estimated total expenditure and liability effect of the reform for low liquid asset renters on age. Estimates based on the period 1993-1995 relative to 1989-1991**



Note: Bandwidths have initially been chosen by generalized cross validation. The kernel regressions presented in both panels are over-smoothed relative to the cross validated level. This is only of presentational importance. Confidence intervals are bootstrap point wise confidence intervals, cf. Härdle (1990).

**Figure 7. Median liquid asset holdings to average income across the period 1988 to 1996 for households with low levels of liquid assets in 1991.**



## Tables to be inserted in the text

**Table 1. Probit estimates for house owners.**

Variable	Param.	Std.err
Housing equity/House value	-0.0561 *	0.0226
(Housing equity/House value) <sup>2</sup>	-0.3038 *	0.0304
ln(House value)	-3.0835 *	0.6274
ln(House value) <sup>2</sup>	0.1052 *	0.0243
ln(Gross income)	-2.0078 *	0.3865
ln(Gross income) <sup>2</sup>	0.0767 *	0.0150
Age	0.0321 *	0.0073
Age <sup>2</sup>	-0.0005 *	0.0001
Single	-0.1183 *	0.0326
UI membership	-0.0097	0.0326
Size of house	0.0002	0.0002
(Size of house) <sup>2</sup>	0.0000	0.0000
Labour supply, male	0.1190 *	0.0297
Labour supply, female	0.0673 *	0.0226
Self-employed, male	0.3310 *	0.0337
Self-employed, female	0.2074 *	0.0331
Education, short	-0.0463 *	0.0156
Education, medium	-0.0723 *	0.0204
Education, long	-0.1701 *	0.0307
1 child	0.1632 *	0.0189
2 children	0.2471 *	0.0195
3 children	0.3904 *	0.0280
4 children	0.5134 *	0.0600
Constant	34.1068 *	4.2918

Note: The dependent variable takes the value 1 if the household holds low levels of liquid assets in 1991. All monetary values are measured in DKK, 1990 price levels. \* significant at the 5 percent level.

**Table 2. Estimates of the average prereform effect for owners holding low levels of liquid assets in 1991, for total expenditure, liabilities, and disposable income**

	Average effect of the reform for low liquid asset households <sup>(1)</sup>		
	(1)	(2)	(3)
	Q=Expenditure	Q= Liabilities	Q= Income
1 $[(Q_{91}+Q_{90})-(Q_{89}+Q_{88})]/2$	0.0066	-0.0012	0.0054
Standard Error <sup>(2)</sup>	0.0078	0.0021	0.0069

Note: All variables are measured in DKK at 1990 price levels. Matching is done using replacement.

(1) Size of low liquid asset group: 12,091. Size of matched high liquid asset group: 9,228.

(2) Standard errors are calculated according to Theorem 7 in Alberto Abadie and Guido Imbens (2006).

**Table 3. Estimates of the average effect of the reform for owners holding low levels of liquid assets in 1991, for total expenditure, liabilities and disposable income**

	Average effect of the reform for low liquid asset households <sup>(1)</sup>		
	(1) Q=Expenditure	(2) Q=Liabilities	(3) Q=Income
1 $[(Q_{96}+Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89}+Q_{88})]/4$	0.0110*	0.0594*	0.0030
Standard Error <sup>(2)</sup>	0.0040	0.0066	0.0028
2 $[(Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89})]/3$	0.0077*	0.0474*	0.0028
Standard Error <sup>(2)</sup>	0.0046	0.0067	0.0027
3 $[(Q_{94}+Q_{93})-(Q_{91}+Q_{90})]/2$	-0.0145*	0.0334*	0.0053*
Standard Error <sup>(2)</sup>	0.0059	0.0071	0.0027
4 $(Q_{93})-(Q_{91})$	-0.0137	0.0316*	0.0062*
Standard Error <sup>(2)</sup>	0.0089	0.0085	0.0031

Note: All variables are measured in DKK at 1990 price levels. Matching is done using replacement. \* significant at the 5 percent level.

(1) Size of low liquid asset group: 12,091. Size of matched high liquid asset group: 9,228.

(2) Standard errors are calculated according to Theorem 7 in Abadie and Imbens (2006).