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Household debt and consumption during the financial crisis: Evidence from Danish micro data

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Abstract

We use data for nearly 800,000 Danish families to examine whether high household leverage prior to the financial crisis may have amplified the reduction in household spending over the course of the crisis. We find a strong negative correlation between pre-crisis leverage and the change in non-housing consumption during the crisis, conditional on a range of other household characteristics. The larger drop in spending among the highly leveraged families reflects that these families consumed a larger fraction of their income than their less-leveraged peers prior to the crisis. But as the crisis unfolded, this difference in consumption levels between high- and low leverage families vanished. Moreover, we find suggestive evidence that the drop in consumption for the highly leveraged families cannot be fully explained by a contraction in credit supply.

Key words: Household debt, financial crises, micro data

JEL Classification: D12, E21, E65

Resumé (Danish summary)

I papiret præsenteres en analyse af sammenhængen mellem belåningsgraden blandt danske boligejerfamilier inden den seneste finanskrise og udviklingen i familiernes forbrug under krisen. Ved brug af data for næsten 800.000 familier finder vi en tydelig negativ sammenhæng mellem en families belåningsgrad i 2007 og udviklingen i forbruget i de efterfølgende år, selv når der kontrolleres for en række karakteristika. Forskellen i forbrugsudvikling mellem familier med henholdsvis høj og lav belåningsgrad dækker over, at førstnævnte gruppe anvendte en højere andel af indkomsten til forbrug inden krisen. Forskellen mellem de to grupper blev imidlertid gradvist indsnævret i løbet af krisen for til sidst at forsvinde helt. Resultaterne antyder derfor, at stigningen i husholdningernes bruttogæld i årene inden finanskrisen bidrog til, at forbruget blev usædvanlig højt blandt nogle familier, hvorefter det faldt kraftigt, da krisen indtraf. Husholdningernes høje gældsniveau bidrog dermed til at forstærke faldet i det private forbrug under krisen. Resultaterne tyder endvidere på, at den store forbrugsreduktion blandt familierne med høj belåningsgrad ikke udelukkende kan tilskrives en stramning af kreditvilkårene under krisen.

1. Introduction

As in many other countries, household debt in Denmark increased sharply in the years preceding the financial crisis that started in 2007/08, and debt-to-income ratios soared. The build-up of debt coincided with a steep rise in house prices, keeping debt-to-assets ratios at a moderate level in the years leading up to the crisis. But when house prices reversed, debt-to-assets ratios also rose dramatically.

In this paper we use household level micro data from Danish administrative registers to examine whether high household leverage prior to the crisis may have amplified the reduction in household spending over the course of the crisis, thereby aggravating the economic downturn. Understanding the role of debt and leverage in household spending decisions during times of financial crisis is important for guiding macro prudential policy. If high debt prompts a larger reduction in consumption when the economy is hit by financial unrest, policies aimed at curbing excessive household borrowing during economic upturns may be successful in reducing macroeconomic volatility. If not, such policies may hamper households' ability to smooth consumption, without reducing systemic risk.

The financial behavior of Danish households during the crisis is an attractive object of study when examining this important issue, for three reasons: First, the pre-crisis build-up of debt seen in many countries was very pronounced in Denmark, and Danish households generally have high debt-to-income ratios compared to households in other countries (Isaksen et al., 2011). Second, as in several other countries, the Danish economy was characterized by steeply rising house prices in the years preceding the crisis, followed by a drastic decline in 2007-09. The increase in house prices contributed to the pre-crisis build-up of debt, whereas the subsequent drop left highly leveraged households with very high loan-to-value (LTV) ratios. Third, the availability of high-quality data from administrative registers that cover the entire Danish population allows us to study the behavior of households at the micro level, using a large data set of almost 800,000 homeowner families.

To determine how initial leverage prior to the crisis may have influenced the change in household spending during the crisis we adopt a strategy similar to that of Dynan (2012). Specifically, we examine whether households that were highly leveraged prior to the crisis reduced spending more than less-leveraged households with similar characteristics. For our empirical analysis we make use of comprehensive micro data on household income and wealth that allows us to construct an imputed measure of non-housing consumption. We are able to control for an exhaustive set of household characteristics that possibly influence

consumption patterns, including income growth and wealth effects from capital gains due to changes in house price.

We find a strong negative correlation between pre-crisis leverage and the change in consumption during the crisis. In our preferred specification, going from an initial LTV ratio of 60 percent to 100 percent is associated with an additional drop in consumption over the years 2007-11 of 8.4 percent of pre-crisis income. This negative correlation is observed in spite of the highly leveraged households generally witnessing more favorable developments in both disposable income and the value of their homes during the crisis, relative to their less-leveraged peers. These results suggest that the high debt level of Danish households prior to the financial crisis contributed to a stronger reduction in aggregate consumption during the crisis.

Our results relate to a number of previous studies that examine the role of debt in macroeconomic outcomes at the aggregate level. Analyzing country variation in leverage, Cecchetti, Mohanty and Sampolli (2011) and Cecchetti and Kharroubi (2012) argue that leverage above a certain threshold depresses economic growth, while Dabla-Norris og Srivisal (2013) find that higher levels of debt amplify macroeconomic volatility. At a more disaggregated level, Mian and Sufi (2010) study US county data and find that local areas with a larger run-up in household leverage prior to the crisis witnessed a more severe recession in the years 2007-09. Similarly, Mian, Rao and Sufi (2013) show that retail sales declined more in counties where households were highly leveraged prior to the crisis.

Few studies, however, have been able to directly observe the change in consumption at the individual household level and simultaneously account for changes in wealth. A notable exception is Dynan (2012) who makes use of the US Panel Study of Income Dynamics to examine how households with different LTV ratios in 2007 responded to the financial crisis. In line with our results, she finds that highly leveraged household reduced spending more than households with lower LTV ratios.

The results in this paper complement her work along several dimensions. First, we document a similar effect of leverage on consumption in a different institutional setting and on a substantially larger dataset. Second, we find that the relationship between pre-crisis leverage and subsequent consumption growth is non-linear, with the negative correlation only present at LTV ratios above a threshold of about 40 percent.

Third, we are able to verify that the negative correlation between leverage and consumption growth exists within all age groups, at all levels of the financial-assets-to-income and net-worth-to-income ratios, throughout the entire income

distribution, and in all geographical regions of Denmark. This is suggestive of the mechanism behind the observed relationship between leverage and consumption growth: If the negative correlation were a result of highly leveraged families being credit constrained, we would expect it to be stronger among groups of families that can a priori be expected to demand credit, e.g. the young and those with a small stock of financial assets, than among other groups of families. Our results show that there is in fact no such difference. Thus, we believe that credit constraints as the main explanation for the observed correlation is not consistent with the data. This leaves us with an unresolved question about the exact mechanism at work. One potential explanation, which is consistent with our results, but not exclusively so, is that increased uncertainty about future financial conditions induced highly leveraged families to reduce consumption through a precautionary saving motive.

Fourth and finally, we augment the empirical analysis in Dynan (2012) by demonstrating an important distinction between changes in and levels of consumption: As explained above, Dynan (2012) finds that highly leveraged US households reduced consumption more than less-leveraged households during the financial crisis, after controlling for wealth effects and other potential determinants of consumption growth – a result that is echoed in our empirical analysis of Danish households. Based on this result, she argues that a debt overhang has held back US consumption in the post-crisis years. However, our analysis also shows that the difference in the change in consumption between high- and low-leverage Danish households is almost exactly mirrored by an opposite-signed difference in pre-crisis consumption *levels*: In 2007, highly leveraged households spent a much higher fraction of their income on non-housing consumption than households with less leverage, conditional on other characteristics. However, by 2010 this level difference had vanished completely.

In light of this latter result, we question the view that the high debt level of Danish households has suppressed private consumption in the aftermath of the financial crisis. Rather, it seems plausible that the build-up of debt prior to the crisis helped high-leverage families reach unsustainably high consumption levels in the years leading up to the crisis, prompting a large reduction in spending when the Danish economy was hit by the international financial turmoil.

The paper continues as follows: Section 2 gives a brief account of the developments in aggregate household debt and house prices in Denmark in the years surrounding the financial crisis. Section 3 discusses our theoretical priors regarding the impact of household leverage on consumption responses during a financial crisis. In section 4 we describe the data used in the empirical analyses, while section 5 presents some descriptive statistics and basic correlations. In

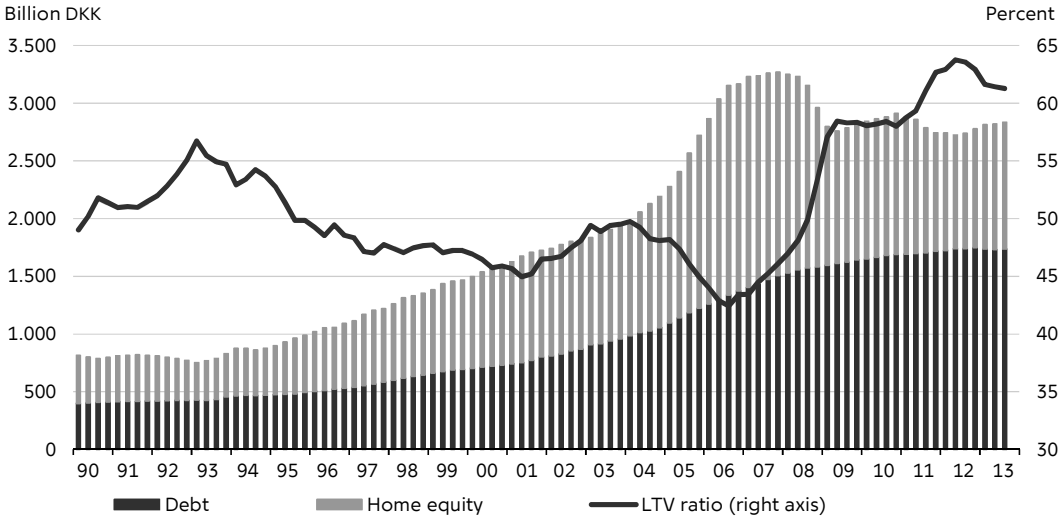
section 6 we present our baseline econometric model, and results for this model are presented in section 7. Section 8 discusses the issue of changes in consumption vs. levels of consumption and presents results for level regressions. In section 9 we present various robustness checks, while section 10 concludes.

2. Macroeconomic background

Danish households' mortgage debt increased steeply during the previous decade, cf. chart 1. The surge in household borrowing was particularly pronounced in the years leading up to the financial crisis. But the rise in debt was more than matched by concurrent increases in house prices. As a result, home equity rose despite the growth in debt, and the aggregate loan-to-value (LTV) ratio was decreasing.

This changed drastically in the years that followed. By late 2007, the development in house prices had reversed, and an economic slowdown had started. In the first quarter of 2008 both house prices and seasonally adjusted quarterly real GDP fell. Thus, the Danish economy was already slowing down when the global financial crisis and the recession in the world economy really took off in late 2008.[1]

Chart 1: Households' aggregate mortgage debt, home equity and LTV ratio



Note: Mortgage debt includes all debt secured against real property. This includes all debt owed to specialized mortgage banks as well as some debt owed to universal (i.e. non-specialized) banks.
Source: Danmarks Nationalbank, Statistics Denmark, and authors' own calculations.

[1] For a detailed account of the real economic consequences of financial crises in Denmark, see Abildgren et al. (2011).

The balance sheets of Danish households were dealt a serious blow during the financial crisis. From the 4th quarter of 2007 to the 1st quarter of 2009 the nominal value of their homes fell by 16 percent. After a temporary rebound, house prices declined further in 2011. Combined with the high debt level, this implied that the aggregate LTV ratio reached an unusually high level. Household debt continued to rise after the crisis, but at a much slower pace, and the aggregate debt-to-income ratio declined slowly. In the first three quarters of 2013 household debt also declined in nominal terms.

The real economic consequences of the crisis were severe. From the 4th quarter of 2007 to the 2nd quarter of 2009 seasonally adjusted real GDP and consumption fell by 8 and 5 percent, respectively. By the end of 2013, both variables remained below their 2007 levels.

3. The role of debt and leverage in household spending decisions

How should we expect household leverage to influence the response of consumption during the financial crisis? Before we can answer this question, we must be careful in describing what the exact aim of our analysis is. This is best explained by use of a stylized example: Consider two families, A and B. The two families are identical with respect to size, age, and income, and they bought their house in the same year. The families also have the same net wealth – i.e. the same absolute difference between assets and liabilities - but family A has a larger balance sheet than family B. That is, family A has a larger gross debt than family B, but also larger assets. For example, we can imagine that family A owns a house worth 2 million DKK and has a gross debt of 1.5 million DKK, while family B owns a house worth 1 million DKK and has a gross debt of 0.5 million DKK. This means that both families have net wealth equal to 0.5 million DKK. However, the LTV ratio in family A's home is 75 percent, whereas family B's LTV ratio is 50 percent. In the terminology used in this paper, family A is more *leveraged* than family B.

Imagine now that the economy is hit by a financial crisis: Asset prices drop, credit standards are tightened, and uncertainty about future economic conditions increases. The question we are interested in is whether the difference in leverage between the two families causes a difference in the response of consumption to the change in financial circumstances. In our empirical analysis, we attempt to answer this question by examining whether families with higher LTV ratios reduced consumption more during the financial crisis, *conditional* on income, net wealth, and other family characteristics.

The financial crisis that started in 2007/08 affected household finances in several ways: Asset prices, including house prices, plummeted, and credit conditions

were tightened. Some families experienced a drop in current income; presumably, many more experienced a drop in expected *future* income, as well as an increase in uncertainty about their future financial situation.

There are good reasons to expect that many of these adverse effects could have been stronger for families that were highly leveraged at the onset of the crisis. To begin with, highly leveraged families typically have larger assets, and the impact on their consumption of falling asset prices may therefore have been magnified through a stronger wealth effect. But there could also be other effects of high leverage on the response of consumption, independent of the wealth effect: First, highly leveraged families may have lost access to credit. For most homeowners, the most important source of credit is borrowing against their home(s). However, if the family's debt is large relative to the value of its home, obtaining further credit via this channel can become difficult, if not impossible. As explained in the previous section, the large drop in house prices during the crisis led to large increases in LTV ratios. For families that had high LTV ratios even before the crisis, this – and the tightening of credit standards – may have led to credit constraints becoming binding, thus forcing a reduction in consumption.

Second, families that were hit by a negative shock to income may have reduced consumption more in response to the shock if they were highly leveraged at the onset of the crisis. Again, binding credit constraints may have played a key role. In addition, highly leveraged families typically spend a larger fraction of their income on servicing their debt. With a large fraction of income "locked in", high-leverage families have few other options than cutting back on consumption when faced with a negative income shock.

Third, high leverage may have induced families that were neither actually credit constrained, nor hit by a negative income shock, to reduce consumption more in response to the crisis. The increase in uncertainty about future financial conditions may have prompted a desire among households to bring down their LTV ratios through a precautionary saving motive (Caroll, 1997). The larger the initial LTV ratio, the larger the desire for deleveraging may have been. Reducing consumption is one way of achieving such deleveraging.

In sum, our theoretical prior is that families that were highly leveraged prior to the crisis reduced consumption more than less-leveraged families, conditional on initial net wealth, the size of wealth effects during the crisis, as well as other family characteristics. As we shall see in the following sections, we find strong support for these priors in the data. However, when it comes to identifying which of the above explanations is the main driver behind the observed relationship between leverage and consumption, our results only provide suggestive evidence.

4. Data

The data used in this article comes from several administrative registers, covering all individuals residing in Denmark. The data is anonymized and made available to researchers by Statistics Denmark. Information on income, wealth and debt originates from the personal income register. The main source for this register is tax returns based on third-party reports. Information regarding e.g. age, area of residence and family relations stems from the population register. Using the information on family relations, we aggregate all individual data on income, wealth and debt to the family level. A family is here defined as either one or two adults plus any number of children (see data appendix for details).

Our data covers the years 2003-11. Starting from the full population of families, we impose several restrictions to obtain our analysis sample. First, we restrict our sample to homeowner families in which at least one person is between 15 and 99 years of age (both included). Second, we exclude families in which at least one of the adults is self-employed, since income and wealth are measured imprecisely in this case. Families in which at least one member is not fully liable to taxation in Denmark are also excluded. Finally, for reasons explained in the next subsection, in each year we exclude families that either bought or sold one or more homes, as well as those families that are outliers in the distribution of imputed consumption-to-income ratios. After these restrictions, we are left with a sample of roughly 800,000 families.

The following subsections explain how the main variables used in this paper are measured. Further details can be found in the data appendix.

4.1. Imputing non-housing consumption from income and wealth data

The main data issue for our purposes is that register-based data on consumption is not available at the household level. Following Browning and Leth-Petersen (2003), Leth-Petersen (2010), and Browning, Gørtz and Leth-Petersen (2013), we instead rely on a measure imputed from data on household disposable income, assets and liabilities. The approach behind this measure starts from the accounting identity that household i's consumption in year t, C_{it}, is equal to disposable income minus saving in that year:

$$C_{it} = Y_{it}^{d} - S_{it}$$

In the above expression, disposable income, Y_{it}^{d}, is directly observable from our data, while saving, S_{it}, is not. We approximate the latter with the change in the

value of household *i*'s total assets from year *t*-1 to *t*, minus the change in its liabilities:

$$C_{it} \approx Y_{it}^{d} - \left(\sum_k \Delta A_{it}^{k} - \sum_h \Delta L_{it}^{h}\right)$$

where ΔA_{it}^{k} and ΔL_{it}^{k} denote the changes in the values of household *i*'s holdings of asset type *k* and liability type *h*, respectively, from year *t*-1 to *t*. Put more simply, saving in year *t* is measured as the change in net nominal wealth from year *t*-1 to *t*.

The main problem with this approach is that the change in the value of a household's holding of a particular asset (or liability) does not necessarily reflect a change in the physical stock of that asset, i.e. saving. Changes in the asset's price, i.e. capital gains or losses, are also included, and it is generally not possible to separate the two sources of variation. This means that the imputed measure of consumption can contain substantial measurement error.

There are three important cases where we are in fact able to do something about the above-mentioned problem: First, for most homeowners, fluctuations in housing prices are undoubtedly the most important source of capital gains or losses. Fortunately, our data allows us to identify those families that are involved in a real estate trade in any given year. We exclude these families from our sample in all that follows. For the remaining families in the sample, who do not change their physical stock of housing during the year, any change in the value of their housing wealth must be due to capital gains or losses.[2] We therefore exclude housing wealth in the summation over the household's assets.

Second, for one particular type of asset, pension savings, we do actually have accurate data for the saving component, in the form of yearly contributions to individual pension accounts. In this case, there is no need for differencing the value of the stock, and we use the yearly contributions as a direct measure of this particular component of total saving.[3]

Third, fluctuations in stock prices is another important source of capital gains or losses for stock-owning families. Unfortunately, our data does not allow us to separate the effect of changing stock prices from the effects of actual buying and selling. Instead, we use a crude adjustment based on the overall development in stock markets: For each family, we multiply the value of stock portfolio at the

[2] We here ignore changes in the physical stock of housing that result from home improvements or extensions. This implies that expenses for such projects are measured as consumption in the year in which they are paid.

[3] Most pension saving accounts are employer-administered, which means that contributions into the accounts are paid directly by the employer. These contributions do not enter the disposable income of the family, so there is no need to subtract them in the imputation. Only contributions to privately administered accounts are subtracted.

beginning of the year with the over-the-year growth rate of the C20 index, the top-tier index of the Copenhagen Stock Exchange. The result of this calculation can be seen as an approximation of the capital gain earned on the family's stock portfolio during the year, so we subtract it from the change in the value of the family's stock portfolio. Naturally, this crude adjustment completely ignores the large variation in price movements between different stocks, but it should take us a long way in removing any systematic differences in the imputed measure of consumption between stock owners and non-owners.

Even after these corrections there is still a good deal of noise in the imputed measure of consumption, sometimes resulting in extreme values. To minimize the impact of such extreme values, we calculate the ratio of the imputed measure of consumption to disposable income for each family. If this ratio is either below the 5^{th} percentile or above the 95^{th} percentile in the sample in a given year, consumption is coded as missing.

It should be noted that the measure of disposable income that we use does not include imputed rent from owner-occupied housing. This implies that the imputed measure described above is in fact a measure of *non-housing* consumption. However, we shall henceforth simply refer to it as consumption.

4.2. LTV ratios and key control variables

Our key measure of leverage is the loan-to-value (LTV) ratio in the family's home(s). The LTV ratio is measured as the family's total debt to Danish financial institutions, divided by the value of its home(s) and multiplied by 100. Both the total debt and the home value are measured at year-end. In Denmark, the lion's share of property financing takes place via specialized mortgage banks. Debt owed to such banks is always secured against real property. However, total debt also includes debt owed to universal (i.e. non-specialized) Danish banks, which may or may not be secured against property. Unfortunately, our data therefore does not allow us to cleanly separate secured and unsecured debt.

The value of a family's home(s) is measured at approximated market values. The point of departure for estimating these values is the official property valuations made by the Danish tax authority. These valuations are reported for each individual in the personal income register. We adjust the official valuations by a scaling factor that reflects the average ratio of actual sales prices to public valuations for the relevant combination of property category, geographical area of residence, and year. The method is described in greater details in Andersen et al. (2012).

Disposable income is measured as total family income net of taxes, interest payments, alimony, and repaid social benefits. As noted in the previous subsection, imputed rent of owner-occupied housing is not included in our measure of disposable income.

Net wealth is calculated as total assets minus total liabilities. Total assets include real property, financial assets, bank deposits and pension savings. The stock of pension savings is imputed from accumulated contributions to pension schemes, as described in Andersen et al (2012). Cash holdings, the value of the family's durable goods (such as cars, boats, household effects and art) and the value of private cooperative housing are not included in our measure of total assets, due to a lack of data, whereas any debt raised in order to acquire these assets is included in total liabilities. Total liabilities, however, exclude any unregistered debt owed to private individuals.

In our econometric analyses we distinguish between liquid and non-liquid assets. The former are defined as deposits in banks, the market value of bonds, mortgage deeds, stocks and investment certificates in the custody of a bank.

5. Some basic correlations

Table 1 shows descriptive statistics for the families in our sample, broken down by the LTV ratio in 2007. Almost half of the families had a pre-crisis LTV below 40 percent. At the other end of the scale, about 66,000 families, corresponding to 8 percent, had an LTV ratio above 100 percent at the end of 2007. The LTV ratio is strongly correlated with a range of other observable family characteristics. Highly leveraged families are generally younger, have more children, and have lived at their current address for a shorter period of time than families with low LTV ratios. They also have higher income, but their debt-to-income ratios are higher and their net worth lower.

We now turn our focus to the development of consumption during the crisis years for families with different pre-crisis LTV ratios. Chart 2 illustrates a simple comparison between high-leverage families (solid lines) and other homeowners (dashed lines). The high-leverage group is here defined as families with an LTV ratio above 100 percent in 2007. In addition to our imputed measure of consumption, the chart also shows the developments in disposable income and housing wealth for each group of families.

Table 1: Descriptive statistics, 2007

LTV ratio in 2007	0-40 percent	40-60 percent	60-80 percent	80-100 percent	Over 100 percent
No. of families	363,142	162,821	127,161	73,145	65,975
No. of children, mean	0.3	0.8	1.0	1.1	1.3
Age of eldest person, mean	64.6	52.5	47.9	45.1	44.0
No. of years since moving to current address, mean	29.2	15.9	12.2	10.3	9.6
Disposable income, mean, DKK	278,437	330,971	337,230	337,058	343,236
Debt-to-income ratio, mean, percent	123.8	297.4	335.4	354.9	364.2
Net worth, mean, DKK	2,450,028	1,337,761	763,072	319,295	-169,659

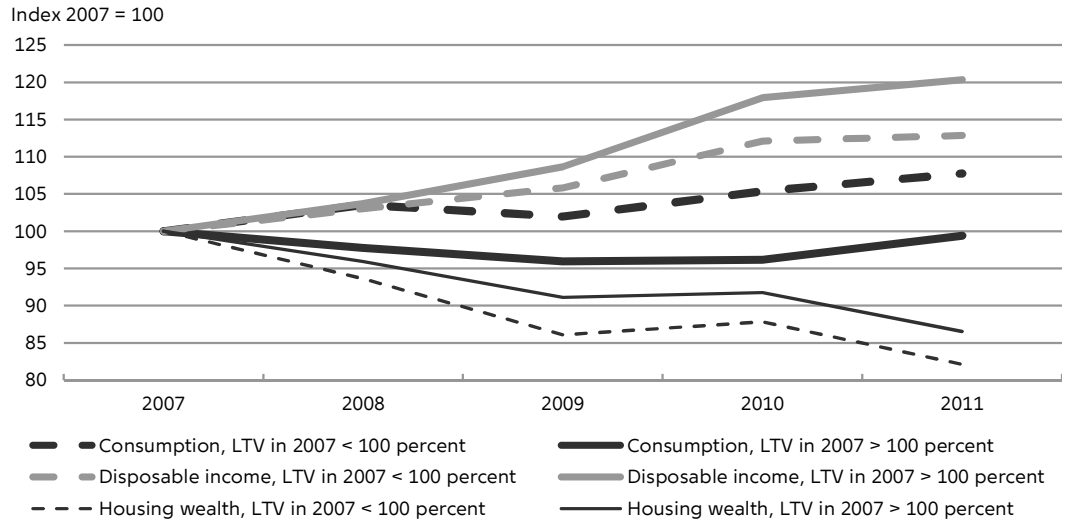
Note: The table shows descriptive statistics for the families in our analysis sample. All entries in the table are based on 2007-numbers.
Source: Authors' own calculations, based on data from administrative registers.

The high-leverage families saw stronger growth in disposable income in the years 2007-11 than other homeowners. This is due to a substantial drop in interest rates, which mainly benefited those with high debt. Due to falling house prices, both groups of families experienced a decline in their housing wealth over the course of the financial crisis, but the decline was less pronounced for the high-leverage families.[4]

Despite these differences, consumption growth in the years 2007-11 was weaker among the high-leverage families than among other homeowners. In the former group, nominal non-housing consumption fell by almost 5 percent from 2007 to 2009 for the median family. For other homeowners, the median growth rate between these two years was just below 2 percent. The gap between the two groups of families widened further from 2009 to 2010 and was still considerable in size by 2011.

[4] Recall that we exclude all families that were involved in a real estate trade in the period under consideration. For the remaining families, a change in the value of their housing stock must therefore reflect changing house prices and/or home improvements to the existing stock.

Chart 2: Disposable income, housing wealth, and non-housing consumption, 2007-11, by LTV ratio in 2007



Note: The chart shows the developments in disposable income, housing wealth, and imputed consumption for i) homeowner families with an LTV ratio below 100 percent in 2007 (dashed lines), and ii) homeowner families with an LTV ratio above 100 percent in 2007 (solid lines). The indexation to 2007 levels is done at the family level. For each year, the chart shows the median value of the indexed variables in each of the two groups. Only families that existed in all years between 2007-11 and did not buy or sell real property in those years are included.
Source: Authors' own calculations. based on data from administrative registers.

Summing up, the simple comparison shows that families that were highly leveraged prior to the financial crisis reduced non-housing consumption more than other homeowners during the crisis, despite better developments in disposable income and housing wealth. This suggests a role for the level of leverage prior to the crisis in explaining consumption responses during the crisis. But as we have already seen, high-leverage families also differ from other homeowner families in a number of other dimensions that may influence growth in consumption. In the following sections, we present results from regressions that compare the consumption response during the crisis for families with different pre-crisis LTV ratios, conditional on a range of other observable family characteristics.

6. Econometric specification

We examine the relationship between pre-crisis leverage and the subsequent change in consumption by estimating variants of the following regression model using OLS:

$$\Delta C_{i;07-s} = \alpha + \mathrm{F}\left(\boldsymbol{\beta}, LTV_{i;07}\right) + \delta_1 \ln\left(Y_{i;07}\right) + \delta_2 NW_{i;07} + \delta_3 LA_{\mathrm{i;07}} + \delta_4 \Delta Y_{i;07-s} + \delta_5 \Delta H_{i;07-s} + \delta_6 \Delta \mathrm{kids}_{\mathrm{i;07-s}} + \delta_7 \Delta C_{i;06-07} + \boldsymbol{\gamma X}_{i;07} + \epsilon_{i;s} \ , \quad (1)$$

where the dependent variable is the change in family *i*'s consumption from 2007 to year *s*. We estimate the model for *s* = 2008, 2009, 2010, and 2011. To ensure comparability across families with different income levels, the change in consumption is measured in percent of family *i*'s pre-tax income in 2007.

The key explanatory variable is the family's LTV ratio in 2007, $LTV_{i;07}$. In the general case, we include this using a parametric function $\mathrm{F}(\boldsymbol{\beta},.)$, where $\boldsymbol{\beta}$ is a vector of parameters to be estimated. As explained further below, we use different functional forms of F to deal with potential non-linearities in the relationship between LTV ratios and consumption growth.

Also included on the right-hand side are family *i*'s disposable income, net wealth, and stock of liquid assets in 2007 ($Y_{i;07}$, $NW_{i;07}$, and $LA_{\mathrm{i;07}}$, respectively). The former variable is transformed using the natural logarithmic function, while the latter two are measured in percent of the family's pre-tax income in 2007. The variables $\Delta Y_{i;07-s}$ and $\Delta H_{i;07-s}$ denote the change from 2007 to year *s* in family *i*'s disposable income and housing wealth, respectively. Both are measured in percent of pre-tax income in 2007. The variable $\Delta \mathrm{kids}_{\mathrm{i;07-s}}$ denotes the change in the number of children in family *i* from 2007 to year *s*. To deal with potential non-linear effects, we treat this as a categorical variable by including a dummy variable for each discrete value it takes in the sample.

The variable $\Delta C_{i;06-07}$ denotes the change in consumption from 2006 to 2007, measured in percent of pre-tax income in 2007. We include this variable to control for extraordinary spikes in consumption in 2007, our base year. Such spikes could arise if the family purchased a large durable consumption good, such as a car. This would show up in our data as a large increase in imputed consumption in the year of purchase and, everything else equal, an equally-sized drop in the subsequent year. Since a car purchase is often financed by borrowing, it could also imply a higher LTV ratio in the base year. Failing to control for such spikes could therefore lead to negative spurious correlation between the LTV ratio and subsequent consumption growth.

Finally, $\boldsymbol{X}_{i;07}$ denotes a vector of family characteristics in 2007: Age of the eldest family member, age of the youngest child and the no. of years since moving to the current address. Exploiting the large number of observations available, we

treat these variables as categorical, meaning that we include a dummy variable for each discrete value they take in our sample.[5] Also included in $\boldsymbol{X}_{i;07}$ are dummy variables for whether any of the family members are retired and whether there is higher education in the family. We also include a set of dummy variables indicating the geographical area of residence for family *i*. Each dummy variable represents one of the 98 municipalities in Denmark.

To ensure comparability across time, we restrict our sample to families in which the number and identity of the adult members are unchanged between 2006 and year *s*. This excludes families that break up due to e.g. divorce or death of a spouse. We also exclude families that either sold or bought one or more homes in any of the years between 2006 and year *s*, both included. This ensures that the physical stock of housing is unchanged in the analysis period, so that the change in the family's housing wealth, $\Delta H_{i;07-s}$, must reflect capital gains due to changing house prices, rather than endogenous responses in the form of selling or buying homes.[6] These restrictions imply that the number of observations in the estimation is decreasing in the length of the time period considered: The higher the value of *s*, the fewer observations are available.

7. Results

7.1. Linear specification

Table 2 shows estimation results for equation (1). We only report coefficient estimates for the LTV ratio and selected control variables.[7] The LTV ratio is included linearly, i.e. $\mathrm{F}\left(\boldsymbol{\beta}, LTV_{i;07}\right) = \beta_1 \cdot LTV_{i;07}$. Each column represents a different end-year *s*.

The coefficient on the LTV ratio in 2007 is negative and highly significant in all four columns. This means that families that were highly leveraged in 2007 experienced weaker consumption growth in the subsequent years than low-leverage families with similar observable characteristics. Looking across columns, the difference between high- and low-leverage families nearly doubles from 2008 to 2010, and then stays at roughly the same level in 2011.

[5] This produces 78 dummies for the age of the eldest family member, 25 for the age of the youngest child, and 38 for the number of years since moving to the current address.

[6] We cannot make the same restriction for other asset types, and we do therefore not attempt to control for the change in the value of e.g. financial assets, since this would introduce obvious endogeneity problems.

[7] A full set of estimates can be obtained from the authors upon request.

Table 2: Regressions of change in consumption on LTV ratio in 2007, linear specification

Dependent variable: Change in consumption from 2007 to year *s*, in percent of pre-tax income in 2007	(1) *s* = 2008	(2) *s* = 2009	(3) *s* = 2010	(4) *s* = 2011
LTV ratio in 2007, percent	-0.068***	-0.102***	-0.123***	-0.118***
	(0.001)	(0.001)	(0.001)	(0.001)
Log of disposable income in 2007	0.651***	-0.025	1.076***	1.451***
	(0.090)	(0.091)	(0.094)	(0.097)
Ratio of financial assets to income in 2007, percent	-0.005***	-0.035***	-0.018***	-0.024***
	(0.000)	(0.000)	(0.000)	(0.000)
Ratio of net wealth to income in year 2007, percent	-0.000	-0.002***	0.000	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Change in disposable income from year 2007 to year *s*, percent of pre-tax income in 2007	0.672***	0.617***	0.628***	0.664***
	(0.003)	(0.002)	(0.002)	(0.002)
Change in housing wealth from 2007 to year *s*, percent of pre-tax income in 2007	0.004***	0.002***	0.002***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
Change in consumption from 2006 to 2007, percent of pre-tax income in 2007	-0.441***	-0.477***	-0.472***	-0.470***
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	683,890	620,849	580,865	538,164
R-squared	0.313	0.392	0.399	0.447
Control variables	Yes	Yes	Yes	Yes

Note: The table reports coefficient estimates from OLS regression of equation (1), using a linear specification for the function F. Standard errors are included in parentheses. *, ** and *** denote significance at the 10, 5, and 1 percent levels, respectively. In each column, the following additional control variables are included: Age of eldest family member (78 dummy variables), age of youngest child (25 dummy variables), change in number of children in the family from 2007 to year *s* (9 dummy variables), no. of years since moving to current address (38 dummy variables), higher education in the family (dummy variable), retirees in the family (dummy variable), and area of residence (97 dummy variables).

Source: Authors' own calculations, based on data from administrative registers.

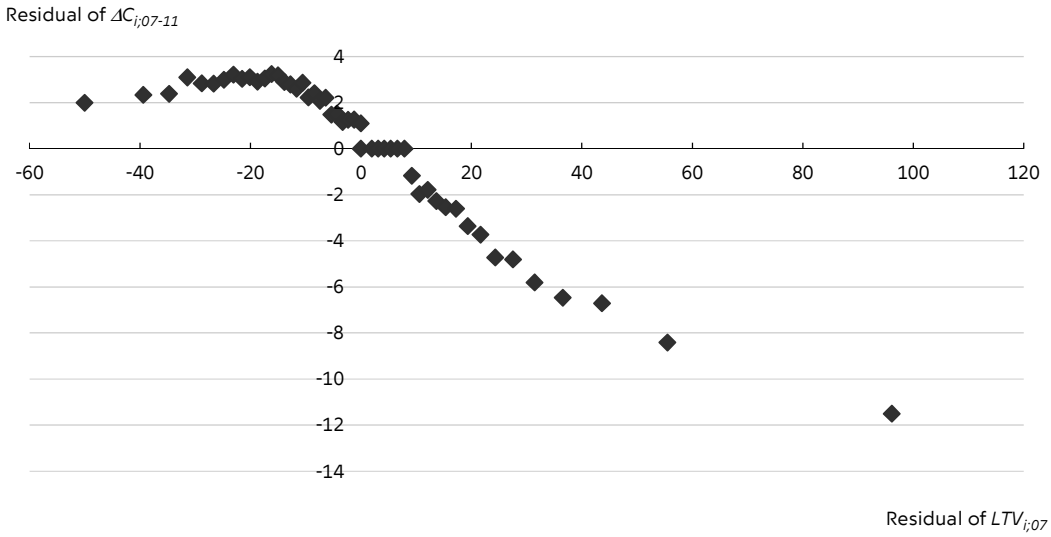
Turning to the control variables, we find that the income level in 2007 is positively correlated with the change in consumption in the subsequent years (although we get a negative but insignificant estimate in column 2). This suggests that high-income families were better prepared to cope with the change in economic climate than low-income families. Families with larger stocks of financial assets reduced consumption more over the course of the crisis, perhaps due to the significant decline in financial asset prices, whereas we find no robust correlation between net worth in 2007 and subsequent consumption growth. The change in disposable income since 2007 is, as expected, strongly positively correlated with the change in consumption. Taken at face value, the coefficient on $\Delta Y_{i;07-s}$ indicates a marginal propensity to consume in the order of 0.6 – 0.7.[8] In contrast,

[8] It should be noted, however, that this estimate may be biased upwards due to the way our imputed measure of consumption is constructed. Disposable income appears directly in the imputation, as explained in section 4.1. Any measurement error in disposable income will therefore be transmitted directly to the dependent variable in equation (1), leading to a potential bias.

the coefficient on the change in the value of housing assets is very small, indicating a low (almost zero) marginal propensity to consume out of housing wealth. Finally, the coefficient on the change in consumption from 2006 to 2007 is negative and highly significant in all columns. The size of the estimated coefficients, just above -0.5, indicates that there is substantial mean reversion in our imputed measure of consumption.

Chart 3 presents a graphical illustration of the relationship between the LTV ratio in 2007 and the change in consumption from 2007 to 2011, conditional on other observable family characteristics. The chart is a non-parametric analog to the regression in column 4 of table 2, in the sense that it places no restrictions on the functional form of $\mathrm{F}(\boldsymbol{\beta}, LTV_{i;07})$. To construct the chart, we first regress $\Delta C_{i;07-11}$ and $LTV_{i;07}$ on all the control variables in equation (1), using two separate regressions. This produces two residuals per family, one for each regression. We then sort the families by the size of the residual from the LTV-regression and divide them into 50 equal-sized groups. The chart plots the mean of the $\Delta C_{i;07-11}$ residuals against the mean of the $LTV_{i;07}$ residuals within each group.

Chart 3: Binned residual plot. LTV ratio in 2007 and change in consumption from 2007 to 2011



Note: The chart shows residuals from a regression of $\Delta C_{i;07-11}$ on the RHS variables in equation (1) (except $LTV_{i;07}$), plottet against residuals from a regression of $LTV_{i;07}$ on the same variables. The residuals have been grouped in 50 bins, sorted by the size of the $LTV_{i;07}$ residual. The chart plots the mean of the $\Delta C_{i;07-11}$ residuals against the mean of the $LTV_{i;07}$ residuals for each group.
Source: Authors' own calculations, based on data from administrative registers.

The chart shows a clear negative correlation between LTV ratios in 2007 and the change in consumption from 2007 to 2011, conditional on other observable family characteristics. This is the equivalent of the negative coefficient on $LTV_{i;07}$ in column 4 of table 2. However, the chart also illustrates that the linear form of $\mathrm{F}(\boldsymbol{\beta}, LTV_{i;07})$ imposed in table 2 does not give an adequate description of the conditional relationship between $LTV_{i;07}$ and $\Delta C_{i;07-11}$. In particular, the chart shows an almost flat region at lower values of $LTV_{i;07}$, while the slope is distinctly negative at higher values. Similar pictures emerge if we plot residuals of $LTV_{i;07}$ against residuals of $\Delta C_{i;07-08}$, $\Delta C_{i;07-09}$ or $\Delta C_{i;07-10}$.

7.2. Piece-wise linear specification

Table 3 presents regression results using a variant of equation (1) that allows for a non-linear conditional relationship between the LTV ratio in 2007 and subsequent consumption growth. Specifically, we now impose the following functional form of F:

$$\mathrm{F}(\boldsymbol{\beta}, LTV_{i;07}) = \begin{cases} \beta_1 \cdot LTV_{i;07} & if \quad LTV_{i;07} \leq 20 \\ \beta_2 \cdot (LTV_{i;07} - 20) + \mathrm{F}(\boldsymbol{\beta}, 20) & if \quad 20 < LTV_{i;07} \leq 40 \\ \beta_3 \cdot (LTV_{i;07} - 40) + \mathrm{F}(\boldsymbol{\beta}, 40) & if \quad 40 < LTV_{i;07} \leq 60 \\ \vdots & \vdots \quad \vdots \\ \beta_7 \cdot (LTV_{i;07} - 120) + \mathrm{F}(\boldsymbol{\beta}, 120) & if \quad 120 < LTV_{i;07} \end{cases}$$

That is, $\mathrm{F}(\boldsymbol{\beta}, LTV_{i;07})$ is now assumed to be a continuous, piece-wise linear function of $LTV_{i;07}$, where the slope is held fixed in pre-defined intervals of 20 percentage points. Table 3 reports estimates for the slope coefficients for the LTV-variable only. The coefficients on the control variables are similar to those reported in table 2 and are omitted.

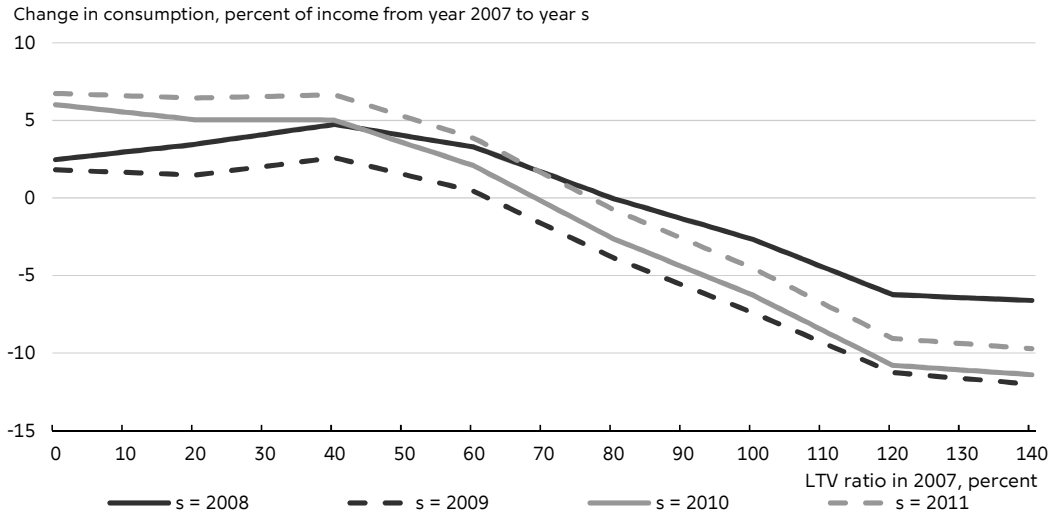
Table 3: Regressions of change in consumption on LTV ratio in 2007, piece-wise linear specification

Dependent variable: Change in consumption from 2007 to year *s*, in percent of pre-tax income in 2007	(1) *s* = 2008	(2) *s* = 2009	(3) *s* = 2010	(4) *e* = 2011
LTV ratio in 2007				
0 to 20 percent	0.049***	-0.017**	-0.049***	-0.015**
	(0.007)	(0.007)	(0.007)	(0.007)
20 to 40 percent	0.064***	0.056***	-0.001	0.010
	(0.007)	(0.007)	(0.008)	(0.008)
40 to 60 percent	-0.073***	-0.108***	-0.148***	-0.140***
	(0.007)	(0.007)	(0.007)	(0.007)
60 to 80 percent	-0.166***	-0.214***	-0.235***	-0.230***
	(0.008)	(0.008)	(0.008)	(0.008)
80 to 100 percent	-0.131***	-0.177***	-0.182***	-0.189***
	(0.011)	(0.011)	(0.011)	(0.011)
100 to 120 percent	-0.178***	-0.193***	-0.226***	-0.226***
	(0.012)	(0.012)	(0.012)	(0.012)
Above 120 percent	-0.019***	-0.038***	-0.030***	-0.033***
	(0.003)	(0.004)	(0.003)	(0.003)
Observations	683,890	620,849	580,865	538,164
R-squared	0.316	0.396	0.402	0.450
Control variables	Yes	Yes	Yes	Yes

Note: The table reports coefficient estimates from OLS regression of equation (1), using a piece-wise linear specification for the function F. Standard errors are included in parentheses. *, ** and *** denote significance at the 10, 5, and 1 percent levels, respectively. The same control variables as in table 2 are included in all columns.
Source: Authors' own calculations, based on data from administrative registers.

The coefficient estimates in table 3 reaffirm the impression from chart 3: The LTV ratio in 2007 is strongly negatively correlated with subsequent consumption growth, conditional on other family observables, but only so at LTV ratios above roughly 40 percent. Below this threshold, there is no clear correlation. This is seen by the fact that the coefficients in the first two rows of table 3 are numerically small, sometimes statistically insignificant, and vary in sign across columns. Chart 4 offers a visual presentation of the conditional relationship between $LTV_{i;07}$ and subsequent consumption growth. The chart plots the sample average of the predicted values of $\Delta C_{i;07-s}$ from the estimated equation (1) for different values of $LTV_{i;07}$. In each 20-percentage point interval of $LTV_{i;07}$, the slope on the curves are equal to the coefficient estimates in the corresponding row of table 3. Thus, the level of each curve reflects the average change in consumption from 2007 to year *s*, while the slope reflects the estimated partial effect of the LTV ratio in 2007.

Chart 4: Regression estimates of equation (1). LTV ratio in 2007 and change in consumption in subsequent years, piece-wise linear specification



Note: The chart shows the average predicted values from the regressions reported in table 3, at different values of the LTV ratio in 2007. The chart is constructed as follows: First, for a given value of $LTV_{i;07}$ we compute the predicted value of $\Delta C_{i;07-s}$ for each family, given the actual family-specific values of the of the control variables. We then take the average over all the families in the sample. This procedure is repeated for different values of the LTV ratio in 2007.
Source: Authors' own calculations based on data from administrative registers.

Taken at face value, the coefficients in table 3 suggest a sizeable effect of a family's pre-crisis LTV ratio on the consumption response during the crisis. For example, the difference in expected consumption growth in the years 2007-11 between a family with $LTV_{i;07}$= 60 and a comparable family with $LTV_{i;07}$= 100 is estimated at 8.4 percent of the family's pre-tax income in 2007. That is, for every 100 DKK of income in 2007, the change in consumption from 2007 to 2011 is 8.4 DKK smaller for a family with an LTV ratio of 100 percent in 2007 than for an otherwise-comparable family with an LTV ratio of 60 percent in 2007. With a pre-tax family income of 550,000 DKK (the sample mean), this is equivalent to a difference of 46,200 DKK (€6,200, $8,600).

7.3. Regressions with 2004 as base year

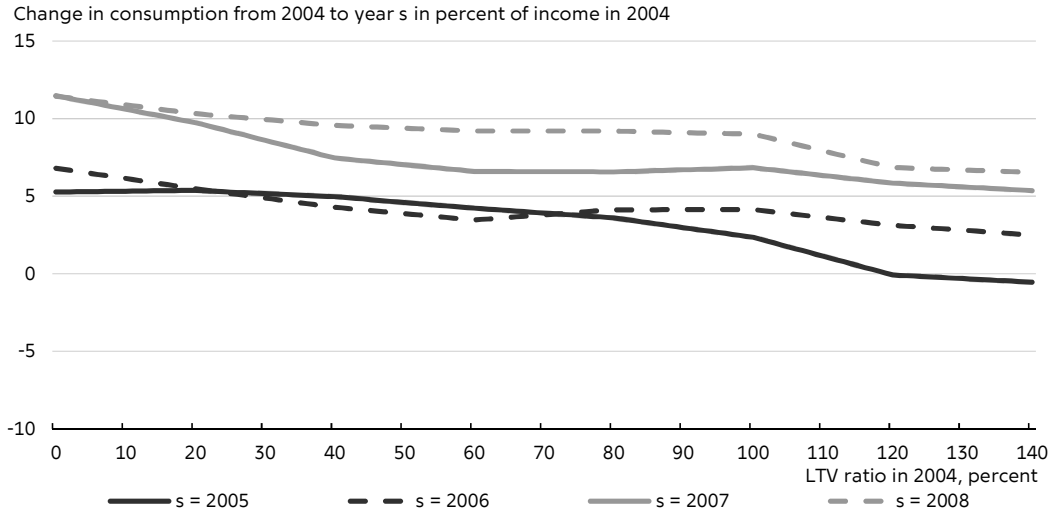
As explained in section 3, our theoretical prior is that it was a combination of high leverage and a sudden change in the economic environment caused by the financial crisis that induced families with high LTV ratios in 2007 to reduce consumption sharply in the subsequent years. Under different macroeconomic circumstances, we would not expect the same strong negative correlation between LTV ratios and consumption growth.

To test this hypothesis, we examine the conditional relationship between LTV ratios and consumption growth in the years *prior* to the financial crisis. Specifically, we estimate a model that is in all ways completely parallel to equation (1), except that the base year is now 2004, rather than 2007. That is, we estimate variants of the following equation:

$$\begin{aligned}\Delta C_{i;04-s} = \alpha + \mathrm{F}\left(\boldsymbol{\beta}, LTV_{i;04}\right) + \delta_1 \ln\left(Y_{i;04}\right) + \delta_2 NW_{i;04} + \delta_3 LA_{\mathrm{i;04}} \\ + \delta_4 \Delta Y_{i;04-s} + \delta_5 \Delta H_{i;04-s} + \delta_6 \Delta \mathrm{kids}_{\mathrm{i;04-s}} \\ + \delta_7 \Delta C_{i;03-04} + \boldsymbol{\gamma X}_{i;04} + \epsilon_{i;s}\ ,\end{aligned} \tag{2}$$

where *s* now takes the values 2005, 2006, 2007, and 2008. The results of these estimations are illustrated in chart 5 below.[9] As in chart 4, we see a negative conditional relationship between LTV ratios and subsequent consumption growth, but the numerically smaller slopes on the curves show that the negative correlation is much weaker in the years 2004-08 than in 2007-11.

Chart 5: Regression estimates of equation (2). LTV ratio in 2004 and change in consumption in subsequent years, piece-wise linear specification



Note: The chart shows the average predicted values from estimation of equation (2), at different values of the LTV ratio in 2004. The chart is constructed as explained in the note to chart 4.
Source: Authors' own calculations based on data from administrative registers.

[9] For the sake of brevity, we do not report coefficient estimates from the estimation of equation (2). These are, like all other estimation results mentioned in this paper, available from the authors upon request.

The contrast between chart 4 and chart 5 suggests that the strong negative correlation between household leverage and subsequent consumption growth in the crisis years is closely related to the extraordinary economic circumstances during those years. Although our results are silent about the exact mechanism at work, we suspect that the development in house prices after 2007 may have played a key role. In particular, it is worth noting that the families that had a high LTV ratio in 2007 must, ceteris paribus, have had an *even higher* LTV ratio in 2009, due to the sharp drop in house prices between those years. If a high LTV ratio affects consumption growth negatively, as our results indicate, the effect must have been amplified by the decline in house prices after 2007. Conversely, the steep rise in house prices after 2004 brought LTV ratios down, thus diluting the effect of being highly leveraged at the end of this year.

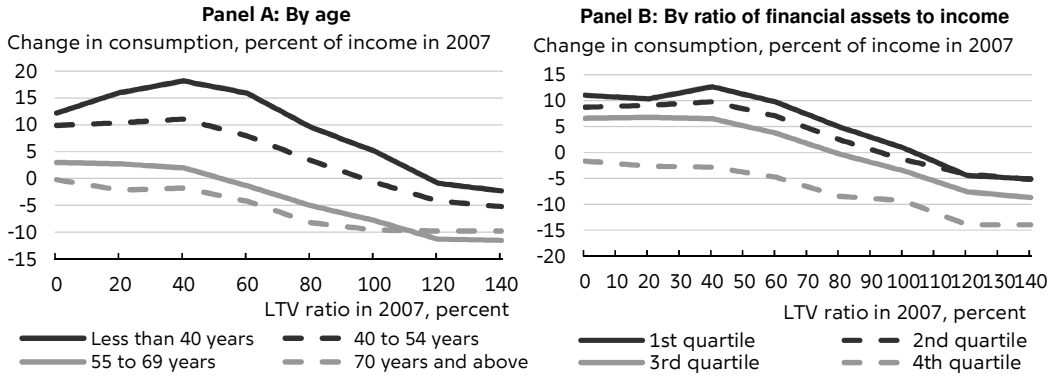
7.4. Results for subsamples

The results in the previous subsections suggest that the change in economic climate during the financial crisis induced families with high pre-crisis LTV ratios to reduce consumption more than comparable families with lower LTV ratios. This could be due to a tightening of credit standards, forcing the highly leveraged families into a prolonged period of deleveraging. But it could also reflect higher uncertainty among leveraged households regarding their financial outlook and future access to credit, prompting a self-imposed increase in precautionary saving.

Unfortunately, the results above are uninformative about the exact mechanism through which the financial crisis affected the consumption of highly leveraged households. However, we may gain some insight by estimating equation (1) on various subgroups of our sample and comparing the results across groups.

Chart 6 shows results for two sets of such subsample estimations, using $\Delta C_{i;07-11}$ as the dependent variable. In panel A, we have split the sample in four groups by the age of the eldest family member. It is evident from the chart that the negative correlation between $LTV_{i;07}$ and $\Delta C_{i;07-11}$ is present in all age groups, and the slopes of the curves in the chart do not differ much. In panel B of Chart 6 we have split the families in our sample in four equal-sized groups, sorted by the ratio of the stock of liquid assets to income in 2007. Again, $LTV_{i;07}$ and $\Delta C_{i;07-11}$ are negatively correlated in all four groups, with no clear difference between the top and bottom quartiles. We get similar results if we split the sample along other dimensions, such as the income level in 2007, the ratio of net worth to income in 2007, the change in income from 2007 to 2011, change in employment status between these two years, or the geographical region in which the family resides.

Chart 6: Regression estimates for split-sample estimation of equation (1), *s* = 2011



Note: The chart shows the average predicted values from split-sample estimations of equation (1), at different values of the LTV ratio in 2007. The chart is constructed as explained in the note to chart 4.
Source: Authors' own calculations based on data from administrative registers.

The fact that there is so little variation across subsamples in the strength of the relationship between $LTV_{i;07}$ and $\Delta C_{i;07-11}$ does, in our view, give us a hint about the mechanism behind this relationship: If the negative correlation were mainly due to a tightening of credit standards, affecting primarily highly leveraged families, we would expect the correlation to be stronger among groups of families in which a large share is likely to demand credit. This would include the young and those with a small stock of liquid assets. The above-mentioned results illustrate that when it comes to the negative correlation between $LTV_{i;07}$ and $\Delta C_{i;07-11}$, these groups are in fact not very different from other groups in our sample.

Thus, we believe that credit constraints cannot be the main explanation for the observed negative relationship between pre-crisis leverage and the change in consumption during the crisis. Nor does it seem that the correlation can be explained by debt amplifying the impact of negative income shocks, since we do not find any systematic pattern between the strength of the correlation and the change in income or employment status during the crisis.

Another potential explanation is that highly leveraged families, across all differences in age, wealth, income, and geography, responded to the increased uncertainty brought by the financial crisis by voluntarily lowering consumption and increasing saving. A related explanation could be that highly leveraged families had more optimistic pre-crisis expectations about their financial future. Such optimism may have led them to take on more debt and increase consumption in the years leading up to the crisis. But when the crisis arrived, the

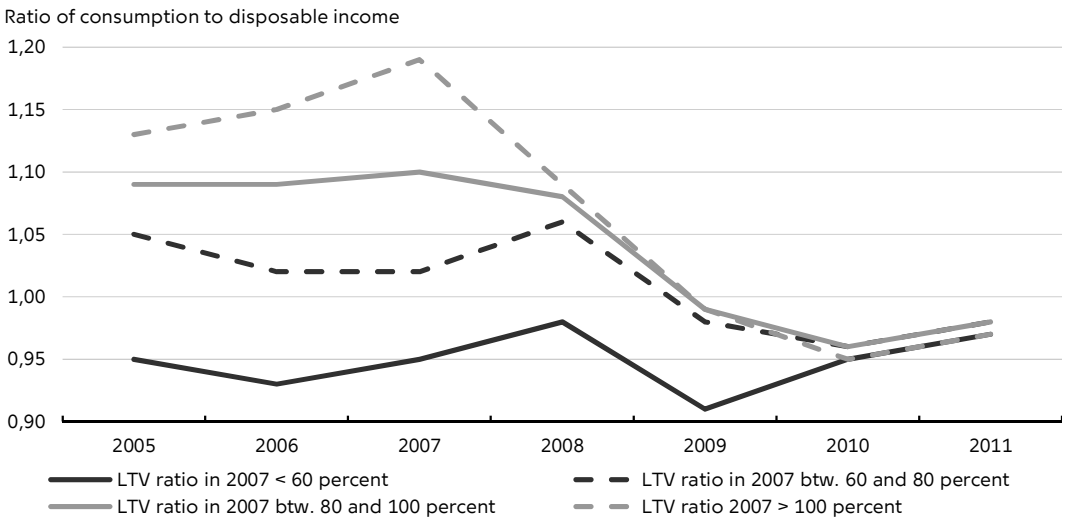
combination of high leverage and a downward adjustment of expectations made them cut spending more than other families. Both of these explanations are consistent with our results. In fact, as we shall see in the next section, the high-leverage families did actually consume more than their less-leveraged peers prior to the crisis. Unfortunately, however, our results do not allow us to distinguish between these two explanations, nor to rule out other potential explanations, and the discussion of the exact mechanism behind our observations remains, admittedly, somewhat speculative.

8. Change in consumption vs. level of consumption

In the previous sections we have focused on the *change* in consumption from 2007 to a subsequent year. As we have seen, families that were highly leveraged prior to the financial crisis reduced consumption during the crisis more than comparable families with less pre-crisis leverage. However, our results, like those in e.g. Dynan (2012), have so far remained silent about how high- and low-leveraged families compare with respect to consumption *levels* over the course of the crisis.

Chart 7 sheds some light on this issue. The chart shows the evolution of median consumption-to-disposable-income ratio during the years 2005-11 for four different groups of families. The families have been grouped by their LTV ratio in 2007.

Chart 7: Level of consumption, by year and LTV in 2007



Note: The chart shows the median ratio of consumption to disposable income within each group of families. Only families that existed in all years between 2005 and 2011 and did not buy or sell real property in those years are included.
Source: Authors' own calculations based on data from administrative registers.

The chart shows that there is a clear unconditional correlation between the LTV ratio in 2007 and the ratio of consumption to disposable income in that year. Families that were highly leveraged prior to the financial crisis consumed a much larger share of their disposable income (in fact, a share well above 1 for the median family) than families with lower pre-crisis LTV ratios. But the gap narrowed considerably in the subsequent years, until closing in 2010.

Of course, the difference in consumption-to-income ratios in 2007, or the lack thereof in 2010 and 2011, could be due to other family characteristics that correlate with the pre-crisis LTV ratio. To examine whether this is the case, we estimate a model that is nearly identical to equation (1), only now with the *level* of consumption in year *s* as the dependent variable. More precisely, we estimate the following equation:

$$\begin{aligned} C_{i;s} = \alpha + \mathrm{F}\left(\boldsymbol{\beta}, LTV_{i;07}\right) + \delta_1 \ln\left(Y_{i;07}\right) + \delta_2 NW_{i;07} + \delta_3 LA_{\mathrm{i;07}} \\ + \delta_4 \Delta Y_{i;07-s} + \delta_5 \Delta H_{i;07-s} + \delta_6 \Delta \mathrm{kids}_{\mathrm{i;07-s}} \\ + \boldsymbol{\gamma} \boldsymbol{X}_{i;07} + \epsilon_{i;s} \ , \end{aligned} \tag{3}$$

where the dependent variable is the level of consumption in year *s*, measured in percent of pre-tax income in 2007.[10] The function F takes the same piece-wise linear form as in section 7.2. We estimate the model for *s* = 2007, 2008, 2009, 2010 and 2011. Results for the coefficients on the LTV ratio are shown in table 4 and a graphical illustration is provided in chart 8. Looking at the results for the level of consumption in 2007, we see a strong positive correlation with the LTV ratio in the same year, even after controlling for other observable family characteristics. It is worth noting that the curve for *s* = 2007 in chart 8 is almost an exact mirror image of the curves in chart 4. As we move forward in time, however, the correlation with the pre-crisis LTV ratio becomes weaker. By 2011, the correlation seems completely gone, as can be seen by the flatness of the curve for that year.

[10] We choose to scale consumption in year *s* relative to income in 2007 in order to mimic the specification in equation (1) as closely as possible, but the results are almost identical if we scale relative to income in year *s*.

Table 4: Regressions of levels of consumption on LTV ratio in 2007, piece-wise linear specification

Dependent variable: level of consumption in year *s*, in percent of pre-tax income in 2007	(1) *s* = 2007	(2) *s* = 2008	(3) *s* = 2009	(4) *s* = 2010	(5) *s* = 2011
LTV ratio in 2007					
0 to 20 percent	-0.086***	-0.005	-0.072***	-0.112***	-0.084
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
20 to 40 percent	0.032***	0.141***	0.136***	0.070***	0.084
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
40 to 60 percent	0.185***	0.123***	0.086***	0.044***	0.057
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
60 to 80 percent	0.266***	0.098***	0.050***	0.022***	0.024
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
80 to 100 percent	0.202***	0.059***	0.009	0.000	-0.004
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
100 to 120 percent	0.236***	0.027**	-0.000	-0.026**	-0.029
	(0.010)	(0.011)	(0.010)	(0.010)	(0.010)
Above 120 percent	0.040***	0.012***	0.005*	0.000	-0.004
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	792,244	683,890	620,849	580,865	538,164
R-squared	0.177	0.248	0.303	0.354	0.424
Control variables	Yes	Yes	Yes	Yes	Yes

Note: The table reports coefficient estimates from OLS regression of equation (3), using a piece-wise linear specification for the function F. Standard errors are included in parentheses. *, ** and *** denote significance at the 10, 5, and 1 percent levels, respectively. The same control variables as in table 2, except the change in consumption from 2006 to 2007, are included where applicable.
Source: Authors' own calculations based on data from administrative registers.

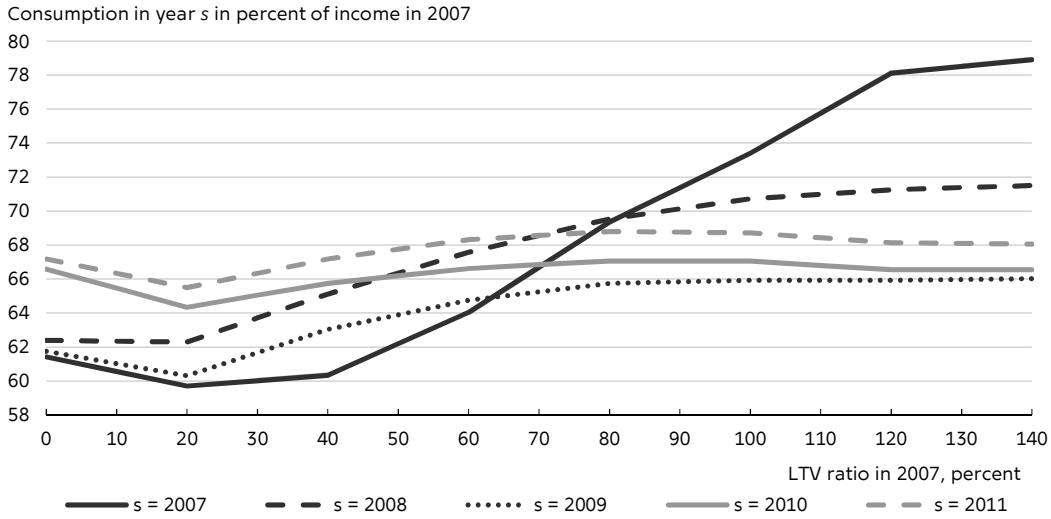
Taken together, these results show that the high-leverage families' disproportionately strong reduction in consumption during the crisis almost entirely reflects the fact that they consumed more than their less-leveraged peers prior to the crisis. It does *not* reflect that post-crisis consumption is lower for highly leveraged families than for other homeowners. In fact, we find that by 2010 there is virtually no difference in consumption levels between high- and low-leverage families, conditional on other family characteristics.[11]

In our view, this raises doubt about the notion that aggregate consumption has been suppressed by a debt overhang in the aftermath of the financial crisis, as asserted by Dynan (2012) for the US case. If that were indeed the case in Denmark, we would expect to see a lower post-crisis consumption level among

[11] As explained in the text, this result is based on a regression of consumption in year *s* on family characteristics in 2007, e.g. $LTV_{i;07}$ and $Y_{i;07}$. However, we have also estimated a model in which all the right-hand side variables are from the same year as the dependent variable, e.g. $LTV_{i;s}$ and $X_{i;s}$. This has little impact on the results. Most importantly, for $s \geq 2010$ we find virtually no correlation between $C_{i;s}$ and $LTV_{i;s}$, conditional on other family characteristics in year *s*.

highly leveraged families than among other families, conditional on other family characteristics.

Chart 8: Regression estimates of equation (3). LTV ratio in 2007 and level of consumption in subsequent years, piece-wise linear specification

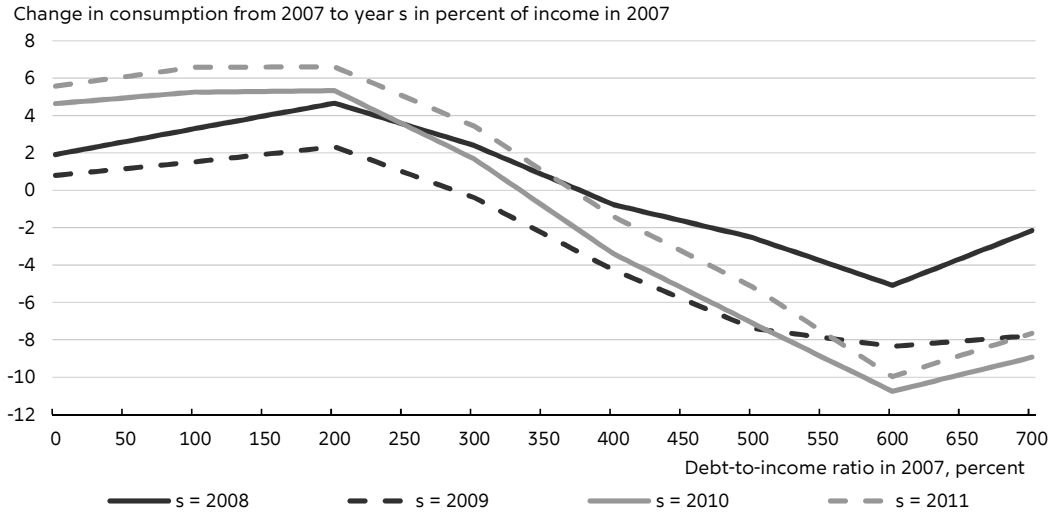


Note: The chart shows the average predicted values from estimation of equation (3), at different values of the LTV ratio in 2007. The chart is constructed as explained in the note to chart 4. The difference in scale compared to chart 7 is due to the fact that consumption is scaled relative to disposable income in chart 7, whereas the dependent variable in equation (3) is the ratio of consumption to pre-tax income in 2007.
Source: Authors' own calculations based on data from administrative registers.

9. Debt-to-income ratios instead of loan-to-value ratios

We have so far used the LTV ratio in 2007 as our preferred measure of pre-crisis leverage. An alternative would be to use the debt-to-income ratio in 2007. Chart 9 illustrates results from regressions using this alternative measure. In parallel with the LTV-based regressions, we opt for a piece-wise linear functional form, allowing kinks at intervals of 100 percentage points of the debt-to-income ratio. The overall picture in the chart is very similar to the results for the LTV ratio: At low levels of the debt-to-income-ratio, there is no clear correlation with the subsequent change in consumption. But once the debt-to-income ratio reaches a certain threshold, around 200 percent, we see a very clear negative correlation. Thus, our main results are not sensitive to the choice of pre-crisis leverage measure.

Chart 9: Regression estimates of alternative version of equation (1). Debt-to-income ratio in 2007 and change in consumption in subsequent years, piece-wise linear specification



Note: The chart shows the average predicted values from estimations of equation (1), using the debt-to-income ratio in 2007 on the RHS instead of the LTV ratio. The chart is constructed as explained in the note to chart 4.
Source: Authors' own calculations based on data from administrative registers.

10. Concluding remarks

Our analysis has shown that families that were highly leveraged prior to the financial crisis that started in 2007/08 reduced consumption more during the crisis than less-leveraged families with similar characteristics. The relationship between leverage and subsequent consumption growth is non-linear, with negative correlation observed at LTV ratios above 40 percent. The results suggest that the build-up of debt and balance sheet expansion that took place among Danish households in the years leading up to the crisis contributed to making the subsequent fall in private consumption larger, thereby amplifying the consequences of the international financial crisis for the Danish economy.

The larger reduction in consumption between 2007 and 2011 among the highly leveraged families reflects that these families consumed a larger fraction of their income than other homeowner families prior to the crisis. However, the difference in consumption levels between high- and low-leverage families narrowed over the course of the crisis. By 2010, there was no difference in the propensity to consume between families with high LTV ratios and families with low ratios.

These results raise doubt about the notion that the high debt level among Danish households has suppressed the level of private consumption in the aftermath of the financial crisis. Rather, the build-up of debt in the years preceding the crisis most likely contributed to an unsustainable consumption level in these years, prompting a large reduction when the Danish economy was hit by the

international financial crisis. The Danish experience therefore indicates that high household leverage may increase macroeconomic volatility in times of financial unrest.

11. References

Abildgren, Kim, Birgitte Vølund Buchholst, Atef Qureshi and Jonas Staghøj (2011), Real economic consequences of financial crises, Danmarks Nationalbank, *Monetary Review*, 3rd Quarter, Part 2.

Andersen, Asger Lau, Anders Møller Christensen, Nick Fabrin Nielsen, Sigrid Alexandra Koob, Martin Oxbjerg and Ri Kaarup (2012), The wealth and debt of Danish families, Danmarks Nationalbank, *Monetary Review*, 2nd Quarter, part 2.

Browning, Martin and Søren Leth-Petersen (2003), Imputing Consumption from income and wealth information, *The Economic Journal*, vol. 113, no. 488.

Browning, Martin, Mette Gørtz and Søren Leth-Petersen (2010), Housing wealth and consumption: A micro panel study, *The Economic Journal,* vol. 123, no. 568.

Caroll, Christopher (1997), Buffer stock saving and the life cycle/permanent income hypothesis, *The Quarterly Journal of Economics*, 112, no. 1.

Cecchetti, Stephen, M. Mohanty and Fabrizio Sampolli (2011), The Real Effects of Debt*, BIS working papers*, no. 352.

Cecchetti, Stephen and Enisse Kharroubi (2012), Reassessing the Impact of Finance on Growth, *BIS working papers*, no. 381.

Dabla-Norris, Era and Narapong Srivisal (2013), Revisiting the Link Between Finance and Macroeconomic Volatility, *IMF working paper*, no. 13/29.

Dynan, Karen (2012), Is a Household Debt Overhang Holding Back Consumption?, *Brookings Papers on Economic Activity*, Spring 2012.

Isaksen, Jacob, Paul Lassenius Kramp, Louise Funch Sørensen and Søren Vester Sørensen (2011), Household balance sheets and debt – an international country study, Danmarks Nationalbank, *Monetary Review,* 3rd Quarter, Part 2.

Leth-Petersen, Søren (2010), Intertemporal consumption and credit constraints: Does consumption respond to an exogenous shock to credit?, *American Economic Review,* vol. 100, no. 3.

Mian, Atif and Amir Sufi (2010), Household Leverage and the Recession of 2007-09, *IMF Economic Review*, vol. 58, issue 1.

Mian, Atif, Kamalesh Rao and Amir Sufi (2013), Household Balance Sheets, Consumption and the Economic Slump, *Quarterly Journal of Economics*, 128 (4).

12. Data appendix

12.1. Statistical definition of a family

The unit of analysis in this article is the *family*, as defined by Statistics Denmark. By this definition, a family consists of either one or two adults and any children living at home. Two adults are regarded as members of the same family if they are living together and meet at least one of the following criteria:

- Are married to each other or have entered into a registered partnership
- Have at least one common child registered in the Civil Registration System (the CPR)
- Are of opposite sex and have an age difference of 15 years or less, are not closely related and live in a household with no other adults

Adults living at the same address who do not meet at least one of the above criteria are regarded as singles. Children living with their parents are regarded as members of their parents' family if they are under 25 years old, have never been married or entered into a registered partnership and do not themselves have children who are registered in the CPR. A family meeting these criteria can consist of only two generations. If three or more generations live at the same address, the two younger generations are considered one family, while the members of the eldest generation constitute a separate family.

12.2. Variables used for imputing non-housing consumption

Non-housing consumption is imputed as follows:

$$\begin{aligned} Consumption = {} & Disposable\ income \\ & - contributions\ to\ privately\ administered\ pension\ schemes \\ & - change\ in\ value\ of\ assets\ (other\ than\ pension\ savings\ and\ real\ property) \\ & + change\ in\ liabilities \\ & . \end{aligned}$$

Disposable income is gross personal income (including wage- and capital income and all government transfers) plus one-off payments from capital pensions and publicly administered pension schemes, less all taxes, interest payments, alimony, and repaid social benefits. Note that the rental value of owner-occupies housing is not included in our measure of disposal income. Neither are contributions to employer-administered pension schemes. These are tax-deductable and, unlike

contributions to privately administered pension schemes, they are paid directly by employers and do not enter the family's cash-flow. Hence, only contributions to privately administered schemes need to be subtracted in the imputation.

The change in the value of assets is calculated as the sum of changes in bank deposits, the market value of bonds and mortgage deeds, the (adjusted) market value of stocks, and the value of foreign assets (financial as well as real). In most cases, the value of foreign assets is self-reported. The change in the market value of stocks is adjusted for price changes in the following way:

$$\widetilde{\Delta v_t} = \Delta v_t - v_{t-1} \cdot \Delta p_t$$

where Δv_t is the actual change in the value of stocks over the year, v_{t-1} is the value of stocks at the beginning of the year, and Δp_t is the relative change in average stock prices over the year, as measured by the C20 index of the Copenhagen Stock Exchange. Thus, the adjustment term in the equation above is equal to the capital gain that the family would have received if i) they did not buy or sell stocks over the year, and ii) the price of their stock portfolio moved in parallel with the overall price development in the stock market over the year.

The change in liabilities is calculated as the sum of changes in debt owed to specialized mortgage banks, debt to universal (i.e. non-specialized) banks, debt raised through mortgage deeds held by non-bank lenders, and debt owed to foreign lenders. Debt owed to central and local governments, pension funds, and insurance companies is also included in total liabilities. Any other debt, e.g. debt owed to private individuals, is not included. Debt owed to specialized mortgage banks constitutes the lion's share of Danish households' total debt. Loans from these banks are financed through issuance of mortgage bonds with maturity up to 30 years, and the remaining debt on such loans is reported at the market value of the underlying bonds. This introduces an additional source of measurement error in our imputed measure of consumption, since changes in debt owed to mortgages banks may stem from fluctuations in bond prices (i.e. capital gains), as well as from payment of the principal (i.e. saving).