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Intertemporal Consumption and Credit Constraints: Does Total Expenditure Respond to An Exogenous Shock to Credit?

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Abstract

Testing for the importance of credit constraints for intertemporal consumption allocation is notoriously difficult. This is because the key variable, the shadow value of the constraint, is unobserved. In this paper the question is asked if total household expenditure is affected by an exogenous increase in the access to credit provided by a credit market reform that gave access for house owners to use housing equity as collateral for consumption. If this is the case it is taken as evidence that some households have been credit constrained prior to the reform. The reform provides an exogenous increase in access to credit comparable to one year of disposable income or more for a considerable fraction of the households in the sample analysed. The analysis is based on Danish panel data with information on income and wealth that facilitates imputing total expenditure at the household level for years around the reform. It is found that some households, particularly among the 30-50-year-olds, have been constrained.

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1. Introduction

The standard model of consumption where consumers maximize expected utility subject to expected life time resources predicts in its simplest version with certainty equivalence that consumption is constant across time, Hall (1978), and that the marginal propensity to consume out of extra credit that does not increase life time wealth is zero. This prediction has been massively refuted. The most popular alternative hypothesis that researchers have turned to is that consumers are credit constrained. In this case consumption is no longer constant, and the marginal propensity to consume out of extra liquidity for constant wealth should be positive.

The literature on tests for credit constraints on micro data is comprehensive. For a survey, see Browning and Lusardi (1996). The main problem with testing for liquidity constraints is that the key variable in the credit constraints model, the shadow value of the constraint, is unobserved. Therefore indirect measures are used in testing for liquidity constrained behaviour. The dominant source of changes in liquidity for constrained consumers is variations in income. This has led to the suggestion that consumption should track income when households are constrained. This is known as the test for excess sensitivity. Testing for excess sensitivity Hall and Mishkin (1982) find evidence for a fraction of consumers being constrained, but Altonji and Siow (1987) do not. The test has been refined by splitting the sample according to the amount of liquid assets held by the household, Zeldes (1989). Sample splitting according to liquid assets improves the power of the test, because it puts focus on a group that is more likely to be constrained. The evidence is however still mixed. Zeldes finds significant excess sensitivity, but Runkle fails to do so[1].

The mixed evidence in the early literature is likely to be due to the excess sensitivity test being a weak test of credit constrained behaviour. Excess sensitivity is consistent with a range of other behavioural patterns. For example, it could appear that consumption is tracking income if income is

[1] Other sample splitting techniques have been applied as well. Jappelli (1990) uses information on discouraged borrowers from the Survey of Consumer Finances (SCF) to identify the characteristics of the people that are constrained and finds that not only financial assets and wealth, but also demographic variables such as age, marital status and family size are predictors for constrained status. The SCF does not collect information on non-durable consumption. However, the results from this study have led to a refinement of the sample splitting technique, where the connection between constrained status and demographics is estimated using the SCF, and the obtained estimates are then used to predict constrained status in another data set containing demographics and panel data on consumption, but no information on constrained status. This approach has been employed by Garcia, Lusardi and Ng (1997), Jappelli, Pischke and Souleles (1998) in order to get a sample split that increases the likelihood of getting a sample of truly constrained households. They both find evidence that liquidity constraints play a role. This does indicate that the approach has higher power than the previous approaches. The test is still not completely satisfactory, though, because constrained status is likely to be idiosyncratic, for example because of idiosyncratic shocks to income or consumption. This information is lost by applying two different data sets to identify constrained status. Moreover constrained status is likely to be non-constant across time, for example to vary with the business cycle, Fissel and Jappelli (1990).

persistent or if the consumer is guided by rule of thumb behaviour where he either does not save at all or saves a constant fraction of his income. Moreover, Carroll (1997) shows that if consumers are impatient and have a precautionary motive for saving then average consumption growth equals average labour income growth. This behaviour arises because the consumer is precautionary and faces a risk that income will be zero at some point in the future. He therefore saves more than what is perhaps needed ex post in order to insure himself against zero consumption events. Also, the expectation of a possible future binding constraint can make the consumer behave as if the constraint is already binding thereby depressing consumption and making consumption changes correlated with income, Deaton (1991). The power of many empirical tests of the liquidity constraints hypothesis is also limited by the use of data on food consumption, because food consumption is not very income responsive and is therefore not the type of good that is expected to be much affected by credit constraints

A number of recent studies try to address some of the issues raised above. Chah, Ramey and Starr (1995) is probably the first study to explicitly recognize and model that constrained households are likely to cut back on durable expenditure rather than on nondurable expenditure when facing a credit constraint. The empirical analysis is based on aggregate data and aggregation issues are therefore likely to influence the empirical results. The important insight, however, is that it is not sufficient to consider nondurable consumption when studying the effect of credit constraints because the action is most likely to take place for durables. Ziliak (1998) recognises that the use of data on food consumption does not give a high power to the test. He uses the income and wealth data in the PSID to impute total expenditure by exploiting that total expenditure in a period is related to income and the change in wealth across the period. Eberly (1994) models adjustments in the car stock using the SCF. Car consumption has the virtue of being a better candidate for identifying effects of credit constraints because car consumption is more income elastic than food consumption. Both Ziliak (1998) and Eberly (1994) test for excess sensitivity and find evidence that a substantial fraction of the households is being constrained.

Meghir and Weber (1996) take a structural approach to the problem of identifying departures from the standard additive model that does not rely on testing for excess sensitivity. They recognise that the fallacy of the standard model can be due both to habit forming preferences and to credit constraints, and both cases will create temporal dependency. Credit constraints will depress the total level of expenditures but not affect the distribution of expenditures across (nondurable) goods. Habits will influence the current distribution of expenditures on commodities through past

demands. They test for this using the panel data on food, transport and services from US Consumer Expenditure Survey (CEX), and do not find evidence in favour of credit constrained behaviour, except possibly for young households. This result could, however, be due to that Meghir and Weber do not consider a broader consumption measure that includes durables. Consumption of durables is more sensitive to credit constraints than nondurable consumption.

The most recent studies trying to identify if credit constraints play any role for intertemporal consumption allocation focus on the impact on consumption of shocks that puts the agent in a new situation where either the access to credit is changed or the agent faces variations in temporary income for exogenous reasons. The idea is that the exogenous variation provided by the shock should give a more direct test of constrained behaviour.

Alessie, Devereux and Weber (1997) (henceforth ADW) is one of the first studies to take this approach. ADW investigate the effect on consumption of durables vs. nondurables of a credit reform that reduces down payment requirements. ADW exploit the reform and the timing of the introduction of it to identify constrained behaviour. However, the study is limited by not having panel data. They take recourse to synthetic panel data methods where a panel is constructed by taking averages across cohorts. Using this type of data it is not possible to deal with idiosyncratic effects which are likely to be important.

Browning and Crossley (2004) look at adjustments in expenditures on nondurables and small durables as a response to moderate changes in transitory income for a sample of Canadians that have recently become unemployed. They identify movements in transitory income by exploiting changes in the Canadian unemployment benefit system and find that households mainly cut back on durable expenditures leaving nondurable expenditures almost unchanged. Cutting back temporarily on durable expenditures by postponing replacement as opposed to cutting back on nondurable expenditure will minimize the utility loss associated with being constrained. This is because a worn durable, for example a pair of jeans, is still serviceable in the next period whereas expenditures on nondurables, such as food, typically are required in every period for utility not to drop drastically.

Another recent approach to testing for credit constraints focuses on credit card use, and exogenous changes in access to non-collateralised credit or changes in interest rates on credit cards. Asking this question really goes to the point. Do consumers respond to a change in credit access that does not change life time wealth. Gross and Souleles (2002) have access to an unusually rich data set on credit card use, and find that consumers respond to both changes in the credit limit as well as the interest rate. This is so both for people close to the limit and for people well below their

limit. The first is interpreted as consistent with some people facing currently binding constraints, and the latter is interpreted as consistent with some people being precautionary and fearing a potential future constraint. Along similar lines Alessie, Hochguertel, Weber (2003) use data from a credit company and exploit the introduction of a usury law in Italy that limits permitted interest rates charged on consumer credit to identify how consumers react to changing interest rates on credit.

This study focuses on the role of changes in access to collateralised credit. Specifically, the objective of this study is to investigate if constrained households increase total expenditure as a response to a reform introduced in 1992 that gave access for house owners to use housing equity as collateral for consumption loans[2]. The empirical analysis is based on panel data with information on income and wealth for the period 1987-1996. These data make it possible to impute total expenditure at the household level for years around the reform. Credit constrained households are identified as those households with a low level of liquid (i.e. non-housing) assets immediately before the reform and the sample is split accordingly, cf. Zeldes (1989). It is implicitly assumed that low liquid households face a currently binding constraint because they have experienced an adverse consumption/income shock. The shock has made them run down liquid assets, and because they are not able to access housing equity they are likely to be constrained prior to the reform. The change in total expenditure across the point of introduction of the reform is compared for the low and high liquid asset households. If low liquid asset households take out housing equity to be able to expand expenditure to a larger extent than an otherwise similar high liquid asset household then it is taken as evidence that households in the low liquid asset group on average have been credit constrained prior to the reform. It is found that some households, particularly among the 30-50-year-olds, have been constrained.

The analysis presented here extends the literature on credit constraints and the work of ADW in particular by using household level panel data on total expenditure and a very large exogenous shock to access to collateralized credit. Household level panel data allow taking into account idiosyncratic aspects that are without doubt important to control for when studying credit

[2] The idea that housing equity plays a role in smoothing consumption is not new. Hurst and Stafford (2002) investigate if people who are likely to be liquidity constrained, those with low liquid assets or being unemployed, use housing equity for financing consumption. Using the PSID wealth surveys of 1989 and 1994 together with a detailed survey on mortgage shopping from 1996 they find that people likely to be constrained do take out housing equity for consumption. Hurst and Stafford do not have access to consumption or expenditure data, but find this by checking if constrained households pay higher interest rates, if they refinance their mortgage differently or if their wealth position changed between 1989 and 1994 in a way different than for unconstrained households. Hurst and Stafford do not have exogenous variation in credit access. Consequently there is a risk that households taking out housing equity are inherently different from households that do not.

constraints, and the use of information on total expenditure implies that expenditures on the goods that are most likely to be affected by limitations in credit access are also considered. Moreover, for many households housing equity accounts for the all dominating part of total net wealth, and the shock provides an increase in access to credit comparable to one year of disposable income or more for a substantial fraction of the households. In total, this should provide very powerful setup for investigating the effect of credit constraints.

The next section outlines the details of the reform, and presents some aggregate evidence showing that the movements in expenditures on durables and nondurables around the reform are consistent with the hypothesis that some households have been constrained prior to the reform. Section 3 sets up a formal model that mimics the features of the aggregate evidence and generates predictions that can be tested on micro data with household level information about total expenditure. This formalizes the notion that the effect of credit constraints shows most strongly on durable expenditure, and emphasizes that a test of credit constraints should be carried out on a measure of expenditure that includes durable expenditure. In this paper the test is based on total expenditure, and a crucial element of the test for credit constraints here is imputation of total expenditure at the household level. Section 4 presents the data and the approach to imputing total expenditure. Section 5 gives details on the empirical strategies, section 6 gives results, and the final section sums up the analysis.

2. The Reform and Aggregate Evidence

The credit market reform exploited for identification takes effect 21 May 1992. The crucial part of the reform for the purpose here is the introduction of the possibility for house owners to establish a mortgage and use the proceeds from the mortgage loan to finance non-housing consumption, i.e. to use the housing equity as collateral for consumption loans.

The financing of real property in Denmark takes place via mortgage banks, so-called mortgage credit institutions. Mortgage credit institutions offer loans where the borrower's real property is used as collateral for the loan. It is possible to mortgage up to 80% 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% of the value of the house. One option is mortgage deeds where the seller of the house issues a mortgage deed, thus classified as an asset to him, to the buyer for whom it is registered as a liability. Loans through the

mortgage credit institutions are funded by the issuing 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 it was possible to establish mortgage loans based on bonds with a maturity of up to 20 years that were only to be used for the financing of real property.

The reform changed the rules about mortgaging in three ways. The most important here is that the reform introduced the possibility to use the proceeds from a mortgage loan for other purposes than financing real property, i.e. the reform introduced the possibility to use housing as collateral for consumption loans established through mortgage banks. The establishment of loans for non-housing purposes is limited to 60% of the value of the house. For the median household in the sample used in this paper this part of the reform provided an increase in access to credit comparable to more than one year of disposable income in 1991. The median household among households with liquid assets corresponding to less than one months of disposable income in 1991, the definition of a credit constrained household in this paper, obtained an expansion in access to credit for consumption purposes corresponding to almost 80% of the annual disposable income.

Another feature of the reform is that the maximum maturity of real credit loans is expanded from 20 to 30 years. For people who already had mortgaged to the limit prior to the reform, and therefore could not establish additional mortgage loans for non-housing consumption, this option provided a possibility for getting more liquidity.

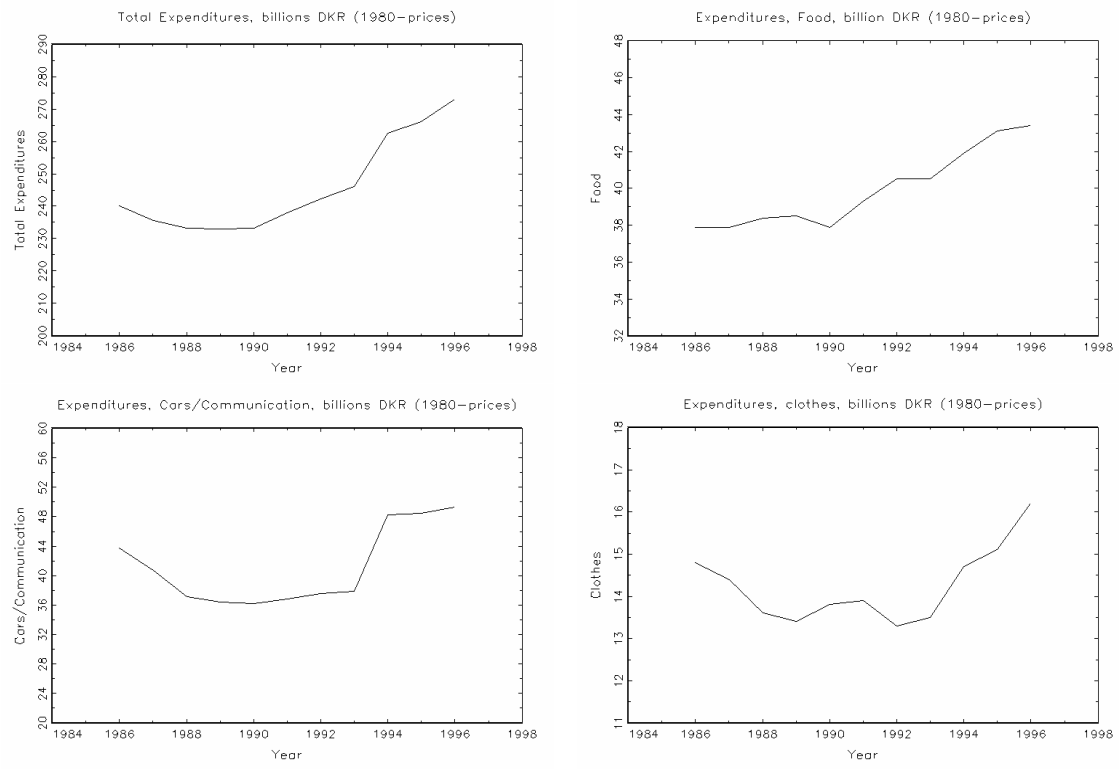
The final element of the reform gave the option to re-mortgage. Re-mortgaging gives the borrower the possibility to lower the cost of the loan when the market interest rate falls. A borrower is entitled to redeem a real credit bond *at par* at any time prior to maturity, for example by prepayment. This 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 loan at the lower coupon rate. This may lower his monthly net 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 two former 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 the mortgage and an overall gain in life time wealth.

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

order to smooth consumption. All households constrained or not, are likely to benefit from the third element of the reform, the remortgaging option, and it is important for the objective set out here that the estimation technique applied is able to purge for this. This issue will be taken up later.

The reform gives a large shock to credit in the household sector. Households that are credit constrained and experience a sudden access to extra credit following the reform, are expected to increase total expenditure. While constrained these households are likely to have had lower levels of durable purchases so that replacement is postponed relative to what would have been the case had they not been constrained. This adjustment has enabled them to maintain a consumption flow of nondurables as well as a flow of services derived from durables albeit from durables depreciated more than what is optimal for the household. In this way the constrained household minimizes the welfare loss from being constrained. For example, being constrained in a period a household may want to postpone replacement of the car rather than cutting back on food consumption. By symmetry when a constrained household obtains access to additional credit it is expected to expand durable purchases by more than non durable purchases.

Figure 1. Aggregate private sector total expenditures, expenditures on transport/ communication, food and clothes



In figure 1 total aggregate private sector expenditure from the National Account Statistics is illustrated along with aggregate expenditures on transport/communication, including purchases of new cars, and aggregate purchases of clothes and food. Total expenditure decreases up to 1990, and then starts to increase again hereafter. In 1994-1996, however, the level of total expenditure is considerably higher than in the previous years. There is indication that the increase in aggregate expenditure happens at the same time as for durable expenditures, for example expenditures on transport/communication (including purchases of new cars) and expenditures on clothes. Also food expenditures increase, but at a slower rate than expenditures on durables.

The pattern in figure 1 is indeed consistent of the mechanism outlined above. In the next section this is put in to a formal model.

3. Theory

An intertemporal model of consumption with two goods, a nondurable good and a durable good is presented. The setup is closely connected to the work by Chah, Ramey and Starr (1995), Hurst and Stafford (2002), ADW, and Browning and Crossley (2004).

The consumer is assumed to face the following intertemporal optimization problem

$$\max_{c_t, S_t, X_t} E\left[\sum_{s=0}^{\infty} \beta^s u\left(c_t^n, S_t\right)\right] \tag{1}$$

s.t.

$$X_t = \left(1 + r_{t-1}\right) X_{t-1} + y_t - c_t^n - c_t^d - f_t R_t \tag{2}$$

$$X_t \leq \phi_{1t} + \phi_{2t}\left(p_t^H H_t - M_t\right) \tag{3}$$

$$c_t^d = S_t - \left(1 - \delta\right) S_{t-1} \tag{4}$$

Where

c_t^n	Nondurable consumption in period t	R_t	Take value one, if new mortgage is established in period t
S_t	Durable (non-housing) stock at the end of period t	M_t	Mortgage at the end of period t
X_t	Liquid assets and housing equity removed at the end of period t	δ	Depreciation rate of durable
r_t	Interest rate on risk free asset in period t	ϕ_{1t}	Time specific constant
y_t	Disposable income in period t	ϕ_{2t}	Parameter indicating the possibility to use housing equity as collateral
c_t^d	Durable purchases in period t	H_t	Stock of housing at the end of period t
f_t	Transaction costs associated with new mortgage in period t	p_t^H	House prices at the end of period t

Utility is derived from nondurable and durable consumption[3]. The stock of the durable is treated as a continuous variable, i.e. durables, S_t, are summarised as a stock of efficiency units. This is, of course not very realistic, but convenient and sufficient for the purpose here. The household holds a liquid asset X_t, and a housing asset, H_t, that is less liquid. Equation (2), gives the period-to-period budget constraint; the household enters period *t* with liquid assets X_{t-1} that earns returns r_{t-1}, and receives disposable income[4] y_t. Out of this he spends an amount for nondurable expenditure, c_t^n, durable expenditure c_t^d, and some transaction costs f_t in case he establishes a new mortgage (after the reform). Transaction costs include a fixed component and a capital loss incurred when establishing the mortgage. The latter component is a function of the market rate of the bond underlying the mortgage, as outlined in the previous section. The presence of transaction costs implies that the household will run down liquid assets before accessing housing equity. Removed housing equity that is not allocated for consumption plus other liquid assets that are left after decisions have been made in period *t* is passed on to the next period as X_t. Equation (3) is central to

[3] The interest of the paper is in the development in nondurable and durable consumption following the credit market reform, but housing and leisure are left out from the utility function. A recent paper by Del Bocca and Lusardi (2003) finds that the choice of mortgage influence women's participation in the labor market. Along similar lines 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 rented to owned housing. In this case there is no evidence in the raw data that the action takes place along these margins. In the empirical analysis labour and housing is conditioned on, since some elements of consumption, for example energy, may be non separable from housing and labour.

[4] Disposable income is net of mortgage interest payments. This is of particular importance here since households that are constrained prior to the reform will be expected to increase mortgage interest payments by more than similar but unconstrained households.

this paper. Equation (3) states that loans taken with housing as collateral should be within the limits of a constant ϕ_{1t} plus the ϕ_{2t} fraction of housing equity, $\left(p_t^H H_t - M_t\right)$. ϕ_{1t} is a parameter that indicates time varying access to credit. It may be a function of household specific characteristics, but cannot be a function of the choice variables in the optimization problem. ϕ_{2t} is a parameter that indicates the access to housing equity for consumption purposes. Before the reform $\phi_{2t} = 0$, and after the reform $\phi_{2t} = 1$ provided that $\phi_{2t}\left(p_t^H H_t - M_t\right) < 0.6 p_t^H H_t$, i.e. the household can maximally mortgage 60% of the total house value for non-housing expenditures[5,6].

The only prices introduced in the model are house prices. This is because there is not much variation in the relative price of durables to nondurables. House prices, however, vary considerably relative to prices of durables and nondurables. House prices steadily declined up to 1993 and started to increase drastically hereafter. In figure A1 in appendix A prices of different durables and nondurables are shown together with house prices. Generally, house price changes imply changes in credit access in post reform years, and a house price increase can provide access to credit for households that did not have any housing equity before. Therefore, both the development of house prices and the development of the market interest rate will influence the mortgaging activity across time.

Denoting λ_t the marginal utility of wealth, and μ_t the shadow price of the borrowing restriction the first order conditions of the problem are given by[7]

$$\frac{\partial u}{\partial c_t^n} = \lambda_t \tag{5}$$

$$\frac{\partial u_t}{\partial S_t} = \lambda_t - E_t\left[\beta \lambda_{t+1}(1-\delta)\right] \tag{6}$$

[5] Note, for a constant value of ϕ_{1t} (3) dictates that if p_t^H is decreasing then the consumer should pay back the part of the collateralised loan that exceeds the new and lower housing equity. House prices were actually decreasing in the period 1987-1993, cf. figure A1 in appendix A. ϕ_{1t} is allowed to vary across time so that lenders do not require this to happen. It is crucial, though, that changes in ϕ_{1t} are not a result of actions taken by the individual as part of his optimization problem.

[6] In this way the model assumes that people do not have access to credit. In reality people may have access to credit, but at higher lending rates, so that borrowing rates are exceeding 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).

[7] Also a restriction that agents should be house owners is imposed.

$$\lambda_t - \mu_t = E_t\left[\beta\left(1+r_t\right)\lambda_{t+1}\right] \tag{7}$$

$$\mu_t\left(X_t + \phi_{1t} + \phi_{2t}\left(p_t^H H_t - M_t\right)\right) = 0 \tag{8}$$

(5) is the usual first order condition for nondurable consumption. (6) gives the marginal utility of durables. For λ constant and $\beta = 1$ marginal utility of durable consumption is derived from the part of the durable that is depreciated in the period, δ. (7) is the Euler equation with a credit constraint. Equation (7) states that households try to smooth marginal utility across time. If the household is credit constrained it will not be able to smooth marginal utility between periods. The shadow value of the credit constraint, μ_t, drives in a wedge between marginal utility in period *t* and *t+1*. Since $\mu_t > 0$ for constrained households their marginal utility will be higher in period *t* than in period *t+1*. Substituting in (5) yields the standard Euler equation for nondurable consumption with credit constraints.

$$\frac{\partial u_t}{\partial c_t^n} - \mu_t = E_t\left[\beta\left(1+r_t\right)\frac{\partial u_{t+1}}{\partial c_{t+1}^n}\right] \tag{9}$$

(9) states that if the household is constrained in period *t* then marginal utility of nondurable consumption is higher in *t* that in *t+1*. If the utility function is monotone then this amounts to saying that nondurable consumption is lower in periods where the household is constrained.

Combining (5) and (6) with (7) yields the marginal rate of substitution between durable and nondurable consumption

$$\frac{\partial u_t}{\partial S_t} = E_t\left[\left(\frac{r_t+\delta}{1+r_t}\right)\frac{\partial u_t}{\partial c_t^n} + \left(\frac{1-\delta}{1+r_t}\right)\mu_t\right] \tag{10}$$

The first term on the right hand side of (10) says (ignoring the constraint) that the marginal utility of spending one unit on durable purchases, i.e. on goods with $\delta < 1$, is lower than the marginal utility of spending the unit on nondurables. This is because the durable will yield utility in future periods as well as the present as opposed to nondurables that only yield utility in the present period. The

first term thus summarizes the total discounted utility flow from spending an extra unit on durable purchases. The second term on the right hand side of (10) shows that when the household is constrained marginal utility of consumption derived from the durable stock is inflated even further relative to that of nondurable consumption. So when the household is constrained it will cut back more on durable consumption than nondurable consumption. Conversely, if the constraint is lifted then the household will expand durable consumption by more than nondurable consumption.

The theory tells about consumption, but the empirical analysis will be based on data for total expenditure. Nondurable expenditure data may provide a reasonable proxy for nondurable consumption. Durable expenditure, on the other hand, is likely not to give a good description of durable consumption. In fact, this is what the theory tells, that facing a credit constraint, the household will cut back durable expenditure relatively drastically without suffering an equally drastic drop in durable consumption. This is because the household will still be able to consume from the worn but still serviceable durable that would have been replaced had the constraint not been there. To see the effect on expenditure assume that preferences take the form $u\left(c_t^n, S_t\right) = \left(1-\rho\right)^{-1}\left[\left(c_t^n\right)^{1-\alpha}\left(S_t\right)^{\alpha}\right]^{1-\rho}$, and for convenience that $r = r_t$ and insert in (10) to get

$$\frac{S_t}{c_t^n} = \frac{\alpha}{1-\alpha}\left[\left(\frac{r+\delta}{1+r}\right) - \left(\frac{1-\delta}{1+r}\right)\mu_t\right] = \gamma - \gamma_t^{\mu} < \gamma \qquad (11)$$

(11) shows that in the absence of a constraint $\left(\gamma_t^{\mu} = 0\right)$ there is a fixed relation between the stock of durables and nondurable expenditure, so that for a given level of nondurable expenditure the agent should make durable expenditure only big enough to cover the depreciation of the durable stock, cf. (4)[8]. If the agent is constrained, the proportion of the durable stock to nondurable expenditure is depressed, $\gamma - \gamma_t^{\mu} < \gamma$, and that the agent does not make durable expenditures sufficient to cover depreciation of the durable stock. In other words, the agent cuts back disproportionately on durable expenditure when constrained. By symmetry, he will expand durable expenditure by more than nondurable expenditure when the constraint is lifted.

In summary, the theoretical model outlined predicts that when a household faces a credit constraint, then the household will respond to a lifting of the constraint by expanding total

[8] This argument draws on Carroll (2004).

expenditure by more than an unconstrained but otherwise similar household. The model shows that the expansion will be concentrated on durable expenditure rather than on nondurable expenditure. This emphasizes the importance of using an expenditure measure that does not just include nondurable expenditure. This is going to form the basis of the empirical analysis presented in the next two sections.

4. Data

The data used in this study are based on Danish public administrative registers which give annual longitudinal wealth and income information on a 10% random sample of the population in the period 1987 to 1996. This information exists because Denmark had a wealth tax in this period, and it led to the details of both income and wealth holdings being automatically reported by banks and other financial intermediaries to the tax authorities for all Danish tax payers. The income and wealth information is used to impute total expenditure at the individual 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. The imputation is developed by Browning and Leth-Petersen (2003) who also investigate the quality of it using data drawn from the Danish Family Expenditure Survey (DES) for the years 1994-1996. The DES gives diary and interview based information on expenditures on all goods and services, which can then be aggregated to give total expenditure in a subperiod within the calendar year. 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. 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. The next section gives a description of the imputation, and section 4.2 a description of the data. Most of sections 4.1 and 4.2 contain a summary of what is already presented in Browning and Leth-Petersen (2003). Many details are left out and the reader is referred to the original text. In section 4.3 the sample selection criteria and some descriptive statistics will be presented.

4.1 The Imputation

The simplest approach to deriving an expression for total household expenditure from the income-tax register is based on an accounting identity in which total expenditure is calculated by subtracting savings components from disposable income for the household. The calculation of total disposable income from income-tax registers is, in principle, straightforward, while savings components are identified by calculating changes in wealth from the end of one tax year to the end of the next. In this section the identity that forms the basis for deriving total expenditure from income-tax registers at the household level is defined.

Consider a household that begins year *t* with a portfolio (vector) of assets $\{A_{kt-1}\}$ where A_{kt-1} is the level of asset *k* at the end of period of *t-1*[9]. These assets are held throughout the year and earn a net return i_{kt} for asset *k*. During the year the household also receives earnings (including transfers) of e_t and pays taxes of τ_t. Total expenditure throughout the year is given by c_t. At the end of the year the household sells the assets $\{A_{kt-1}\}$ at prices p_{kt} and buys a new portfolio $\{A_{kt}\}$ at the same prices. The identity of revenue and purchases gives

$$\begin{aligned} c_t + \sum_k p_{kt} A_{kt} &\equiv \left(e_t + \sum_k i_{kt} A_{kt-1} - \tau_t \right) + \sum_k p_{kt} A_{kt-1} \\ &= y_t + \sum_k p_{kt} A_{kt-1} \end{aligned} \qquad (12)$$

so that total expenditure equals disposable income, y_t, if the agent leaves the end-of-period-*t* value of the portfolio unchanged. If disposable income and all assets and asset prices were observed then it would be possible to use this equation to construct a measure of total expenditure, c_t. In the data used here the stock of each asset (except for housing) is not observed, but only the values of each at the beginning and end of the year: $W_{ks} = p_{ks} A_{ks}$ for $s = t-1, t$. To deal with this equation (12) is re-arranged to give

[9] The notation is changed slightly compared to the one used in the previous section. All assets are here collected in a vector $\{A_{kt-1}\}$.

$$
\begin{aligned}
c_t &= y_t + \sum_k p_{kt} A_{kt-1} - \sum_k p_{kt} A_{kt} + \sum_k p_{kt-1} A_{kt-1} - \sum_k p_{kt-1} A_{kt-1} \\
&= y_t - \Delta W_t + \sum_k \left(p_{kt} - p_{kt-1} \right) A_{kt-1}
\end{aligned} \tag{13}
$$

where $W_t = \sum W_{kt}$ and Δ is the first difference operator. The final term on the right-hand side is the capital gains on the portfolio held at the beginning of the year. The price change term is not observed. Most of the asset/liability variables available are composed of quite diverse assets/ liabilities which have very different returns; for example, one asset group includes both cash-in-hand and interest bearing bonds. Consequently, it is not attempted to construct a measure of the final term, except for housing. In the results section some consistency checks will be performed to make sure that the omission of this term is not the driving force behind the results. Thus, the following equation is used for imputing total expenditure[10]:

$$
c_t = y_t - \Delta W_t \tag{14}
$$

4.2 The Register Data

The study is based on a 10% random sample of the Danish population. The data set contains longitudinal information from different public administrative registers that are merged together. It holds detailed information on family composition, characteristics of the dwelling, and most importantly in this context high quality longitudinal information on income and wealth from the public income and wealth tax registers. The income tax registers contain information about total taxable income and transfers, taxable wealth, and total final tax payments. Information in these registers is based on the tax form. Many entries on the tax form, both relating to the income, assets and liabilities, are reported directly from employers, banks and other credit institutions, and are therefore considered reliable. For the purpose of implementing (14) information about total taxable income, some non-taxable income components, final tax payments, wealth, and wealth for the previous year is needed, so that a change-in-wealth measure can be calculated. One notable feature of the register data is that the data on asset holding 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. An

[10] With allowance for housing capital gains.

overview is given in figure A2 in the appendix. Before the reform assets are given in 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, and the content of shares, deposited mortgage deeds, cash holdings are self explaining, the latter is more complex. This category contains self reported information about non-deposited 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. The quality of the information in the latter category is low. No information is held about accumulated pension funds. The bulk of wage earners is enrolled in employer organised 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 organised in which case contributions are included in the total expenditure measure. The size of the liability stock is also available in the registers. This is because the wealth tax is paid of net wealth. Liabilities are generally registered for different categories such as mortgage and bank debt. Importantly, the size of the mortgage is known up to 1993. A measure of liabilities that is consistent across the observation period can, however, only be obtained for the total size of the liability stock, cf. figure A2 in Appendix A.

4.3 Sample Selection and Descriptive Statistics

The sample used in the analysis is drawn from a gross sample with information about 10% of the Danish population for the period 1987-1996. To focus the analysis a relatively homogenous sub-sample hereof is selected to minimize the risk of making erroneous inference. First, all self employed individuals are left out because such individuals have highly unstable income-tax conditions, and because own-business wealth is not likely to be measured well. Moreover, it is required that the individual sampled is not living together with his parents, and that he is not part of a common household. This is necessary in order to identify the income and wealth variables of individual households. Also, it is required for a person to enter the sample that he is aged between 18 and 75, and that the household does not move in the sample period. Movers are deselected because the interest is not in the moving decision as noted in section 3. The accounting imputation is noisy and generates some negative values of total expenditure. A household with negative imputed expenditures is deselected. Finally, conditional on these selection criteria it is required that the household is observed in all years in the period 1987-1996. This leaves a sample of 38,486 households of which 25,275 live in owner-occupied housing. The latter is the group of interest in

this paper, because they are the ones potentially gaining 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 assumption in this paper is that credit constrained households can be identified as households with little or no liquid assets, where liquid assets are defined as the amount of non-housing assets in 1991, the year prior to the reform. This is similar to the approach taken by Zeldes (1989), Runkle (1991) and Ziliak (1998). The analysis here will be done for two different sample splits. In the most restrictive split, denoted D1, the low liquid asset group is delimited to have liquid assets worth less than one month of disposable income. In the second split, denoted D2, households in the low liquid asset group are allowed to have liquid assets corresponding to two months of disposable income or less.

When the sample is split according to these two criteria for being constrained the number of observations is distributed as shown in table 1.

Table 1. Distribution of households according to the two sample splits

	D1	D2
Low liquid assets	5,886	10,499
High liquid assets	19,389	14,776

The model presented in section 3 suggests 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. Accordingly, the sample should be split into two groups, one with no liquid assets, and one with positive liquid assets. Most people, however, get paid out the salary for December a few days before the turn of the year, where the holding of assets are summarised for tax purposes. For many people liquid asset holdings corresponding to one month of disposable income thus amounts to having virtually no liquid assets as a buffer, hence the D1 split. For some households the definition of liquid assets may include assets that are in fact not very liquid. To allow for this the second sample split is introduced[11].

It is of some interest to present the portfolio composition for these groups, because this may have implications for the imputation. Table 2 presents the distribution of the portfolio for the

[11] Liquid assets may not be a perfect indicator of constrained status. As mentioned in the introduction other sample splitting techniques imputing constrained status from complementary survey information have been used that are claimed to be more likely to identify households that are in fact constrained, Jappelli, Pischke and Souleles (1998). That approach requires access to a survey with information about demographics and constrained status. Survey information of this type that is complementary to the sample analysed here does not exist. As mentioned in the introduction the approach based on complementary data sources relies on constrained status not being idiosyncratic. This is another, but also potentially restrictive, identifying assumption.

constrained sample, and in table 3 for the unconstrained sample according to sample split D1. Although each row in the table does not give assets and liabilities for the same person it seems safe to conclude from table 2 and 3 that the majority of households in the sample holds only two assets, cash and housing, and does this whether constrained or not. In particular, very few households appear to hold stocks and bonds. Similarly, it appears from table 2 and 3 that most people have simple liability structures holding only bank loans and mortgages. In terms of the imputation of total expenditure this is attractive, because it suggests that the failure to take capital gains/losses into account in the imputation may be a relatively small problem. Finally, a similar picture as given by the numbers in table 2 and 3 appears when the sample is split according to the D2 sample split. These tables are therefore not presented here.

Table 2. Distribution of portfolio for low liquid asset group in 1991 according to the D1 split. 5,886 observations

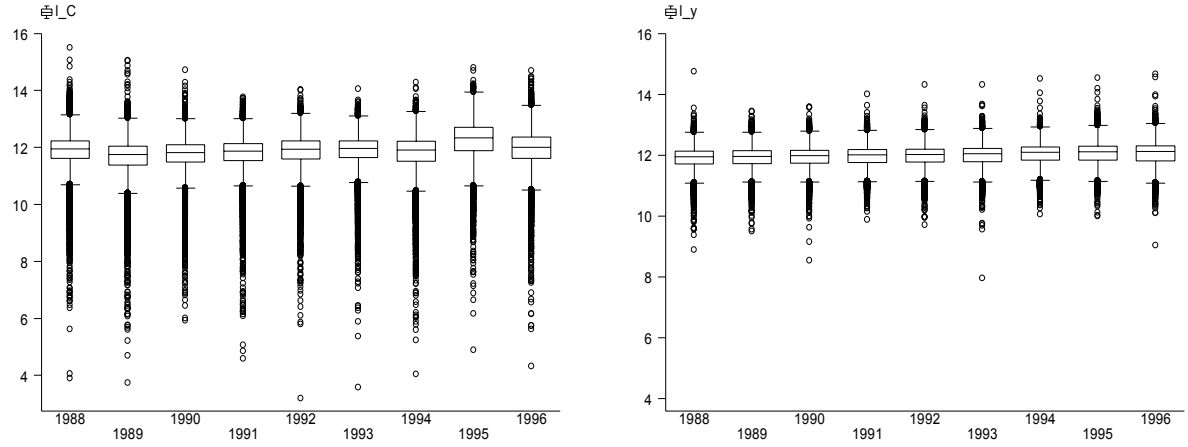
DKK	Assets						Liabilities			
Centile	House	Shares	Cash	Mortg deeds	Bonds	Other	Mortgage	Bank	Mortg deeds	Other
0	3,041	0	0	0	0	0	0	0	0	0
10	283,820	0	104	0	0	0	66,746	10,948	0	0
20	354,775	0	1,196	0	0	0	114,942	30,912	0	0
30	395,321	0	2,621	0	0	0	157,885	50,192	0	0
40	456,140	0	3,969	0	0	0	202,404	68,815	0	0
50	486,549	0	5,365	0	0	0	248,036	88,841	0	0
60	527,095	0	6,774	0	0	0	295,742	110,405	0	0
70	577,777	0	8,348	0	0	0	346,049	136,491	0	0
80	628,460	0	10,228	0	0	29,239	410,318	169,562	41,667	0
90	719,688	588	12,614	0	0	63,352	500,133	220,354	84,987	3,716
100	1,378,558	19,578	26,939	13,276	15,243	1,111,111	1,251,209	950,489	602,563	313,168

Table 3. Distribution of portfolio for high liquid asset group in 1991 according to the D1 split. 19,389 observations

DKK	Assets						Liabilities			
Centile	House	Shares	Cash	Mortg deeds	Bonds	Other	Mortgage	Bank	Mortg deeds	Other
0	2,605	0	0	0	0	0	0	0	0	0
10	304,093	0	13,316	0	0	0	12,208	0	0	0
20	375,048	0	18,658	0	0	0	54,539	0	0	0
30	425,731	0	23,978	0	0	0	93,239	0	0	0
40	466,276	0	30,754	0	0	0	133,771	6,924	0	0
50	516,959	0	39,500	0	0	0	180,156	21,966	0	0
60	562,573	0	51,664	0	0	102	236,643	42,469	0	0
70	608,187	2,354	70,213	0	0	24,366	297,196	67,291	0	0
80	679,142	7,514	99,138	0	2,134	48,732	370,118	100,716	14,919	0
90	780,506	22,587	158,628	599	48,915	86,092	483,514	1,562,48	72,744	0
100	1,875,244	1,253,579	1,691,677	1,764,819	14,500,000	714,830	1,392,898	9,745,491	743,089	14,700,000

The interest here lies in giving a description of the development of total expenditure. Figure 2 gives box plots of total expenditure and disposable income across the period 1988 to 1996 for all house owners. The left graph shows that imputed total expenditure tends to increase from 1990 and that there is a considerable expansion in 1995. These features roughly[12] match those of the aggregate total expenditure data presented in figure 1. Since the imputed total expenditure measure relies heavily on disposable income, cf. (14), one could justly be worried that the movements in the total expenditure measure just mimic those of disposable income. The right hand graph in figure 2 shows that this is not the case.

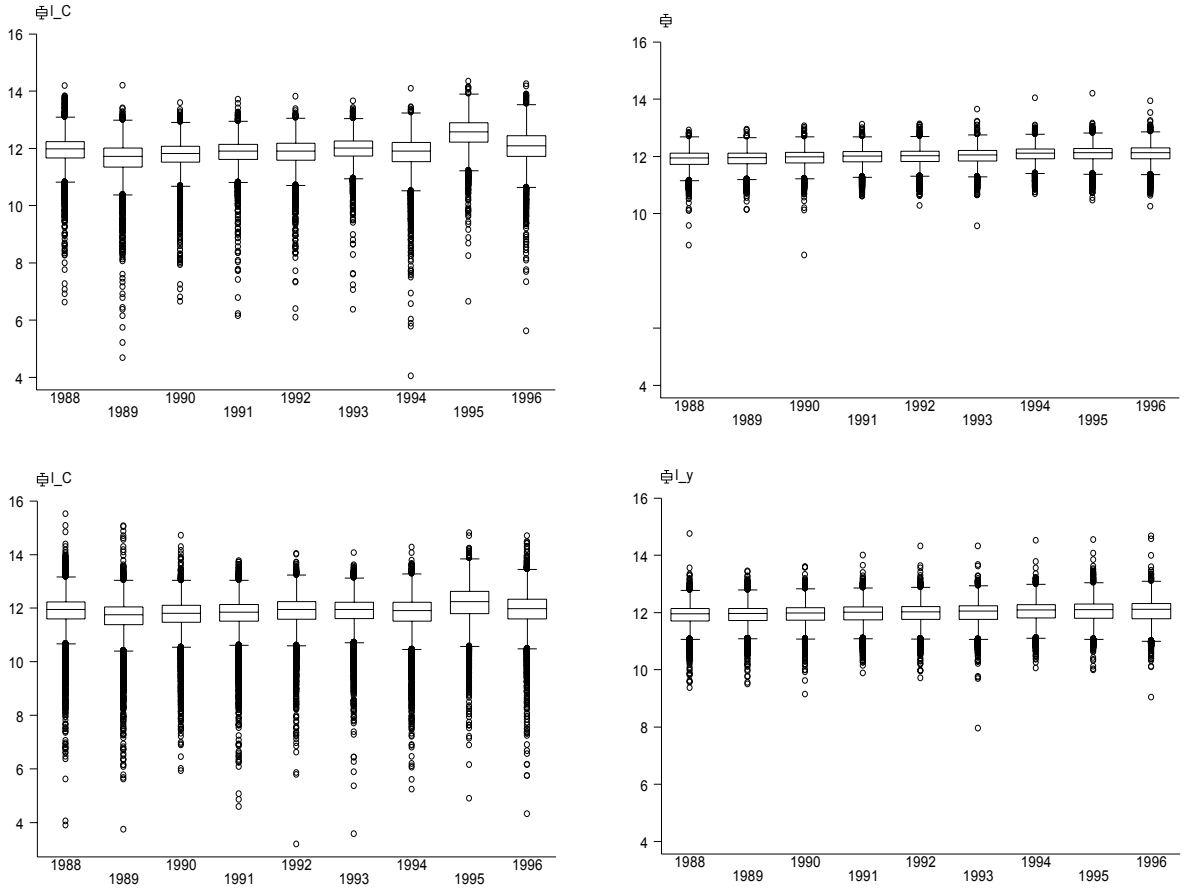
Figure 2. Box plots of imputated total expenditure (left) and disposable income (right) across the observation period for owners



Box plots of imputed total expenditure and disposable income for high and low liquid asset households according to the D1 sample split are given in figure 3. The left hand side column of figure 3 confirms that total expenditure is generally increasing from 1990 throughout 1996, and appears to accelerate sharply in 1995. Moreover, the sample splits indicate that the low liquid asset group seems to exhibit more variability in total expenditure than does the group with more liquid assets.

[12] Aggregate total expenditure increases continuously from 1990 and throughout 1996, but increases particularly drastic from 1994-1996. The micro data exhibit a small drop in 1994 and a pronounced jump in 1995. There could be at least two explanations for this deviation. First, measurement error can play a role. Second, and probably more important, the sample used here does not cover the whole private sector why it would be unlikely to observe exactly the same pattern.

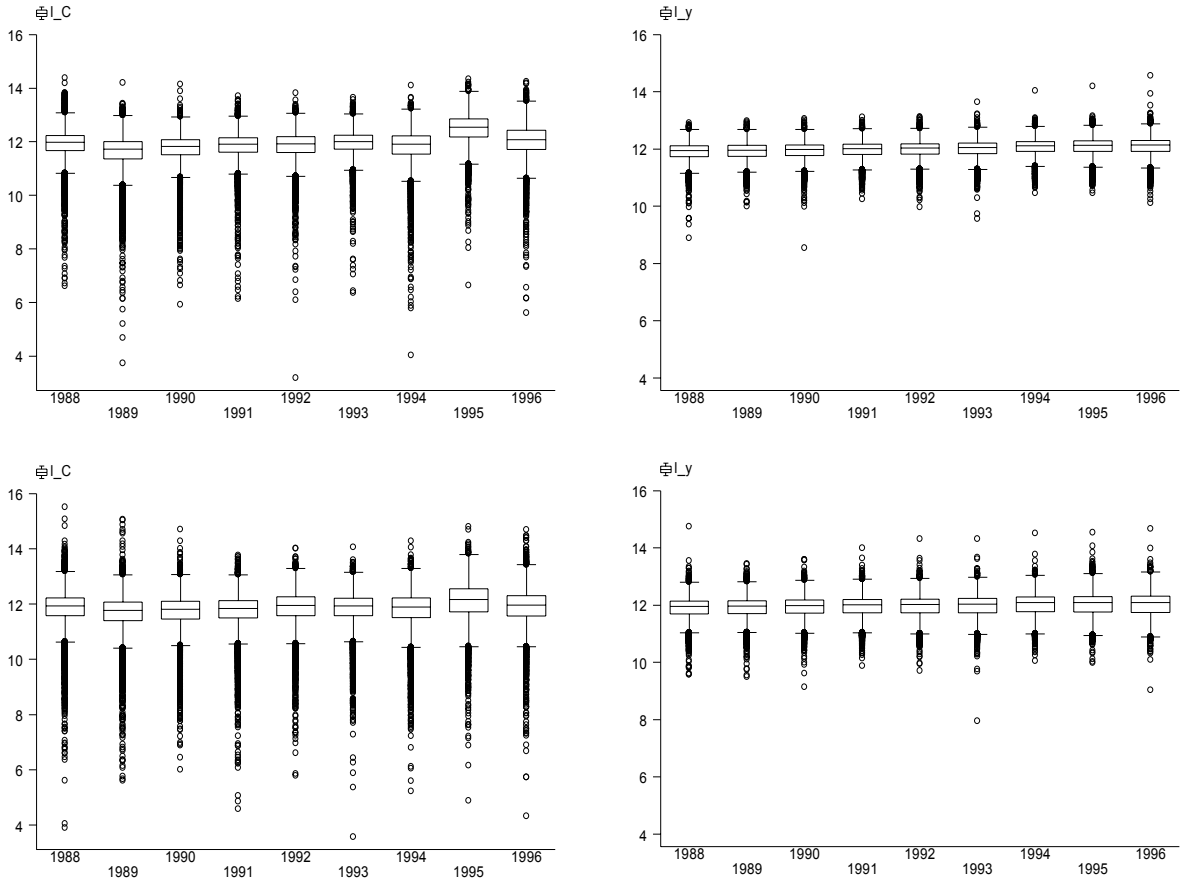
Figure 3. Box plots of imputed total expenditure and disposable income across the observation period for house owners for the D1 split. The left column shows total expenditure, and right column disposable income. The top row shows the constrained sample, and the bottom row shows the unconstrained sample



Again it seems important to confirm that the movements observed in the expenditure measure are not just a mirror of the movements in disposable income. Box plots of disposable income for the D1 split are shown in the right hand side column of figure 3. They suggest that the movements in imputed total expenditure are not just due to movements in disposable income[13]. The same picture is found for the D2 sample split, cf. figure 4.

[13] Even though the descriptive evidence just presented does not indicate any close connection between variations in total expenditure and disposable income, a significant correlation might be found in a formal test for excess sensitivity. Such a test is, however, likely not to be informative about credit constraints, but rather about the nature of the imputation. Even though there is evidence that the imputation used here has good quality compared to what is known from the previous literature, cf. Browning and Leth-Petersen (2003), it is certainly measured with error. Therefore, a test for excess sensitivity is likely to be biased towards accepting excess sensitivity because of the prominent role played by income in the imputation. Ziliak (1998) uses an imputation that is similar in nature to the one used here. He finds, not surprisingly, evidence of excess sensitivity.

Figure 4. Box plots of imputed total expenditure and disposable income across the observation period for house owners for the D2 split. The left column shows total expenditure, and right column disposable income. The top row shows the constrained sample, and the bottom row shows the unconstrained sample



The evidence presented thus far appears to be consistent with the hypothesis that some movements in total expenditure have taken place after the introduction of the credit market reform. It is still needed, however, to look into the micro 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.

5. Empirical strategy

The empirical test for credit constraints will be based on the prediction that households that are constrained immediately prior to the reform will have a larger total expenditure growth across the reform period than households that are not constrained. It is assumed that consumers with a low level of liquid assets in 1991 are constrained immediately prior to the reform, and the sample is split accordingly. Specifically, two sample splits are applied: one split where households with liquid assets corresponding to less than one month of disposable income by the end of 1991 are considered constrained, and another split where households with liquid assets corresponding to less than two months of disposable income by the end of 1991 are considered constrained. The test is implemented by statistical matching[14], where for each individual in the constrained group an individual from the unconstrained with similar observed characteristics is found, and the growth rates of total expenditure across the reform period are compared. If the total expenditure growth rate of the constrained household around the reform is higher than for the unconstrained household it is taken as evidence that credit constraints have influenced the intertemporal consumption plan as shown in the theory section.

An advantage of the data set used here is that all the components of the collateralised loans constraint (3) are observed along with a host of other variables that are conventionally included in Euler equation studies. It therefore seems natural to implement the test by statistical matching where for each household believed to be constrained another household is found that is identical in terms of a number of observed characteristics except that it is not constrained. In particular, housing equity and the level of liquid assets are observed. It is therefore possible to match people with similar access to credit after the reform, but where one had a low level of liquid assets before the reform and the other one did not. To ensure that the matching procedure compares a constrained household with an otherwise similar household that is not constrained, households are also matched on a number of other variables that are known from the empirical literature on consumption Euler equations to correlate with consumption growth: family composition, age, and labour supply. Moreover, matching is done on unemployment insurance membership. The ideal experiment compares two households that are identical in terms of the life cycle model, i.e. households with the same life time wealth, except that one individual is constrained prior to the reform, and the other one is not.

[14] The idea to use statistical matching to address questions about intertemporal consumption allocation originates from other ongoing work together with Karsten Albæk and Martin Browning.

Households are therefore also matched on disposable income and the size and the value of the house as indicators for the level of life time wealth.

The objective is to obtain an estimate of the effect of the reform on expenditure growth around the reform period for a constrained household. That is, the expected growth rate of the a priori constrained household conditional on pre-reform characteristics should be compared with the growth rate it would have experienced had it not been constrained. This is known from the evaluation literature as the average treatment effect on the treated, and is given by (15).

$$E\left(\Delta C_{1,t+1} - \Delta C_{0,t+1} \middle| D_t = 1, X_t\right) = E\left(\Delta C_{1,t+1} \middle| D_t = 1, X_t\right) - E\left(\Delta C_{0,t+1} \middle| D_t = 1, X_t\right) \qquad (15)$$

$E(\ )$ is the cross sectional expectation operator, $\Delta C_{j,t+1}$ is the log total expenditure change measured at time *t+1* for a household with constrained status *j* at time *t*. *t* indicates pre-reform time period and *t+1* indicates post-reform time period. $D_t = 1$ indicates that the household was constrained prior to the reform. X_t is a vector of observed characteristics at time *t* containing the variables described before.

Potentially, the household may adjust behaviour so that variables such as income, labour supply, and housing assets may change as a response to the reform. By conditioning on pre-reform values of these variables they are surely not under influence of the reform. The implicit assumption made is that a situation with low liquid assets by the end of 1991 has arisen because the household has experienced an adverse income or consumption shock, so that a situation with low liquid assets at the end of 1991 is not a consequence of maximizing behaviour that makes the constrained households systematically different from the unconstrained for unobserved reasons. This assumption is also invoked by Zeldes (1989) estimating the parameters of the Euler equation on the unconstrained sample and subsequently using these parameters to evaluate the shadow value of the credit constraint for the households in the constrained sample.

The difficulty in implementing the estimator is in estimating $E\left(\Delta C_{0,t+1} \middle| D_t = 1, X_t\right)$, i.e. the change in total expenditure conditional on X_t for the constrained had they not been constrained. This is a counterfactual. It is therefore assumed that $E\left(\Delta C_{0,t+1} \middle| D_t = 1, X_t\right) = E\left(\Delta C_{0,t+1} \middle| D_t = 0, X_t\right)$, i.e. that conditional on observed characteristics X_t the expected change in total expenditure for the constrained had they not been so is the same as the expected change in total expenditure for the

unconstrained, i.e. those who are not affected by the credit market reform, but otherwise have similar characteristics. This is labelled mean independence, and it amounts to assuming that conditional on X_t the constrained group differs from the unconstrained group only by being constrained. This implies, for example, that conditional on X_t the households in the constrained group are not allowed to have different attitudes to risk relative to the unconstrained group. Moreover, in terms of the Euler equation[15] the mean independence assumption corresponds to assuming that $E\left(\varepsilon_{0,t+1}\middle|D_t=1,X_t\right)=E\left(\varepsilon_{0,t+1}\middle|D_t=0,X_t\right)$ where $E\left(\varepsilon_{0,t+1}\middle|D_t=1,X_t\right)$ is the cross sectional average expectation error of the constrained households had they not been constrained and $E\left(\varepsilon_{0,t+1}\middle|D_t=0,X_t\right)$ is the cross sectional average expectation error of the matched unconstrained households. This implies that conditional on X_t the two groups are assumed on average to guess wrong in the same direction and quantity at a given point in time. This assumption is to be compared to the assumption usually invoked in empirical Euler equation studies that conditional on the information set the *time* average of the expectation error is zero, $E_t\left(\varepsilon_{0,t+1}\middle|I_t\right)=0$.

An important feature of the data applied here is that total expenditure is imputed and is therefore measured with error. Assume that the measurement error is additive in log total expenditure, so that $\Delta\tilde{C}_{j,t+1}=\Delta C_{j,t+1}+\Delta\omega_{j,t+1}$, where $\Delta\tilde{C}_{j,t+1}$ is the observed measure, $\Delta C_{j,t+1}$ is the true but unobserved measure and $\Delta\omega_{j,t+1}$ is the measurement error. For the matching estimator to give an unbiased estimate of the mean effect of the reform on the constrained households it is required that conditional on X_t, on average the measurement error cancels out between the constrained and the matched unconstrained households, i.e.

$$\begin{aligned}&E\left(\Delta\tilde{C}_{1,t+1}\middle|D_t=1,X_t\right)-E\left(\Delta\tilde{C}_{0,t+1}\middle|D_t=0,X_t\right)\\&+\left(E\left(\Delta\omega_{0,t+1}\middle|D_t=0,X_t\right)-E\left(\Delta\omega_{1,t+1}\middle|D_t=1,X_t\right)\right)\\&\qquad=E\left(\Delta\tilde{C}_{1,t+1}\middle|D_t=1,X_t\right)-E\left(\Delta\tilde{C}_{0,t+1}\middle|D_t=0,X_t\right)\end{aligned}\tag{16}$$

.

As mentioned in section 3 the measurement error is likely to relate to the portfolio composition of the household and to be most important where capital gains are not taken in to account in the imputation. It was shown that most households in the constrained and unmatched unconstrained

[15] Talking about the implications for the Euler equation, strictly speaking, assumes that the analysis is based on consumption data rather than expenditure data.

groups hold simple portfolios and this suggests that the matching estimator should be able to pick a comparison group so that the measurement error balances out[16].

As noted in section 2 there are three elements of the reform; two of them gives additional access to the housing equity and the third element introduces the possibility to remortgage so that low market interest rates can be locked in and a gain in life time wealth achieved. To check for credit constraints the interest centres on the two first elements of the reform, and these should only be exploited by those who are constrained before the reform. Both constrained and unconstrained households have an incentive to exploit the remortgaging option. Thus, if matching is done successfully, so that a constrained individual is matched to an otherwise identical unconstrained individual, the effect of remortgaging on total expenditure should cancel out when comparing the growth in expenditure, since both constrained and unconstrained households should have exploited this option if profitable.

As a practical matter it is difficult to match on a high dimensional X_t. The practice in the economic literature using matching methods is therefore followed, and the result of Rosenbaum and Rubin (1983) that matching can be done on the propensity score, provided that this is known, is exploited.

Matching on the propensity score requires that

$$E\left(\Delta C_{0t+1}\middle|D_t=1,P\left(X_t\right)\right)=E\left(\Delta C_{0,t+1}\middle|D_t=0,P\left(X_t\right)\right) \qquad (17)$$

Furthermore, it is required that $P\left(D_t=1\middle|X_t\right)<1$, so that common support is feasible. This is to make sure that for every constrained household it is possible to find an unconstrained household that has the same observed characteristics.

The estimator proposed here is similar to the so-called conditional difference-in-difference estimator of Heckman, Ichimura and Todd (1997). In this case the estimator has the same characteristic as the estimators usually applied in Euler equation studies that unobserved household specific level effects are differenced away. What remains are unobserved characteristics that cause growth rates of total expenditure to differ across individuals. Such unobserved characteristics are

[16] Measurement error is an important reason for not implementing the test in an IV-regression framework. Because the change in log consumption is imputed: $\Delta \ln \tilde{c}_{t+1}=\ln\left[y_{t+1}-\left(W_{t+1}-W_t\right)\right]-\ln\left[y_t-\left(W_t-W_{t-1}\right)\right]$ it would be necessary to take recourse to variables dated *t-2* as instruments when estimating the equation dated *t+1*, and the potential problems associated with weak instruments would then be imminent.

assumed to be identically and independently distributed so that the effect of these cancels out between the two groups on average.

The simplest matching method available, the so-called one-to-one matching, where each individual in the constrained group is paired with a single individual from the unconstrained group is employed. Matching is done with replacement, so that the same individual from the unconstrained group can act as matched control for different constrained individuals.

6. Results

In this section results from estimating the average effect of the credit market reform on total expenditure for those households that were constrained prior to the reform are presented. Results are presented in two steps. First, the main set of results is presented for the two sample splits for house owners. Next a consistency check is performed on the sample of renters as supplementary evidence to confirm that the main results are indeed indicative of credit constraints.

Estimates are obtained by statistical matching. For each person in the constrained group a match is found in the unconstrained group, and the change in log total expenditure is then compared between the constrained and the matched unconstrained. This is done for the whole sample of constrained as explained in the previous section. The matching is done by matching on the probit propensity score. The probit model gives the probability of being constrained as a function of housing equity, disposable income, the number of children, single status, and membership of unemployment insurance, age, labour supply, and the value and size of the house. All these variables are measured in 1991, the year preceding the introduction year of the reform. All continuous variables are split into intervals and it is the dummy variables indicating the relevant interval that is included in the probit model. This is to protect against the results being driven by functional form assumptions in the probit index. Estimates of the probit models are given in table 4.

The estimation results in table 4 indicate that the probability of being constrained is negatively correlated with the size of the housing equity; it is increasing with the number of children, and increasing with labour market participation. There is a tendency that the probability of being constrained decreases with the income level, and the size and the value of the house consistent with these factors acting as indicators of life time wealth. The age dummies indicate that particularly households aged over 55 are less prone to be constrained.

Table 4. Probit estimates for D1 split and D2 split for house owners

	D1		D2	
Variable	Parameter	Std.err	Parameter	Std.err
Constant	-0.9584**	0.0749	-0.4172**	0.0673
Housing equity, ≤ 50000	0.0871**	0.0394	0.1184**	0.0373
50000<Housing equity≤100000	0.0659	0.0445	0.1274**	0.0421
100000<Housing equity≤150000	0.1349**	0.0423	0.1235**	0.0401
150000<Housing equity≤200000	0.0818*	0.0420	0.1206**	0.0394
250000<Housing equity≤300000	0.0357	0.0414	0.0703*	0.0381
300000<Housing equity≤350000	0.0213	0.0424	0.0438	0.0389
350000<Housing equity≤400000	-0.0578	0.0441	-0.0180	0.0400
400000<Housing equity≤450000	-0.1323**	0.0492	-0.1245**	0.0440
450000<Housing equity≤500000	0.0042	0.0521	-0.0039	0.0467
500000<Housing equity≤550000	-0.1464**	0.0598	-0.0884*	0.0523
550000<Housing equity≤600000	-0.1108**	0.0679	-0.0954	0.0592
Housing equity>600000	-0.0984*	0.0586	-0.1149**	0.0522
Disposable income ≤ 50000	0.3586*	0.1940	0.4770**	0.1688
50000< Disposable income ≤100000	0.2121**	0.0422	0.2493**	0.0384
100000< Disposable income ≤150000	0.0835**	0.0238	0.0838**	0.0224
200000< Disposable income ≤250000	-0.1059**	0.0264	-0.1303**	0.0242
250000< Disposable income ≤300000	-0.2923**	0.0529	-0.3746**	0.0465
300000< Disposable income ≤350000	-0.2332**	0.1025	-0.3812**	0.0915
Disposable income >350000	-0.5512**	0.1926	-0.8853**	0.1768
1 child	0.1562**	0.0279	0.2140**	0.0251
2 children	0.3087**	0.0293	0.3303**	0.0269
3 children	0.5121**	0.0430	0.6020**	0.0418
4 children	0.8177**	0.0999	0.7687**	0.1043
Single	-0.1417**	0.0448	-0.2734**	0.0396
Age≤25	-0.2112	0.3054	-0.2469	0.2801
25<Age≤30	0.0569	0.0596	0.0654	0.0585
30<Age≤35	0.0236	0.0374	0.0861**	0.0365
35<Age≤40	0.0103	0.0300	0.0411	0.0288
45<Age≤50	-0.0083	0.0299	-0.0443	0.0280
50<Age≤55	-0.0665	0.0358	-0.0971**	0.0328
55<Age≤60	-0.1613**	0.0420	-0.2428**	0.0379
60<Age≤65	-0.3113**	0.0531	-0.4148**	0.0468
65<Age≤70	-0.6143**	0.0644	-0.7351**	0.0555
Age>70	-0.0682**	0.2668	-0.1902	0.2358
UI Membership	-0.0185	0.0355	-0.0220	0.0317
Labour supply, male	0.1897**	0.0416	0.1410**	0.0364
Labour supply, female	0.1399**	0.0320	0.1899**	0.0289
$M^2 \leq 75$	0.0252	0.0516	0.0855*	0.0475
$75 < M^2 \leq 100$	-0.0380	0.0323	0.0163	0.0296
$100 < M^2 \leq 125$	-0.0568**	0.0242	-0.0475**	0.0224
$150 < M^2 \leq 175$	-0.0530*	0.0293	-0.0532**	0.0270
$175 < M^2 \leq 200$	-0.0630	0.0441	-0.0863**	0.0406
$M^2 > 200$	-0.0411	0.0584	-0.0210	0.0534

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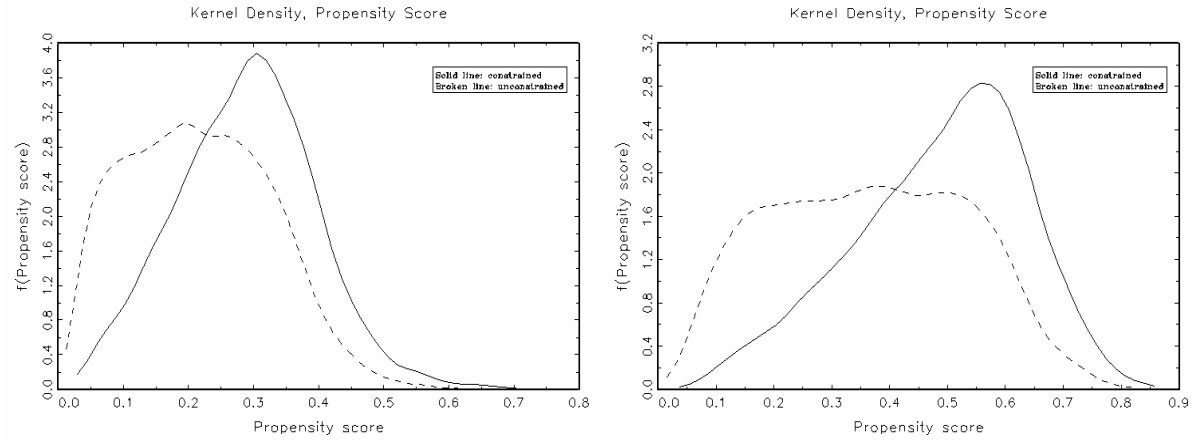
House val. ≤200000	0.3729**	0.0774	0.3590**	0.0756
200000<House val. ≤300000	0.1466**	0.0389	0.1433**	0.0368
400000<House val. ≤500000	-0.1209**	0.0300	-0.1069**	0.0280
500000<House val. ≤600000	-0.1271**	0.0318	-0.1195**	0.0298
600000<House val. ≤700000	-0.1927**	0.0371	-0.1889**	0.0344
700000<House val. ≤800000	-0.2631**	0.0471	-0.2711**	0.0431
House val. >800000	-0.2495**	0.0534	-0.2939**	0.0486

Note: The reference household is a couple without children, with housing equity in the interval 200,000-250,000, disposable income in the interval 150000-200000, aged 41-45, no UI membership, do not participate in the labour market, live in a house sized 126-150 m^2, valued 300,000-400,000 DKK. All money values are measured in DKK, 1990 price levels. ** significant at 5% level. * significant at 10% level.

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 constrained and the unconstrained groups. Figure 5 shows kernel densities of the estimated propensity scores for the constrained and unconstrained for the D1 and the D2 split.

Figure 5. Kernel densities of propensity scores for constrained and unmatched unconstrained house owners. D1 split to the left, and D2 split to the right



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

Generally, for both sample splits the graphs indicate that there is common support. The D1 graph of densities of propensity scores points to that there may be a support problem at the right tale of the distribution. All the calculations have been repeated conditioning on the difference in propensity scores between constrained and matched unconstrained not exceeding 0.0001 in order to check if lack of common support is any problem. This did not affect the estimates. To check the balance

properties of the propensity scores for the constrained and matched unconstrained two-sample t-test for all the included explanatory variables included in the probit estimation are calculated. Each t-test tests for the variable in question if the mean for the constrained group is different from the mean in the matched unconstrained group. If such a test is rejected it is indication that, on average, the constrained households do not have characteristics similar to the matched unconstrained households, so that the functional form of the probit index plays a role in matching. These t-tests are reported in table B2 in the appendix, and they show no evidence of differences in the characteristics between the constrained group and the matched unconstrained group.

The estimates of the average effect of the credit reform on total expenditure for the constrained group are reported in table 5 for the D1 split and in table 6 for the D2 split. For each split the annualized change in total expenditure is calculated over four different horizons: 1993-1996 relative to 1988-1991, 1993-1995 relative to 1989-1991, 1993-1994 relative to 1990-1991, 1993 relative to 1991. The expenditure effect is calculated for four different horizons to follow when the expenditure effect kicks in, if it does so. Besides reporting the estimated average effect on total expenditure table 5 and 6 also report the estimated average difference in the development in log disposable income between the constrained group and the matched unconstrained group. This is done to check that the estimated total expenditure effect is not driven by different developments in income between the constrained group and the matched unconstrained group. Finally, also the estimated average change in total liabilities is reported. This is done to confirm that any positive expenditure effect that might be found is associated with accumulation of liabilities. As mentioned in section 4 the imputed measure of total expenditure used here does not deal with potential capital gains on the portfolio (except for housing). Thus, if unconstrained households have different portfolios than constrained 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 constrained and the matched unconstrained. Potentially, problems with capital gains are biggest for households holding shares, bonds or similar traded papers. From the descriptive evidence on portfolio composition presented in section 4 it was seen that portfolios are mainly centred on housing and cash, and that the portfolios are not very diversified for neither constrained nor unconstrained households. It is therefore not expected that capital gains are driving the results presented here. However, if constrained households accumulate more debt than unconstrained households it is a good confirmation that constrained households do indeed take out housing equity for consumption purposes. Ideally, this check should be done on the mortgage itself, but due to changes in variable

definitions across the period, cf. figure A2 in Appendix A, it is only possible to do this check on total liabilities.

Table 5. Estimates of the average effect of the reform on constrained owners, for total expenditure, disposable income and liabilities using the D1 split

		Average effect of the reform on the constrained		
		(1)	(2)	(3)
		Q=ln(Expenditure)	Q=ln(Disp. Income)	Q=Liabilities[(1)]
1	$[(Q_{96}+Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89}+Q_{88})]/4$	0.0255	-0.0096	44,235
	Bootstrap confidence intervals[(2)]	(0.0482 ; 0.0051)	(-0.0012 ; -0.0209)	(51,388 ; 37,569)
2	$[(Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89})]/3$	0.0323	-0.0063	32,465
	Bootstrap confidence intervals[(2)]	(0.0549 ; 0.0060)	(0.0008 ; -0.0164)	(38,281 ; 26,563)
3	$[(Q_{94}+Q_{93})-(Q_{91}+Q_{90})]/2$	-0.0490	-0.0034	14,251
	Bootstrap confidence intervals[(2)]	(-0.0243 ; -0.0752)	(0.0034 ; -0.0131)	(19,288 ; 10,055)
4	$(Q_{93})-(Q_{91})$	-0.0432	-0.0080	15,012
	Bootstrap confidence intervals[(2)]	(0.0014 ; -0.0719)	(-0.0005 ; -0.0161)	(19,894 ; 10,250)

Note: All variables are measured in DKK at 1990 price levels. Matching is done with replacement. Size of constrained group: 5,886 size of matched unconstrained group 3,702.
(1) Liabilities are measured in DKK (normal scale) because there are some individuals without mortgage.
(2) The bootstrap confidence intervals are bounded by the 99th percentile and 1st percentile of the bootstrap distribution, respectively. The bootstrap distribution is based on 1,000 replications. The resampling preserves the proportion of constrained and unconstrained households in each sample. For computational tractability the resampling is done conditional on the propensity score estimated on the original sample.

From table 5, it is seen that there is a significant effect on total expenditure of the reform on the constrained group according to the D1 split. The estimation results indicate that the effect does not show until 1995 and the average effect is estimated to be 3%, i.e. that total expenditure for the constrained group has on average increased about 3% more than for the matched unconstrained group following the reform. This effect could have been caused by income developing more rapidly for the constrained group than for the matched unconstrained group. Column 2 in table 5, however, shows clearly that this is not the case. In fact, over all horizons the average development in disposable income for the constrained households is always the same or slightly lower than for the matched unconstrained group. Column 3 confirms that the matched controls have accumulated more liabilities over the period than the matched unconstrained. The effect is given in normal scale, because some households have zero liabilities. This does confirm that the constrained group has financed the total expenditure expansion by accumulating debt[17].

The results for the D1 split are confirmed when the D2 sample split is applied, as shown in table 6. Expenditure effects show from 1995. There is no indication that the expenditure effects are

[17] In this case the mean may not be a good measure of the location of the distribution of debt accumulation effects. The median effect (not reported) is, however, similar.

caused by disposable income developing more rapid in the constrained group than in the matched unconstrained group, cf. column (2). The constrained group also accumulates more debt than the matched unconstrained group.

Table 6. Estimates of the average effect of the reform on constrained owners for total expenditure, disposable income and liabilities using the D2 split

		Average effect of the reform on the constrained		
		(1)	(2)	(3)
		Q=ln(Expenditure)	Q=ln(Disp. Income)	Q=Liabilities[1]
1	$[(Q_{96}+Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89}+Q_{88})]/4$	0.0307	-0.0091	48,191
	Bootstrap confidence intervals[2]	(0.0472 ; 0.0104)	(-0.0010 ; -0.0164)	(53,333 ; 41,892)
2	$[(Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89})]/3$	0.0454	-0.0068	36,412
	Bootstrap confidence intervals[2]	(0.0583 ; 0.0180)	(0.0010 ; -0.0132)	(40,574 ; 31,124)
3	$[(Q_{94}+Q_{93})-(Q_{91}+Q_{90})]/2$	-0.0422	-0.0039	17,737
	Bootstrap confidence intervals[2]	(-0.0260 ; -0.0698)	(0.0033 ; -0.0104)	(21,710 ; 12,953)
4	$(Q_{93})-(Q_{91})$	-0.0462	-0.0054	16,871
	Bootstrap confidence intervals[2]	(-0.0160 ; -0.0781)	(0.0011 ; -0.0123)	(22,192 ; 13,108)

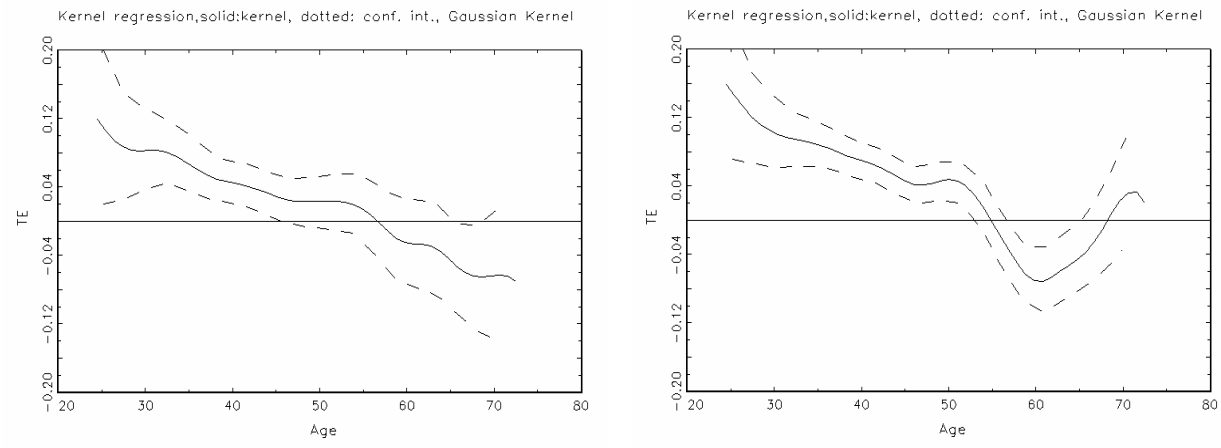
Note: All variables are measured in DKK at 1990 price levels. Matching is done with replacement. Size of constrained group: 10,499 size of matched unconstrained group 4,728.
(1) Liabilities are measured in DKK (normal scale) because there are some individuals without mortgage.
(2) see note (2) of table (5).

At the first glance it may seem that the expenditure effects should have been observed immediately after the reform, i.e. in 1992/1993 instead of 1995, since if people are really constrained then they should act as soon as possible in order to increase utility. There can be a couple of reasons for this. First of all, it may be that people have to learn about the new possibilities for using housing equity for consumption purposes. Secondly, there are transaction costs associated with accessing housing equity, cf. (2), and these transaction costs vary with the market interest rate of the bonds underlying the mortgage, so that when the interest rate is low the transaction costs are low. In figure A1 in the appendix the average market interest rate on mortgage bonds is graphed, and there is no indication that there is a sudden drop in the market interest rate at the point where the expenditure effect hits in. A third reason for the total expenditure effect to show in 1995 may have to do with the collateralised loans constraint. This is a function of the house price, so that if house prices go up then the access to additional credit goes up correspondingly. As it is seen from figure A1 house prices have been declining up to 1993, and increasing hereafter. However, as noted in section 2 many constrained households had quite a large housing equity before the reform. Yet another explanation may be related to subjective expectations about house prices. If households do not wish to access housing equity in a period with falling house prices because they perceive declining house

prices as indicative of a permanent decrease in life time wealth then this may explain the timing of the expenditure effect. Modelling of subjective expectations of house prices is beyond the scope of this paper.

It is not likely that all households in the constrained group respond equally to the reform. The matching estimator produces individual estimates for the effect of lifting the constraint for all constrained households. It is therefore possible to explore if there are systematic differences in the responses across age groups. This is done by regressing the estimated total expenditure effect for the constrained group for the two sample splits non-parametrically on age of the oldest member of the household. These regressions are shown in figure 6 for the case where effects are estimated over the horizon 1993-1995 relative to 1989-1991, cf. row (2) in table 5 and 6. The graphs show that there is a positive effect on total expenditure mainly for age groups 30-50, and that the estimated average effect for this age band ranges 4-10% with largest effects for the younger people. These estimates indicate that constrained households belonging to the age band 30-50 on average have increased total expenditure by 4-10% more than unconstrained, but otherwise similar households. There appears to have been no positive expenditure effects for households aged more than 50. That younger people are more likely to be constrained is found also by Jappelli (1990), Gross and Souleles (2002), and Alessie Deverux and Weber (1997).

Figure 6. Kernel regressions of estimated total expenditure effect of the reform on the constrained owners against age. D1.2 is shown to the left, and D2.2 is shown to the right



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 pointwise confidence intervals, cf. Härdle (1990).

The estimates presented so far provide the main set of results from this study. To make sure that the effects found are in fact expenditure effects caused by the reform a consistency check is done where the same estimation exercise is carried out 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 effects should be found for renters. The sample of renters is split into renters with liquid assets corresponding to less/more than one (two) months of income. Matching is done on the same variables as for owners, except that it is of course not possible to match on housing equity and the value of the house.

Estimation results for the D1 split for renters are presented in table 7 and for the D2 split in table 8. The probit estimates, balance t-tests and kernel densities of the propensity scores are referred to appendix C. The estimation results for both splits indicate that total expenditure has on average developed slower for constrained renters than for matched unconstrained renters. Negative expenditure effects are always associated with a similar or negative development in the disposable income relative to matched unconstrained. Moreover, constrained renters with low liquid assets do on average tend to accumulate more debt than the matched unconstrained. This difference is modest, though, and in most cases there is no excess accumulation of debt when the median effect is considered (not reported).

Table 7. Estimates of the average effect of the reform on constrained renters, for total expenditure, disposable income and liabilities using the D1 split

		Average effect of the reform on the constrained		
		(1)	(2)	(3)
		Q=ln(Expenditure)	Q=ln(Disp. Income)	Q=Liabilities[1]
1	$[(Q_{96}+Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89}+Q_{88})]/4$	-0.0306**	-0.0134**	4,973**
	Bootstrap confidence intervals[2]	(0.0389 ; -0.0607)	(0.0226 ; -0.0380)	(12,075 ; 150)
2	$[(Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89})]/3$	-0.0304**	-0.0086**	3,757**
	Bootstrap confidence intervals[2]	(0.0391 ; -0.0658)	(0.0248 ; -0.0322)	(8,399 ; -1,773)
3	$[(Q_{94}+Q_{93})-(Q_{91}+Q_{90})]/2$	-0.0399**	-0.0051	372
	Bootstrap confidence intervals[2]	(0.0157 ; -0.1042)	(0.0233 ; -0.0316)	(3,462 ; -4,731)
4	$(Q_{93})-(Q_{91})$	-0.0736**	-0.0091**	143
	Bootstrap confidence intervals[2]	(0.0207 ; -0.1477)	(0.0177 ; -0.0272)	(3,460 ; -4,292)

Note: All variables are measured in DKK at 1990 price levels.
Matching is done with replacement. Size of constrained group: 5,337 size of matched unconstrained group 864.
(1) Liabilities are measured in DKK (normal scale) because there are some individuals without mortgage.
(2) see note (2) of table (5).

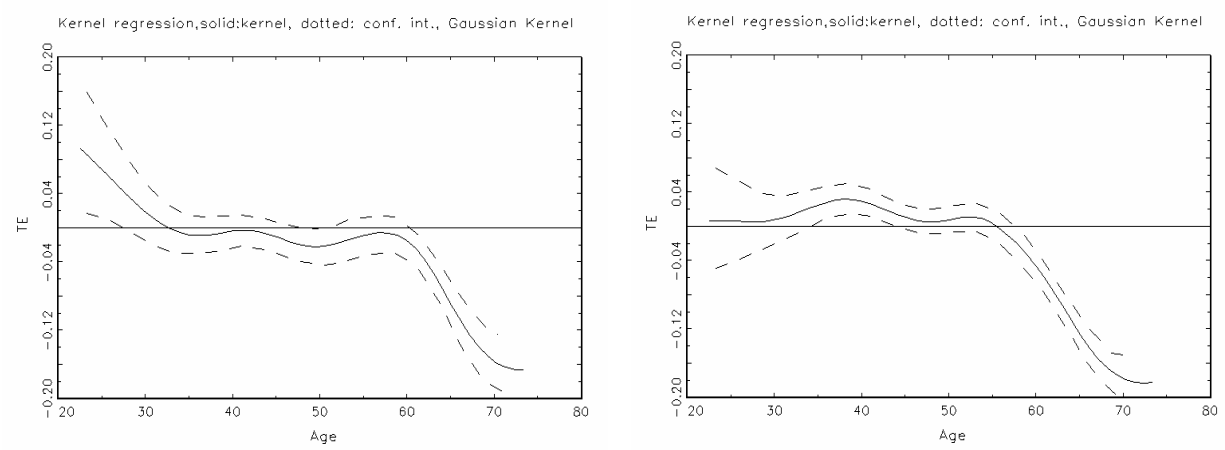
Table 8. Estimates of the average effect of the reform on constrained renters, for total expenditure, disposable income and liabilities using the D2 split

		Average effect of the reform on the constrained		
		(1)	(2)	(3)
		Q=ln(Expenditure)	Q=ln(Disp. Income)	Q=Liabilities[1]
1	$[(Q_{96}+Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89}+Q_{88})]/4$	-0.0258**	0.0040	10,792**
	Bootstrap confidence intervals[2]	(0.0482 ; -0.0688)	(0.0260 ; -0.0356)	(16,989 ; 5,559)
2	$[(Q_{95}+Q_{94}+Q_{93})-(Q_{91}+Q_{90}+Q_{89})]/3$	-0.0318**	0.0011	7,604**
	Bootstrap confidence intervals[2]	(0.0510 ; -0.0745)	(0.0258 ; -0.0309)	(12,509 ; 2,717)
3	$[(Q_{94}+Q_{93})-(Q_{91}+Q_{90})]/2$	-0.0511**	0.0024	1,259**
	Bootstrap confidence intervals[2]	(0.0260 ; -0.1278)	(0.0230 ; -0.0305)	(5,428; -1,972)
4	$(Q_{93})-(Q_{91})$	-0.0801**	-0.0131**	700
	Bootstrap confidence intervals[2]	(0.0259 ; -0.1817)	(0.0168 ; -0.0311)	(3,791; -3,020)

Note: All variables are measured in DKK at 1990 price levels.
Matching is done with replacement. Size of constrained group: 7,687, size of matched unconstrained group 795.
(1) Liabilities are measured in DKK (normal scale) because there are some individuals without mortgage.
(2) see note (2) of table (5).

In figure 7 kernel regressions of the estimated average effect of the reform on the constrained is graphed for the two sample splits for renters for the case where effects are estimated over the horizon 1993-1995 relative to 1989-1991. The picture is confirmed. There is no evidence of any positive expenditure effect of the reform on the constrained households for renters. Negative expenditure effects are estimated for households aged more than 60. This is probably what causes the average negative expenditure effects reported in table 7 and 8. The overall conclusion drawn from the results presented in table 7 and 8, and figure 7 is that the evidence for renters does not contradict the basic result of the analysis that the credit reform has brought positive effects on total expenditure for younger house owners with little liquid assets consistent with these households having been constrained prior to the reform.

Figure 7. Kernel regression of estimated total expenditure effect of the reform on constrained renters against age. D1.2 is shown to the left, and D2.2 is shown to the right



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 pointwise confidence intervals, cf. Härdle (1990).

7. Conclusion

Testing for the importance of credit constraints is notoriously difficult because the parameter of interest, the shadow value of the credit constraint, is unobserved. In this study a reform providing an exogenous shock to access to collateralized credit is used to identify the effects of credit constraints on total expenditure. The reform gave access for house owners to use housing equity for establishing mortgage loans where the proceeds could be used for financing non-housing expenditure. The test is developed from a theoretical model of intertemporal durable and nondurable consumption allocation with time varying credit access. The model shows that expenditure should expand more for constrained households than for otherwise similar unconstrained households when the constraint is lifted, and that durable expenditure should expand more than nondurable expenditure. Descriptive aggregate evidence on expenditures of durables and nondurables confirms that expenditures on durables expanded more than expenditures on nondurables in post-reform years. The model and the aggregate evidence emphasize the need to use data that contain a broader measure of expenditure than just nondurable expenditure. The model is tested on household level panel data with information about total expenditure. Households that were constrained before the reform are identified as having a low ratio of liquid assets to income. This setup should provide a powerful environment for testing the effect of credit constraints. Effects of the reform on total expenditure are estimated by statistical matching by comparing the development in total expenditure around the reform for constrained households with that of otherwise identical (in terms of observed character-

istics) unconstrained households. Significant effects of the reform on total expenditure are found, and the results are robust to a number of consistency checks. Estimates suggest that the reform has made house owners aged 30-50 expand total expenditure by 4-10% relative to otherwise similar, but unconstrained households.

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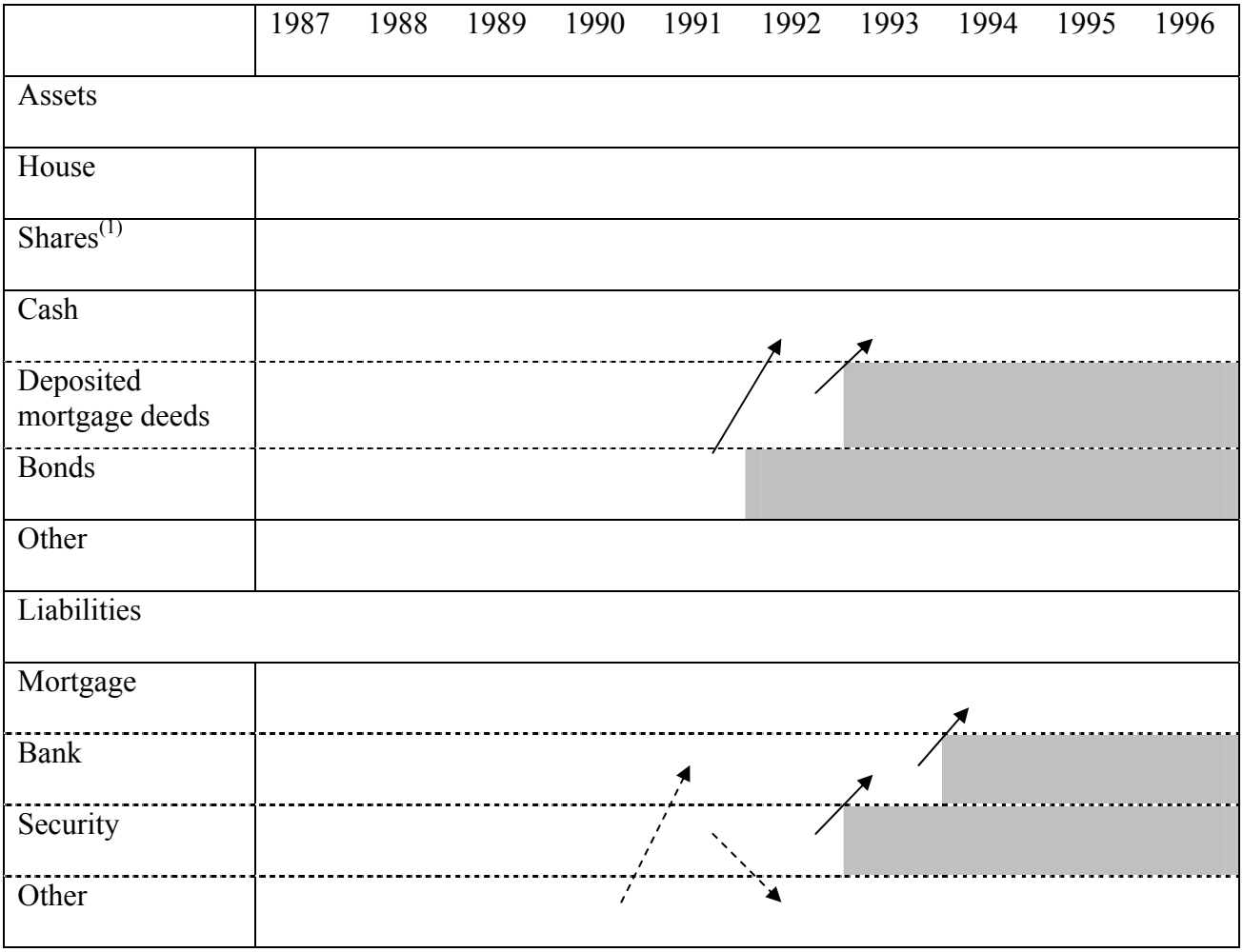
Appendix A

Figure A1. Price indices of different goods and houses (left), and average real credit interest rate (right)

Note: Food prices in top graph in 1996, clothes prices second from the top in 1996, and transport prices third from the top in 1996. House prices in bottom graph.

Figure A2. The Development in Definitions of Asset and Liabilities in the Tax Registers



Note: Solid arrow indicates that a variable is merged into the variable indicated by the arrow. A broken arrow indicates that an item included in a variable is moved to another variable. Shaded areas indicate that a variable ceases to exist.
(1) A particular type of unquoted shares in ships is included in 'other'. Thus, formally, we cannot identify total amount of shares. This is why these categories are considered jointly in Browning and Leth-Petersen (2003).

Appendix B. Summary statistics and balance tests for owners

Table B1. Summary statistics for owners

	D1				D2			
	Constrained		Unconstrained		Constrained		Unconstrained	
Variable	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Hous. Eq. ≤ 50000	0.1730	0.3782	0.1032	0.3042	0.1641	0.3704	0.0877	0.2829
50000<Hous. Eq.≤100000	0.0916	0.2884	0.0605	0.2384	0.0898	0.2859	0.0520	0.2221
100000<Hous. Eq.≤150000	0.1109	0.3141	0.0688	0.2530	0.1017	0.3023	0.0621	0.2414
150000< Hous. Eq.≤200000	0.1028	0.3037	0.0761	0.2651	0.1004	0.3005	0.0694	0.2542
250000< Hous. Eq.≤300000	0.0958	0.2944	0.0948	0.2929	0.0974	0.2966	0.0933	0.2909
300000< Hous. Eq.≤350000	0.0877	0.2828	0.0981	0.2975	0.0899	0.2861	0.0998	0.2997
350000< Hous. Eq.≤400000	0.0712	0.2572	0.0951	0.2934	0.0774	0.2673	0.0981	0.2975
400000< Hous. Eq.≤450000	0.0466	0.2107	0.0771	0.2667	0.0510	0.2199	0.0834	0.2766
450000< Hous. Eq.≤500000	0.0432	0.2032	0.0600	0.2376	0.0441	0.2053	0.0646	0.2459
500000< Hous. Eq.≤550000	0.0255	0.1576	0.0499	0.2177	0.0299	0.1703	0.0543	0.2267
550000< Hous. Eq.≤600000	0.0183	0.1342	0.0371	0.1890	0.0203	0.1410	0.0416	0.1996
Hous. Eq.>600000	0.0401	0.1962	0.0917	0.2886	0.0417	0.2000	0.1067	0.3087
Disp. Inc. ≤ 50000	0.0019	0.0432	0.0029	0.0537	0.0020	0.0447	0.0031	0.0557
50000< Disp. Inc. ≤100000	0.0849	0.2788	0.1170	0.3215	0.0858	0.2801	0.1264	0.3323
100000< Disp. Inc. ≤150000	0.2808	0.4494	0.2731	0.4456	0.2766	0.4473	0.2737	0.4459
200000< Disp. Inc. ≤250000	0.1622	0.3687	0.1742	0.3793	0.1666	0.3726	0.1748	0.3798
250000< Disp. Inc. ≤300000	0.0251	0.1566	0.0444	0.2060	0.0263	0.1600	0.0496	0.2171
300000< Disp. Inc. ≤350000	0.0061	0.0780	0.0108	0.1033	0.0058	0.0760	0.0125	0.1109
Disp. Inc.>350000	0.0014	0.0368	0.0045	0.0668	0.0010	0.0324	0.0057	0.0752
1 child	0.2239	0.4169	0.2135	0.4098	0.2343	0.4236	0.2028	0.4021
2 children	0.4037	0.4907	0.2718	0.4449	0.3869	0.4871	0.2426	0.4286
3 children	0.0943	0.2923	0.0453	0.2079	0.0870	0.2818	0.0352	0.1843
4 children	0.0153	0.1227	0.0044	0.0665	0.0117	0.1076	0.0036	0.0598
Single	0.0663	0.2488	0.1025	0.3034	0.0657	0.2478	0.1142	0.3181
Age≤25	0.0008	0.0291	0.0008	0.0287	0.0009	0.0293	0.0008	0.0285
25<Age≤30	0.0350	0.1838	0.0191	0.1368	0.0325	0.1773	0.0159	0.1251
30<Age≤35	0.1092	0.3120	0.0624	0.2419	0.1064	0.3084	0.0498	0.2176
35<Age≤40	0.1949	0.3961	0.1225	0.3279	0.1885	0.3911	0.1045	0.3059
45<Age≤50	0.1784	0.3829	0.1630	0.3694	0.1763	0.3811	0.1597	0.3663
50<Age≤55	0.1070	0.3092	0.1292	0.3354	0.1119	0.3153	0.1326	0.3392
55<Age≤60	0.0668	0.2496	0.1033	0.3044	0.0693	0.2540	0.1129	0.3165
60<Age≤65	0.0462	0.2100	0.1067	0.3088	0.0515	0.2211	0.1218	0.3271
65<Age≤70	0.0285	0.1665	0.1204	0.3254	0.0351	0.1839	0.1444	0.3515
Age>70	0.0010	0.0319	0.0014	0.0373	0.0010	0.0324	0.0015	0.0386
UI Membership	0.8957	0.3057	0.7806	0.4139	0.8875	0.3160	0.7505	0.4328
Labour supply, male	0.9020	0.2974	0.7717	0.4197	0.8893	0.3137	0.7401	0.4386
Labour supply, female	0.8502	0.3570	0.7350	0.4414	0.8460	0.3610	0.7019	0.4574
M^2≤75	0.0486	0.2150	0.0466	0.2108	0.0474	0.2126	0.0468	0.2113
75<M^2≤100	0.1395	0.3465	0.1499	0.3570	0.1416	0.3487	0.1517	0.3587
100<M^2≤125	0.2871	0.4525	0.2951	0.4561	0.2898	0.4537	0.2956	0.4563
150<M^2≤175	0.1380	0.3449	0.1412	0.3482	0.1386	0.3455	0.1417	0.3488
175<M^2≤200	0.0486	0.2150	0.0503	0.2185	0.0476	0.2130	0.0515	0.2210
M^2>200	0.0263	0.1601	0.0269	0.1619	0.0264	0.1603	0.0271	0.1623

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House val. ≤200000	0.0212	0.1442	0.0119	0.1085	0.0183	0.1340	0.0111	0.1048
200000<House val. ≤300000	0.0994	0.2992	0.0764	0.2657	0.0927	0.2900	0.0740	0.2618
400000<House val. ≤500000	0.2317	0.4220	0.2162	0.4117	0.2338	0.4233	0.2099	0.4072
500000<House val. ≤600000	0.2226	0.4160	0.2147	0.4106	0.2252	0.4177	0.2103	0.4076
600000<House val. ≤700000	0.1305	0.3369	0.1483	0.3554	0.1357	0.3425	0.1502	0.3573
700000<House val. ≤800000	0.0579	0.2336	0.0793	0.2702	0.0614	0.2401	0.0835	0.2767
House val. >800000	0.0556	0.2291	0.0901	0.2863	0.0561	0.2301	0.1004	0.3006
# obs	5,886		19,389		10,499		14,776	

Table B2. Balance of individual characteristics. Two-sample t-test for D1 and D2 split for owners

	D1			D2		
Variable	E(constrain)	E(unconstr)	t	E(constrain)	E(unconstr)	t
Hous. Eq. ≤ 50000	0.1730	0.1757	-0.0273	0.1641	0.1710	-0.0803
50000<Hous. Eq.≤100000	0.0916	0.0912	0.0039	0.0898	0.0800	0.1330
100000<Hous. Eq.≤150000	0.1109	0.1099	0.0113	0.1017	0.1032	-0.0186
150000< Hous. Eq.≤200000	0.1028	0.1053	-0.0286	0.1004	0.0999	0.0062
250000< Hous. Eq.≤300000	0.0958	0.0994	-0.0406	0.0974	0.1020	-0.0598
300000< Hous. Eq.≤350000	0.0877	0.0817	0.0698	0.0899	0.0919	-0.0267
350000< Hous. Eq.≤400000	0.0712	0.0712	0.0000	0.0774	0.0769	0.0079
400000< Hous. Eq.≤450000	0.0466	0.0484	-0.0251	0.0510	0.0544	-0.0519
450000< Hous. Eq.≤500000	0.0432	0.0488	-0.0759	0.0441	0.0430	0.0181
500000< Hous. Eq.≤550000	0.0255	0.0236	0.0294	0.0299	0.0287	0.0216
550000< Hous. Eq.≤600000	0.0183	0.0185	-0.0029	0.0203	0.0217	-0.0270
Hous. Eq.>600000	0.0401	0.0384	0.0239	0.0417	0.0436	-0.0303
Disp. Inc. ≤ 50000	0.0019	0.0017	0.0051	0.0020	0.0020	0.0000
50000< Disp. Inc. ≤100000	0.0849	0.0734	0.1378	0.0858	0.0777	0.1107
100000< Disp. Inc. ≤150000	0.2808	0.2669	0.1292	0.2766	0.2661	0.1125
200000< Disp. Inc. ≤250000	0.1622	0.1624	-0.0017	0.1666	0.1702	-0.0423
250000< Disp. Inc. ≤300000	0.0251	0.0240	0.0187	0.0263	0.0228	0.0642
300000< Disp. Inc. ≤350000	0.0061	0.0053	0.0192	0.0058	0.0051	0.0176
Disp. Inc.>350000	0.0014	0.0010	0.0114	0.0010	0.0010	0.0038
1 child	0.2239	0.2249	-0.0098	0.2343	0.2247	0.1062
2 children	0.4037	0.4117	-0.0705	0.3869	0.4036	-0.1706
3 children	0.0943	0.0887	0.0647	0.0870	0.0782	0.1196
4 children	0.0153	0.0119	0.0619	0.0117	0.0117	0.0000
Single	0.0663	0.0569	0.1181	0.0657	0.0639	0.0261
Age≤25	0.0008	0.0003	0.0205	0.0009	0.0010	-0.0039
25<Age≤30	0.0350	0.0365	-0.0220	0.0325	0.0278	0.0808
30<Age≤35	0.1092	0.1103	-0.0113	0.1064	0.1102	-0.0489
35<Age≤40	0.1949	0.1906	0.0419	0.1885	0.1899	-0.0163
45<Age≤50	0.1784	0.1786	-0.0017	0.1763	0.1762	0.0011
50<Age≤55	0.1070	0.1050	0.0228	0.1119	0.1167	-0.0604
55<Age≤60	0.0668	0.0641	0.0339	0.0693	0.0718	-0.0350
60<Age≤65	0.0462	0.0483	-0.0274	0.0515	0.0473	0.0644
65<Age≤70	0.0285	0.0279	0.0103	0.0351	0.0337	0.0224
Age>70	0.0010	0.0007	0.0124	0.0010	0.0015	-0.0180
UI Membership	0.8957	0.9140	-0.2099	0.8875	0.8970	-0.1225
Labour supply, male	0.9020	0.9151	-0.1510	0.8893	0.8966	-0.0932
Labour supply, female	0.8502	0.8687	-0.1946	0.8460	0.8599	-0.1673
M^2≤75	0.0486	0.0471	0.0205	0.0474	0.0410	0.1023
75<M^2≤100	0.1395	0.1369	0.0269	0.1416	0.1366	0.0614
100<M^2≤125	0.2871	0.2927	-0.0515	0.2898	0.3027	-0.1362
150<M^2≤175	0.1380	0.1352	0.0287	0.1386	0.1374	0.0139
175<M^2≤200	0.0486	0.0433	0.0713	0.0476	0.0404	0.1145
M^2>200	0.0263	0.0195	0.1089	0.0264	0.0247	0.0309

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House val. ≤200000	0.0212	0.0192	0.0337	0.0183	0.0165	0.0358
200000<House val. ≤300000	0.0994	0.0917	0.0873	0.0927	0.0884	0.0573
400000<House val. ≤500000	0.2317	0.2474	-0.1482	0.2338	0.2446	-0.1180
500000<House val. ≤600000	0.2226	0.2202	0.0229	0.2252	0.2223	0.0317
600000<House val. ≤700000	0.1305	0.1337	-0.0344	0.1357	0.1356	0.0012
700000<House val. ≤800000	0.0579	0.0511	0.0883	0.0614	0.0567	0.0702
House val. >800000	0.0556	0.0533	0.0287	0.0561	0.0569	-0.0114

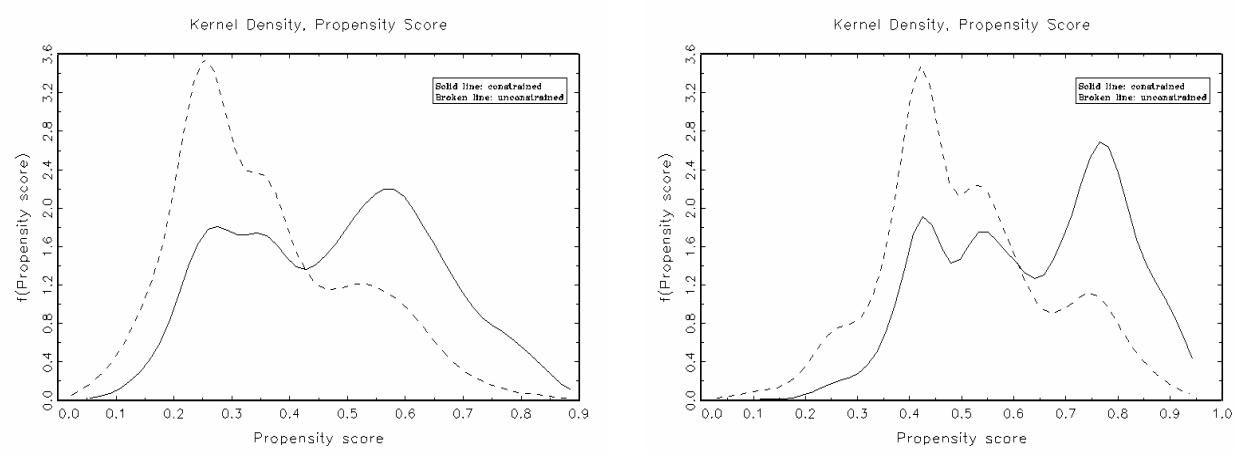
Appendix C. Probit estimates, propensity score densities, balance tests, and summary statistics for renters

Table C1. Probit estimates for D1 split and D2 split for renters

	D1		D2	
Variable	Parameter	Std.err	Parameter	Std.err
Constant	0.0088	0.1416	0.4598**	0.1075
Disposable income ≤ 50000	0.4599**	0.1509	0.4667**	0.1572
50000< Disposable income ≤100000	0.5699**	0.0542	0.6612**	0.0531
100000< Disposable income ≤150000	0.1675**	0.0421	0.1742**	0.0407
200000< Disposable income ≤250000	-0.3163**	0.0462	-0.2777**	0.0463
250000< Disposable income ≤300000	-0.6209**	0.1026	-0.7640**	0.0973
300000< Disposable income ≤350000	-1.0262**	0.3120	-1.1493**	0.2748
Disposable income>350000	-1.0128**	0.3560	-1.4950**	0.3576
1 child	0.4834**	0.0374	0.4862**	0.0389
2 children	0.6704**	0.0481	0.6833**	0.0514
3 children	0.9768**	0.0894	1.0205**	0.1050
4 children	0.9730**	0.1654	0.8793**	0.1918
Single	-0.3139**	0.0382	-0.4211**	0.0376
Age≤25	0.0532	0.1727	0.1713	0.1944
25<Age≤30	0.0473	0.0830	0.0177	0.0888
30<Age≤35	0.1009	0.0621	0.0846	0.0672
35<Age≤40	0.1258**	0.0519	0.0702	0.0559
45<Age≤50	-0.1061**	0.0477	-0.0162	0.0503
50<Age≤55	-0.1728**	0.0503	-0.1935**	0.0515
55<Age≤60	-0.2583**	0.0517	-0.3087**	0.0521
60<Age≤65	-0.6529**	0.0528	-0.7194**	0.0522
65<Age≤70	-0.9131**	0.0535	-0.9903**	0.0529
Age>70	-0.7572**	0.1545	-0.8908**	0.1487
UI Membership	-0.0605	0.0386	-0.0676*	0.0391
Labour supply, male	-0.0636	0.0394	-0.1056**	0.0387
Labour supply, female	-0.1637**	0.0369	-0.1101**	0.0370
M^2≤75	0.0443	0.1126	0.1330	0.0890
75<M^2≤100	-0.0210	0.1119	0.0954	0.0876
100<M^2≤125	-0.0154	0.1151	0.0956	0.0938
150<M^2≤175	-0.1132	0.1752	-0.1155	0.1628
175<M^2≤200	-0.1412	0.2495	-0.1191	0.2390
M^2>200	-0.1238	0.1913	-0.2536	0.1783

Note: The reference household is a couple without children, has income in the interval 150000-200000, aged 41-45, no UI membership, do not participate in the labour market, live in a dwelling sized 126-150 m^2. ** significant at 5% level. * significant at 10% level.

Figure C1. Kernel densities of propensity scores for constrained and unmatched unconstrained renters. D1 to the left, and D2 to the right



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

Table C2. Balance of individual characteristics. Two-sample t-test for D1 and D2 split for renters

	D1			D2		
Variable	E(constrain)	E(unconstr)	t	E(constrain)	E(unconstr)	t
Disp. Inc. ≤ 50000	0.0082	0.0092	-0.0186	0.0074	0.0070	0.0089
50000< Disp. Inc. ≤100000	0.3496	0.3652	-0.1358	0.3419	0.3581	-0.1559
100000< Disp. Inc. ≤150000	0.3270	0.3249	0.0182	0.3289	0.3181	0.1045
200000< Disp. Inc. ≤250000	0.0991	0.0963	0.0312	0.1062	0.1012	0.0593
250000< Disp. Inc. ≤300000	0.0107	0.0081	0.0511	0.0109	0.0086	0.0495
300000< Disp. Inc. ≤350000	0.0007	0.0004	0.0148	0.0009	0.0009	0.0000
Disp. Inc.>350000	0.0006	0.0000	0.0312	0.0004	0.0001	0.0138
1 child	0.1904	0.1958	-0.0523	0.1774	0.1709	0.0699
2 children	0.1383	0.1330	0.0542	0.1242	0.1323	-0.0924
3 children	0.0382	0.0319	0.0898	0.0317	0.0222	0.1565
4 children	0.0105	0.0112	-0.0141	0.0083	0.0072	0.0262
Single	0.5248	0.5321	-0.0625	0.5096	0.5047	0.0451
Age≤25	0.0064	0.0060	0.0081	0.0060	0.0055	0.0125
25<Age≤30	0.0307	0.0268	0.0582	0.0277	0.0252	0.0408
30<Age≤35	0.0701	0.0658	0.0519	0.0624	0.0582	0.0583
35<Age≤40	0.1289	0.1330	-0.0429	0.1119	0.1171	-0.0611
45<Age≤50	0.1409	0.1388	0.0212	0.1435	0.1384	0.0569
50<Age≤55	0.1130	0.1158	-0.0301	0.1136	0.1177	-0.0487
55<Age≤60	0.1068	0.1104	-0.0386	0.1089	0.1123	-0.0400
60<Age≤65	0.1137	0.1135	0.0020	0.1255	0.1262	-0.0075
65<Age≤70	0.1334	0.1345	-0.0116	0.1557	0.1551	0.0072
Age>70	0.0049	0.0047	0.0043	0.0052	0.0053	-0.0032
UI Membership	0.5303	0.5467	-0.1411	0.5266	0.5492	-0.2123
Labour supply, male	0.4060	0.4133	-0.0630	0.4011	0.4201	-0.1793
Labour supply, female	0.4145	0.4193	-0.0419	0.4216	0.4322	-0.0992
$M^2 \leq 75$	0.4266	0.4341	-0.0644	0.4227	0.4301	-0.0698
$75 < M^2 \leq 100$	0.4368	0.4448	-0.0691	0.4456	0.4554	-0.0928
$100 < M^2 \leq 125$	0.1029	0.0935	0.1038	0.1004	0.0865	0.1709
$150 < M^2 \leq 175$	0.0067	0.0052	0.0326	0.0064	0.0056	0.0186
$175 < M^2 \leq 200$	0.0026	0.0006	0.0644	0.0025	0.0007	0.0622
$M^2 > 200$	0.0045	0.0062	-0.0378	0.0040	0.0048	-0.0201

Table C3. Summary statistics for renters

	D1				D2			
	Constrained		Unconstrained		Constrained		Unconstrained	
Variable	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Disp. Inc. ≤ 50000	0.0082	0.0904	0.0051	0.0711	0.0074	0.0858	0.0049	0.0697
50000< Disp. Inc. ≤100000	0.3496	0.4769	0.3016	0.4590	0.3419	0.4744	0.2920	0.4547
100000< Disp. Inc. ≤150000	0.3270	0.4691	0.3668	0.4820	0.3289	0.4698	0.3811	0.4857
200000< Disp. Inc. ≤250000	0.0991	0.2989	0.1099	0.3127	0.1062	0.3081	0.1046	0.3061
250000< Disp. Inc. ≤300000	0.0107	0.1028	0.0194	0.1380	0.0109	0.1040	0.0228	0.1493
300000< Disp. Inc. ≤350000	0.0007	0.0274	0.0034	0.0585	0.0009	0.0302	0.0043	0.0658
Disp. Inc.>350000	0.0006	0.0237	0.0023	0.0478	0.0004	0.0198	0.0033	0.0570
1 child	0.1904	0.3926	0.1059	0.3078	0.1774	0.3821	0.0880	0.2833
2 children	0.1383	0.3452	0.0583	0.2343	0.1242	0.3299	0.0438	0.2047
3 children	0.0382	0.1918	0.0095	0.0971	0.0317	0.1753	0.0063	0.0794
4 children	0.0105	0.1019	0.0023	0.0478	0.0083	0.0909	0.0018	0.0425
Single	0.5248	0.4994	0.4783	0.4996	0.5096	0.4999	0.4797	0.4996
Age≤25	0.0064	0.0796	0.0030	0.0551	0.0060	0.0771	0.0022	0.0466
25<Age≤30	0.0307	0.1726	0.0164	0.1270	0.0277	0.1641	0.0145	0.1195
30<Age≤35	0.0701	0.2553	0.0331	0.1790	0.0624	0.2420	0.0281	0.1652
35<Age≤40	0.1289	0.3351	0.0560	0.2300	0.1119	0.3152	0.0487	0.2153
45<Age≤50	0.1409	0.3480	0.1049	0.3064	0.1435	0.3506	0.0860	0.2804
50<Age≤55	0.1130	0.3166	0.1053	0.3069	0.1136	0.3173	0.1012	0.3016
55<Age≤60	0.1068	0.3089	0.1165	0.3208	0.1089	0.3115	0.1177	0.3222
60<Age≤65	0.1137	0.3175	0.1848	0.3881	0.1255	0.3313	0.1986	0.3990
65<Age≤70	0.1334	0.3400	0.2880	0.4529	0.1557	0.3626	0.3228	0.4676
Age>70	0.0049	0.0696	0.0076	0.0870	0.0052	0.0720	0.0083	0.0909
UI Membership	0.5303	0.4991	0.4703	0.4991	0.5266	0.4993	0.4499	0.4975
Labour supply, male	0.4060	0.4911	0.3611	0.4803	0.4011	0.4901	0.3488	0.4766
Labour supply, female	0.4145	0.4927	0.3942	0.4887	0.4216	0.4939	0.3756	0.4843
M^2≤75	0.4266	0.4946	0.4261	0.4945	0.4227	0.4940	0.4314	0.4953
75<M^2≤100	0.4368	0.4960	0.4538	0.4979	0.4456	0.4971	0.4488	0.4974
100<M^2≤125	0.1029	0.3038	0.0865	0.2811	0.1004	0.3006	0.0829	0.2758
150<M^2≤175	0.0067	0.0819	0.0070	0.0833	0.0064	0.0796	0.0076	0.0869
175<M^2≤200	0.0026	0.0512	0.0028	0.0528	0.0025	0.0497	0.0031	0.0554
M^2>200	0.0045	0.0669	0.0055	0.0737	0.0040	0.0634	0.0065	0.0805
# obs	5,337		7,874		7,687		5,524	