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RESUME

I papiret foretages en undersøgelse af danske husholdningers forbrugs- og opsparingsbeslutninger før og under finanskrisen samt i de senere års lavrentemiljø. Alle grupper af husholdninger reducerede deres forbrug umiddelbart efter finanskrisens begyndelse, men nettoopsparere har igen øget deres forbrugskvoter til et niveau svarende til før krisen. Omvendt har nettolåntagere, særligt dem med høj bruttogæld, øget konsolideringshastigheden yderligere over de senere år. Det indikerer, at ændringer i husholdningernes balancer er en længerevarende proces, som har strakt sig ind i begyndelsen af det seneste økonomiske opsving. Vi estimerer desuden den marginale forbrugstilbøjelighed ud af boligformuestigninger på en etårig horisont til 4-6 pct. Yngre og mere belånte husholdninger har en større marginal forbrugstilbøjelighed ud af boligformueændringer, hvilket kunne indikere, at mulighederne for sikkerhedsstillelse og belåning spiller en betydelig rolle for husholdningernes forbrugsbeslutninger. Den marginale forbrugstilbøjelighed er asymmetrisk. Husholdningernes forbrug reagerer kraftigere på negative stød til boligformuen end på positive. Endelig simulerer vi konsekvensen af en rentestigning for de enkelte husholdningers rentebetalinger, og finder herudfra en begrænset likviditetseffekt på det aggregerede forbrug. Forbrugets rentefølsomhed er dog betydeligt større for nogle grupper af husholdninger, såsom boligejere med høj gæld og variabelt forrentede lån.

ABSTRACT

This paper studies consumption and savings decisions of Danish households before and during the financial crisis as well as in the more recent years characterized by negative policy rates. While all household groups decreased their consumption ratios immediately in response to the financial crisis, net savers have increased their consumption ratios to pre-crisis levels again. Net borrowers, in particular those with high gross debt, have increased their speed of consolidation further during recent years. This indicates that household balance-sheet adjustment is a relatively long process, which has extended into the beginning of the recent economic upturn. Further, we estimate the marginal propensity to consume (MPC) out of increasing housing wealth over one year to be around 4-6 per cent. Younger and more levered households have a larger MPC out of housing wealth, suggesting that collateral effects may play a role. The MPC is asymmetric; households adjust their consumption more in response to negative housing wealth shocks than to positive. Finally, we simulate an increase in interest rates at the household level, and find that the impact of the implied changes in liquidity on overall consumption is modest. However, the interest-rate sensitivity is considerably higher for at-risk groups, such as households with large debt and adjustable-rate mortgages.

KEY WORDS

Households; Consumption; Low Interest Rates; Balance-Sheet Adjustment.

JEL CLASSIFICATION

D12; D14; D31; D91; E21.

ACKNOWLEDGEMENTS

The results reported in section 6 are based on a joint project with the International Monetary Fund, IMF. We thank colleagues in Danmarks Nationalbank, Evan Papageorgiou, at IMF, and participants at the Economic Policy Research Network Conference 2017 at the University of Copenhagen as well as at the Household Finance and Consumption Network meeting in Cyprus, June 2017, for useful comments and discussions. The viewpoints and conclusions stated in this paper do not necessarily reflect the views of Danmarks Nationalbank.

Consumption and savings in a low interest-rate environment*

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Abstract

This paper studies consumption and savings decisions of Danish households before and during the financial crisis as well as in the more recent years characterized by negative policy rates. While all household groups decreased their consumption ratios immediately in response to the financial crisis, net savers have increased their consumption ratios to pre-crisis levels again. Net borrowers, in particular those with high gross debt, have increased their speed of consolidation further during recent years. This indicates that household balance-sheet adjustment is a relatively long process, which has extended into the beginning of the recent economic upturn. Further, we estimate the marginal propensity to consume (MPC) out of increasing housing wealth over one year to be around 4-6 per cent. Younger and more levered households have a larger MPC out of housing wealth, suggesting that collateral effects may play a role. The MPC is asymmetric; households adjust their consumption more in response to negative housing wealth shocks than to positive. Finally, we simulate an increase in interest rates at the household level, and find that the impact of the implied changes in liquidity on overall consumption is modest. However, the interest-rate sensitivity is considerably higher for at-risk groups, such as households with large debt and adjustable-rate mortgages.

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1 Introduction

Consumption ratios in Denmark have been low since the financial crisis despite very low interest rates. A proper understanding of the drivers behind the high savings propensity of households is key to understanding the long period of slow recovery, which has followed the deep recession after the financial crisis, as well as the forces underlying the substantial current-account surplus of the Danish economy in the same period. Using individual-level data for the universe of Danish households, this paper studies savings and consumption decisions over different parts of the business cycle; before and during the financial crisis as well as in the more recent period characterized by negative policy rates.

Danish households hold a large stock of debt in an international comparison. Previous research has found that debt played a major role for the consumption decisions of households during the crisis, and, more generally, that debt and house price developments are important factors for understanding macroeconomic volatility. For example, an adverse relation between household leverage when entering the financial crisis and the consumption development during the crisis has now been established in several countries (see e.g. Andersen et al. (2016); Dynan (2012); Fagereng and Halvorsen (2016)). In addition, significant boom-bust cycles of most forms of private debt have been documented (Garriga et al. (2017)). While the focus of most of these studies has been on the consumption behavior during the crisis years, in this paper, we focus on the importance of debt and housing wealth for consumption decisions over the business cycle. Our results suggest that a leverage effect has not only been present during the crisis, but that deleveraging is a process which has extended and accelerated over a longer period than the immediate crisis years.

In particular, we find that during the most recent years characterized by negative policy rates, households with high gross debt have increased savings, while 'savers' with positive net financial wealth have increased their consumption ratios to pre-crisis levels. Thereby, we confirm and extend the findings in previous empirical studies (See e.g. Baker (2015), Mian et al. (2013), Bunn and Rostom (2015), and Dynan (2012)). Our results indicate that consolidation among households with high gross debt still played a significant role for the economy-wide consumption ratio 7-8 years after the onset of the financial crisis. Households with large leverage have - to a substantial extent - utilized the low interest rates to increase debt repayment or savings in other forms. In a counterfactual exercise, we find that changes in distributions (e.g. of income and wealth) as well as in demographics did not play a significant role for the aggregate consumption development over the decade which our data spans.

The reasons for the strong consolidation may include a more realistic risk assessment compared to that of the pre-crisis period, as well as lower expected permanent income or a larger uncertainty around the permanent income level. Results are also consistent with expectations of relatively lower house price-growth and increasing interest rates. A part of the explanation for the increased consumption ratios for households with high financial wealth may be increased capital gains on investment portfolios. Our findings indicate that household balance-sheet ad-

justments may take long time - even longer than the usual length of the business cycle. This may be consistent with, and a contributing factor to, the presence of medium-term co-movements in house prices, credit and GDP (Drehmann et al. (2012)).

Furthermore, we estimate the marginal propensity to consume (MPC) out of changes in housing wealth using the panel dimension of data. We estimate an MPC out of positive shocks to housing wealth over one year at around 4-6 per cent, except during the crisis years 2008-10 where it was lower, at around 2 per cent. This level is comparable to macro-based estimates for the US and UK, see e.g. Slacalek (2009), but somewhat larger than estimates from the Netherlands (van Beers et al. (2015)) and France (Arrondel et al. (2015)).

Further, in line with results from the US (Engelhardt (1996)), the UK (Disney et al. (2010)) and Netherlands (van Beers et al. (2015); Christelis et al. (2017)), we find that the MPC out of housing wealth changes is asymmetric. Households that experienced a negative housing wealth shock reacted more strongly in terms of adjusting their consumption than did households that experienced a positive housing wealth shock. The difference is present throughout the sample period, but it has been larger in the years with negative policy rates, indicating a stronger deleveraging response by households that have experienced decreasing housing wealth in more recent years.

Our results may be consistent with a wealth effect, as documented for the UK over 1988-2000 (Campbell and Cocco (2007)) as well as for the US over 1968-93 (Lehnert (2004)). However, if the main explanation is a 'pure' wealth effect, older households should be expected to respond more to changes in housing wealth due to a shorter expected time remaining on the housing market. On the contrary, we find that the MPC out of housing wealth is higher for households with debt and younger households. This indicates that collateral constraints also play a role; a finding which is in line with previous evidence from Denmark (Browning et al. (2013)) as well as the theoretical prediction of Guerrieri and Iacoviello (2017). In particular, the stronger consumption response by more indebted households to *increasing* housing wealth may indicate the presence of collateral constraints. At the same time, the stronger consumption response by more indebted households to *decreasing* housing wealth may indicate deleveraging.

Given the relatively long period of very low interest rates, concerns have been raised as to the macroeconomic impact of rising rates. The short run repayment capability of Danish households in the event of even quite severe interest rate shocks is good (Andersen et al. (2012)). But even if households are able to service their debt in the event of rising interest rates, they are likely to adjust their consumption substantially in response. To evaluate the short run interest-rate sensitivity of consumption, as a final exercise, we simulate the effect of an interest-rate increase on consumption through the cash-flow channel. We find the direct impact on overall consumption of an increase in interest rates to be modest. However, the interest-rate sensitivity is considerably larger for at-risk groups, such as households with large debt and adjustable-rate mortgages.

Overall, our results indicate that the low level of interest rates in more recent years may have countered an even larger drop in private consumption than what has actually been observed.

The MPC out of a positive housing wealth shock was around 6 per cent in 2013-14, which was similar to or somewhat higher than in the years leading up to the financial crisis. Thus, in the coming years, the current strong house price growth may contribute towards a normalization of consumption ratios. Recent evidence points to house price developments in Denmark to some extent being influenced by overoptimism (Abildgren et al. (2016)). While our results show a stronger consumption response from house price decreases than from increases, this further underlines the importance of macroeconomic policies to aim at stabilizing house price growth and in particular at reducing the probability of prolonged periods of house price declines.

The paper proceeds with an illustration of the basic effects through which consumption may be impacted by interest rates. The following sections describe the data and provide descriptive evidence of the consumption development for different groups of households. Sections 5 and 6 present our main empirical findings, and the final section concludes.

2 Theoretical framework

The aim of this paper is neither to challenge nor to improve on the existing theories and models in the literature (See e.g. the permanent income hypothesis (Friedman, 1957) and the life-cycle hypothesis (Brumberg and Modigliani, 1954)), which have been of theoretical interest for many decades. Rather, we set up a simple framework from which we can make qualified choices in our subsequent empirical study and make coherent inference based on our findings.

2.1 A model of household consumption and savings

We set up a life-cycle model of a price-taking household with a lifespan of T years. The household receives income in every period, Y_t, which, along with net assets, is divided between consumption, C_t, and savings, S_t, for future consumption. The level of net assets is a result of past savings decisions of the household, S_{t-1}. Consumption yields utility in accordance with the per-period utility function $u(.)$, which is increasing and strictly concave, $u' > 0$ and $u'' < 0$. The household receives interest on savings, r, and we define the gross interest rate as $R \equiv 1 + r$. We do not explicitly consider the composition of the household portfolio - but only the net position. The household prefers current consumption over future consumption by discounting at the subjective rate $\beta < 1$. The optimal consumption path is determined from the solution to the intertemporal maximization problem,

$$\begin{aligned} &\max_{C} \sum_{t=0}^{T} \beta^t u(C_t), \\ &\text{s.t. } C_t + S_t = Y_t + S_{t-1}R, \\ &\quad C_t \geq 0, \\ &\quad S_T \geq 0. \end{aligned}$$

The conditions reflect a standard budget constraint, non-negativity of consumption and a terminal condition, which ensures that the household can meet all its liabilities at the terminal period. Solving the problem leads to the standard Euler equation,

$$R\beta = \frac{u'(C_t)}{u'(C_{t+1})},$$

which basically states that the marginal rate of substitution should equal the relative price. Assuming an isoelastic utility function, $u(x) = \frac{x^{1-\sigma}-1}{1-\sigma}$, implying constant relative risk aversion with risk aversion σ and constant intertemporal elasticity of substitution of the order $\frac{1}{\sigma}$ yields a closed form solution to the problem. Inserting the budget constraint then yields the optimal savings choice

$$S_t = \frac{Y_t + S_{t-1}R - (Y_{t+1} - S_{t+1})\,(R\beta)^{\frac{1}{-\sigma}}}{(R^{1-\sigma}\beta)^{\frac{1}{-\sigma}} + 1}. \tag{1}$$

From this optimal savings decision, we can determine the optimal consumption ratio, which will be a core focus of the empirical part of the paper:

$$\frac{C_t}{Y_t} = \left[1 + \frac{S_{t-1}R}{Y_t} + \frac{1}{R}\frac{Y_{t+1} - S_{t+1}}{Y_t}\right] \frac{\left(R^{1-\sigma}\beta\right)^{\frac{1}{-\sigma}}}{(R^{1-\sigma}\beta)^{\frac{1}{-\sigma}} + 1} \tag{2}$$

We see that the consumption ratio depends on net assets and liabilities of the household, i.e. S_{t-1}, and future income, which for obvious reasons is unobserved. Furthermore, it depends on future savings decisions, i.e. life-cycle aspects of the household. In addition, heterogeneity in marginal returns on household portfolios, impatience, and risk aversion is expected to affect the cross-sectional distribution of consumption ratios.

In order to shed light on the implications of low interest rates for household consumption choices, we can use the optimal savings decision in equation (1) to disentangle the basic consumption effects of a change in the interest rate. The timing of the model is such that the interest-rate change is imposed just after the household has made the savings decision in the previous period. This implies that the household is not able to reoptimize before the current period. Interest-rate changes are likely to affect market values of assets and liabilities, i.e. it

affects the value of savings from the previous period. We denote this change by S'_{t-1}.[1]

$$\begin{aligned}\frac{\partial S_t}{\partial R} =& \frac{(\frac{1}{\sigma}-1)\left(Y_t + S_{t-1}R - (Y_{t+1}-S_{t+1})(R\beta)^{\frac{1}{-\sigma}}\right)(R\beta)^{\frac{1}{-\sigma}} + \frac{1}{\sigma}(Y_{t+1}-S_{t+1})(R^{1+\sigma}\beta)^{\frac{1}{-\sigma}}}{\left((R^{1-\sigma}\beta)^{\frac{1}{-\sigma}}+1\right)^2} \\ &+ \frac{S_{t-1}}{\left((R^{1-\sigma}\beta)^{\frac{1}{-\sigma}}+1\right)^2} \\ &+ \frac{S'_{t-1}R}{\left((R^{1-\sigma}\beta)^{\frac{1}{-\sigma}}+1\right)^2} \end{aligned} \tag{3}$$

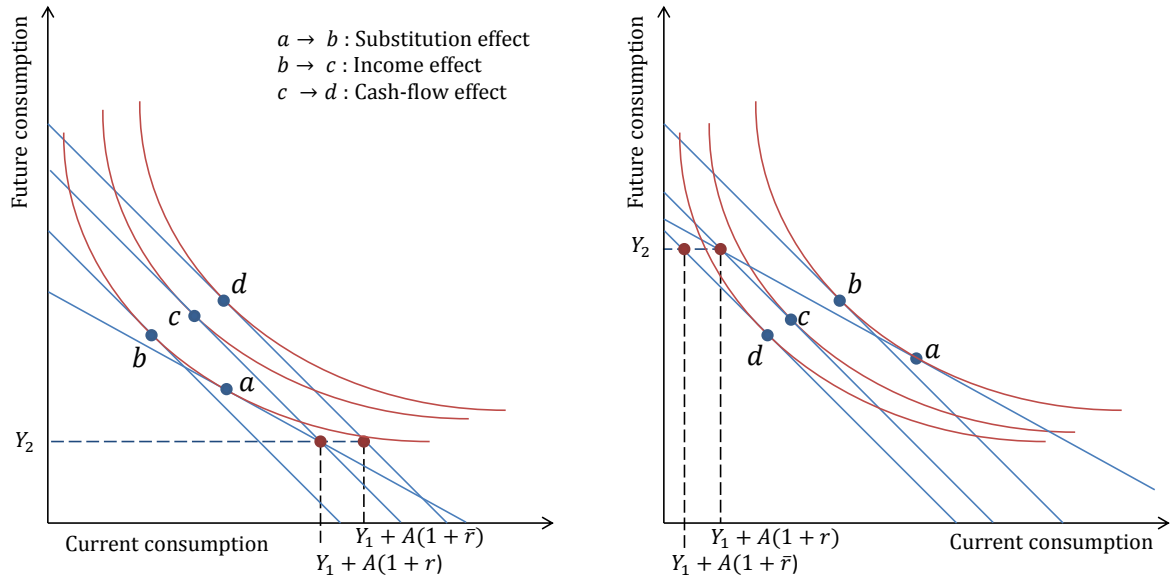
The individual components are described below. Knowing how the interest rate affects savings allows us to evaluate the effects on current and future consumption. These individual effects are illustrated in figure 1 in a two-period version of the model.

The substitution effect First of all, a change to the interest-rate changes the relative price of consumption in the first and the second period, which leads to a change in the optimal consumption scheme, i.e. the substitution effect. In general the substitution effect unambiguously affect the consumption choice, such that an increase in the interest rate increases the cost of current period consumption and thereby decreases current consumption, and vice versa for an interest rate decrease. The substitution effect is unaffected by the division of the endowment into the current and the future periods.

The income effect The intertemporal budget constraint is affected by an interest-rate change as the present value of assets, liabilities, and income in the current and future periods changes, i.e. the income effect. The income and substitution effects are presented in the first line of equation (3). The two are combined in one expression, since the split between the two can be made in various ways. The sign of the income effect depends on whether the household is a net borrower or a net saver before the interest rate change is realized. The division of the life-time income between current and future periods has important implications for the size and sign of the income effect, implying that a household characterized as a saver will experience an increase in lifetime income when interest rates are increasing, whereas the opposite holds for a borrower. Therefore, the income effect mitigates the substitution effect on current period consumption for a saver, but amplifies the drop in consumption for a borrower.

Figure 1 illustrates the income and substitution effects from $a \to b \to c$ for two types of households in the case of an interest-rate increase. The first household, in (a), is a wealthy saver, meaning that the household holds positive initial net assets, for whom it is optimal to save for future consumption and the other, in (b), is an indebted borrower in the sense that the household has negative net assets and relatively large future income in which case the household borrows

[1] For simplicity we hold S_{t+1} fixed in this derivation.



(a) Wealthy saver (b) Indebted borrower

Figure 1: Decomposition to the consumption response of an increase in the interest rate.

Note: Illustration of the substitution, income (Hicks decomposed), and cash-flow effects of an increase in the interest rate, $r < \bar{r}$, in a two periods model in the case of (a) a wealthy saver, i.e. a household with positive initial assets choosing to save for second period consumption and (b) an indebted borrower, i.e. a household initial negative net assets and borrowing in future income for current consumption. The ambiguous wealth effect is excluded from the illustration but would cause an (additional) left-right movement of the intertemporal budget constraint.

for current consumption. We utilize these theoretical differences in consumption responses in our empirical specification as we would expect diverging consumption responses from borrowers and savers during the transition into a low interest-rate environment.

The cash-flow effect In the literature, little attention has been given to the difference between the capital stock and the capital income as distinct drivers of household consumption. However, as Kaplan et al. (2014) have illustrated, an important driver of household consumption is liquid wealth, a point that has been supported by the findings in e.g. Fagereng et al. (2016). If liquidity matters, households are expected to react more to changes in capital income than to unrealized capital gains. Additionally, households have to actively reinvest the flow of capital income, whereas capital gains are as such automatically reinvested.

Our model explicitly allows for a cash-flow effect, though this effect should be thought of as the effect of an unanticipated interest-rate change. This is expressed in the middle line of equation (3). The effect follows from the timing of the model, i.e. a change to the interest rate is realized after the household has made the savings choice in the previous period. The cash-flow effect is in spirit similar to an income shock since it affects the endowment of the household. Illustrated graphically in figure 1, the cash-flow effect is seen as a left-right movement of the intertemporal budget constraint causing the consumption change $c \rightarrow d$. In this simple

framework with only one asset, the relative sign of the cash-flow effect is determined from the net position of the household, i.e. whether the household is initially wealthy or indebted. We use this observation in our empirical specification, where we distinguish households according to their net position. Subsequently, in a simulation we exercise quantify the pure cash-flow effect for Danish households in order to shed light on the potential extent of the effect.

The wealth effect In addition to the income, substitution, and cash-flow effect, there can be a more indirect effect – the wealth effect. If the value of some assets and/or liabilities in the household portfolio are correlated with the interest rate, changes in the interest rate will affect the intertemporal budget constraint and thereby household savings and consumption choices. The wealth effect is expressed in the bottom line of equation (3). In the case of a simple CAPM model, the value of an asset will be affected by a change to the riskless rate in two ways. First, by the direct effect on returns. Whether this impact is positive or negative, depends on whether the portfolio beta is smaller or larger than 1. In addition, a decrease in the riskless rate can impact the betas of individual portfolios. Secondly, the discounting of future returns is affected unambiguously positive by a decrease in the interest rate.[2] Housing is the single largest asset of most Danish households, and house prices are affected substantially by movements in interest rates. In the empirical analysis, we will focus on quantifying the marginal propensity to consume out of changes in housing wealth.

For obvious reasons there is a close connection between the wealth effect and the cash-flow effect. To illustrate our distinction between the two, consider two different liabilities of a household, a fixed-rate mortgage and an adjustable-rate mortgage. In the case of an increase in the interest rate, the interest paid on the fixed-rate mortgage will not increase and therefore there is no cash-flow effect. However, the present value of the outstanding debt decreases, which leads to a (positive) wealth effect. On the other hand, an adjustable-rate mortgage will be affected by a proportional increase in the mortgage rate, hence, there is a cash-flow effect. But in this case, the value of the outstanding debt is unaffected and there is no wealth effect. Hence, the wealth effect is related to changes in the stock of the household portfolio, whereas the cash-flow effect covers immediate effects on the flow of payments related to the household balance sheet.

In sum, figure 2 illustrates the propensity to consume for various combinations of second period income and initial wealth for two different levels of the interest rate in a two-period version of the model. The effects in the two planes include the substitution, income and cash-flow effects. Roughly speaking, borrowers are located in the leftmost half of the figure, and savers are located in the rightmost half. Overall, we would expect to see a positive consumption response of a decrease in the interest rate for borrowers and indebted households and vice versa for (wealthy) savers. However, other factors than the decrease in the interest rate have most

[2]Note that an underlying assumption in the CAPM model is that households are price takers, i.e. in line with the model described above.

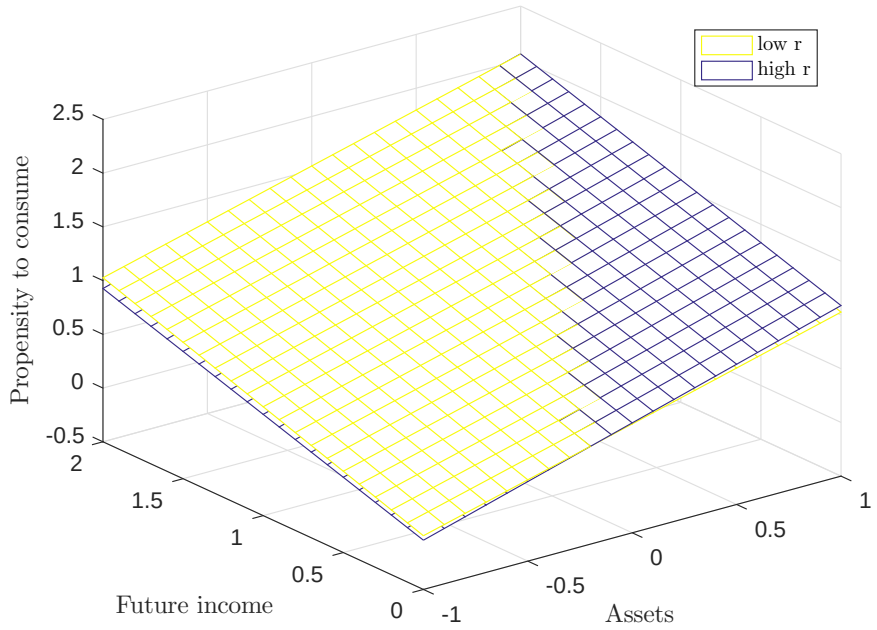


Figure 2: Differences in propensity to consume.

Note: Illustration of consumption effects for combinations of initial assets and future income in a two-period model. All variables are measured in units of first period income. r denotes the interest rate.

likely contributed to the development of household consumption in the years following the financial crises and in the low interest-rate environment of more recent years.

2.2 Additional effects

In addition to the effects of changes in interest rates, household choices can be affected by other exogenous shocks. Obviously, the model agent has perfect foresight and uncertainty does not influence household choices. However, a large fraction of the literature investigates the importance of uncertainty in household consumption-savings choices and corresponding precautionary savings in various settings (see e.g. Carroll (2012), Munk and Sørensen (2010)), which we abstract from here, since good measures of perceived uncertainty are hard to come by. Although, broadly taken, uncertainty leads households to increase saving rates as a precautionary measure.

Furthermore, from the wake of models of household life-cycle consumption stems the distinction between permanent and transitory income shocks and their different implications for household choices. In short, households are expected to react less to a transitory shock, as the shock will be smoothed over the remaining life time. In contrast, a permanent positive shock to household income will increase the consumption level today a lot more since less smoothing is needed. In the years following the financial crisis, we would expect a negative effect to future income to have influenced household prospects and increased saving rates.

Household balance sheets were to some extent inflated prior to the financial crisis. This could force households to engage in some degree of balance-sheet normalization through increased savings rates. As argued in Andersen et al. (2016), this can be a result of mean reversion in the sense that households have invested in some amount of durable consumption goods in the years preceding the crisis and subsequently have a lower need for such goods. Alternatively, the normalization can be interpreted as the household response to a negative shock to the intertemporal budget constraint leading to a forced reduction in the propensity to consume. If households have some sort of habit in their consumption pattern, such as modelled by e.g. Overland et al. (2000), Kraft et al. (2015), and Aydilek (2013) to mention a few, then the reduction of propensities to consume can be expected to take place over a prolonged period of time, and even at an accelerating rate. Due to the importance of the balance-sheet size and composition, and in particular the importance of debt, we pay special attention to leverage in the empirical analysis.

3 Data

Our dataset consists of detailed tax and employment data on Danish households from 2004 to 2015. We combine individual-level, 3rd party reported tax data, demographic characteristics and employment information to obtain a dataset covering almost the full population of Danish households. We use the official price deflator from Statistics Denmark to deflate all relevant variables, unless otherwise noted.

Following Browning and Leth-Petersen (2003); Leth-Petersen (2010); Andersen et al. (2016), we impute consumption expenditures from changes in net wealth from one year to another. In particular, we use the accounting identity

$$C_t \equiv Y_t - S_t = Y_t - \left(W_t - W_{t-1}\right) \tag{4}$$

where C_t is consumption, Y_t is disposable income, S_t is savings and W_t is net wealth in period t. W_t is here defined as liquid assets (i.e. bank deposits, stocks and bonds) minus debt.

One challenge 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. However, we are able to improve the measure in a number of respects. First, housing assets is by far the largest asset category among households. Families involved in a real-estate trade clearly change the physical stock of assets. We exclude families involved in real-estate transactions from our dataset in both the year in which the real estate sale took place, the previous year and the subsequent year. The remaining variation in housing stock is therefore due to capital gains and losses, and therefore,

we disregard housing wealth in our measure of net wealth. Still, however, housing investment cannot be identified separately and is therefore counted as consumption in our measure.

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 proceed by using a crude adjustment based on the overall development in stock markets: For each family, we multiply the value of their stock portfolio at the 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 viewed as an approximation to 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 across 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. Furthermore, instead of using the change in pension assets to approximate pension savings, we use data on annual pension contributions. This measure is much more precise than data on pension assets during the sample period.

Finally, an additional issue is related to mortgage debt. While changes in outstanding bank debt is a good measure of repayments, the same is not true for mortgage debt. The issue is, that all we observe is the market value of mortgage debt at the end of each year. All loans from mortgage banks in Denmark are financed by the issuance of bonds, and loans are issued with an option to repay the loan by purchasing bonds equivalent to the notional loan amount. Borrowers with fixed-rate loans have the additional option to purchase bonds at par in order to repay their loan. The problem of only observing the market value of mortgage debt is that in periods with falling interest rates, the market value of outstanding debt is increasing. Thereby, we would underestimate savings and overestimate consumption for households that do not refinance their loans in a given year. An adjustment is available through utilization of detailed data from the mortgage banks, which, however, is only available from 2009 and onwards. The main results are robust to using an improved measure of consumption which takes this problem into account, cf. the appendix.

While house prices do not enter the definition of consumption, we use house prices to evaluate the marginal propensity to consume out of shocks to housing wealth. House values are estimated by Statistics Denmark based on a granular estimation method. Specifically, the method entails scaling the public valuation of a given housing unit by a correction factor, the ratio of actual sales prices to public valuation of similar housing units. The correction factor has been calculated in each year and within each of 40 property types at the zip code level if a sufficient number of sales have taken place. Otherwise, the municipal, regional or country level has been used to construct the correction factor within each of the property types. Furthermore, a correction has been imposed in cases in which there is a statistically significant difference between correction factors for different groups defined by quartiles and medians within each cell in which the correction factor is calculated.

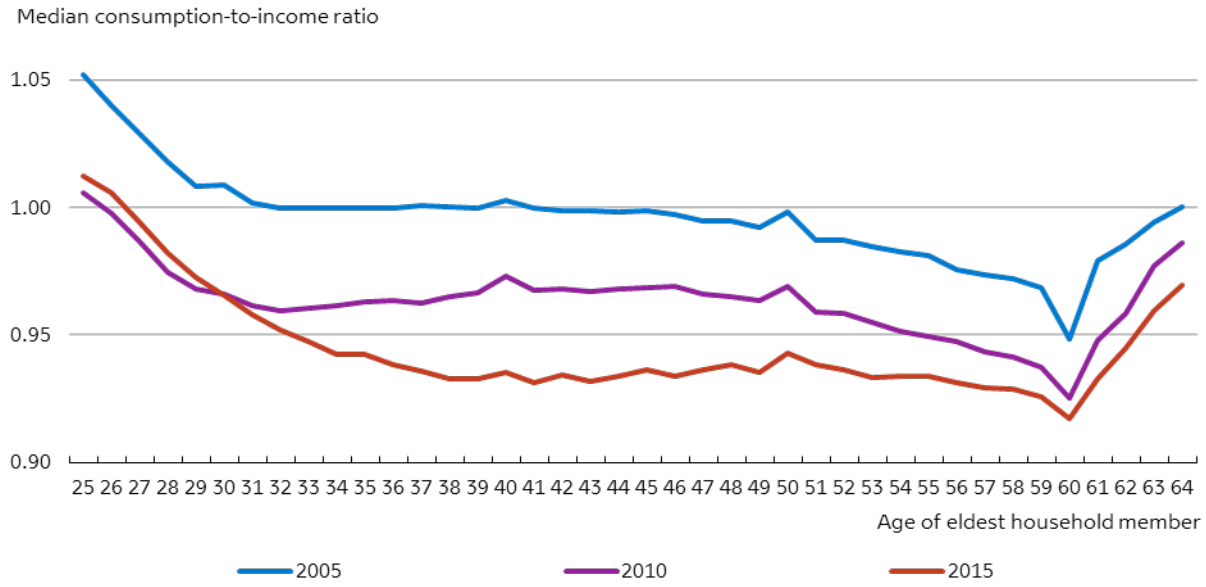


Figure 3: Consumption ratios across age groups

4 Some stylized facts about the consumption development in Denmark

Danish households had large consumption ratios in the years leading up to the financial crisis. One financing source has for some households been the extraction of housing equity through increasing debt. From 2008 to 2010, when the crisis was at its highest, households reduced their consumption substantially. This was in particular the case for highly leveraged households, which reduced their consumption from high levels before the crisis to levels more comparable to less leveraged households, cf. Andersen et al. (2016). However, also less leveraged households reduced their consumption in response to the crisis. The decrease in consumption ratios from 2005 to 2010 was found across all age groups, as evidenced from the almost vertical movement of the graph from 2005 to 2010 in figure 3. In the more recent years, households have continued their consolidation at an increased speed. This is in particular so for middle-aged households, aged in their late 30s until their late 40s. The net savers in the economy, who are in general in the older age groups, have over the past years, characterized by very low interest rates, slightly increased their consumption ratios, while net borrowers have continued their consolidation at an increased speed, thereby reducing consumption ratios, cf. figure 4.

Decomposing savers and borrowers further into income quartiles (figure 5), we see a quite clear tendency towards the higher-income groups having lower consumption ratios on average. The immediate response to the financial crisis implied a substantial reduction in consumption ratios across all income groups. However, interestingly, in particular borrowers in the highest income quartiles continued their consolidation at an increased speed by further reducing their consumption ratios in the years 2011-15. Borrowers with below median income have not

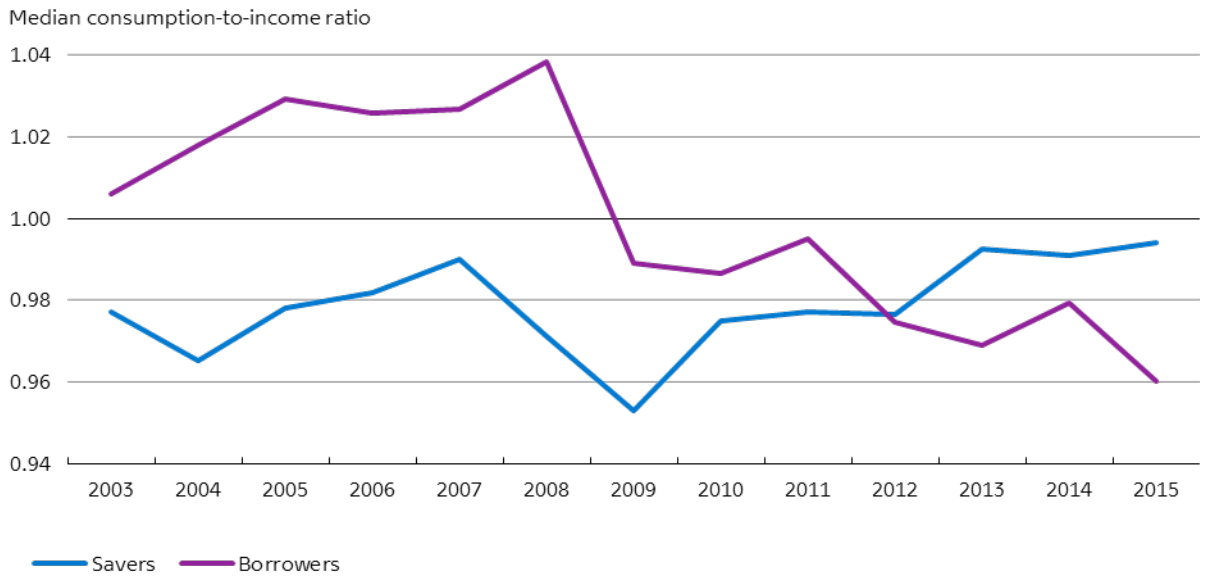


Figure 4: Consumption ratios – borrowers vs. savers

Note: Borrowers are defined as households whose financial liabilities exceed their financial assets (excl. pension savings) and vice versa for savers.

changed their consumption ratios much since the immediate adjustment following the crisis. On the other hand, savers have increased their consumption ratios again to levels similar to those just before the financial crisis. This is the case across all income quartiles.

Our measure of income does not necessarily allow a direct comparison between homeowners and renters. This is because certain expenses related to housing (e.g. interest and property tax) are not included in the income and consumption measures for homeowners, whereas rent is included in consumption for renters. Thus, in many cases, it will make more sense to view owners and renters as two separate groups. Figure 6 decomposes the development seen in figure 4 into homeowners and renters. The consumption of homeowners is clearly more volatile than the consumption of renters. This indicates that the behavior of homeowners is key to understanding the low consumption ratios during the more recent years.

Recall from theory that households who are net borrowers may be expected to increase their consumption ratio when interest rates fall, all else equal. However, as demonstrated, borrowers have instead continued their balance-sheet consolidation which was initiated in the wake of the financial crisis. Borrowers in our definition are households whose financial liabilities exceed their financial assets. We exclude pension wealth from financial assets since pension wealth due to its illiquid nature is not likely to play a large role for consumption decisions - at least not for households which are not close to retirement. Borrowers constitute around 60 per cent of all households in Denmark. To further evaluate the role of continued balance sheet consolidation for the consumption development in this large group of households, we in figure 7 consider the extent to which developments differ across groups of households with different degrees of leverage. Before the crisis, households with high leverage had large consumption

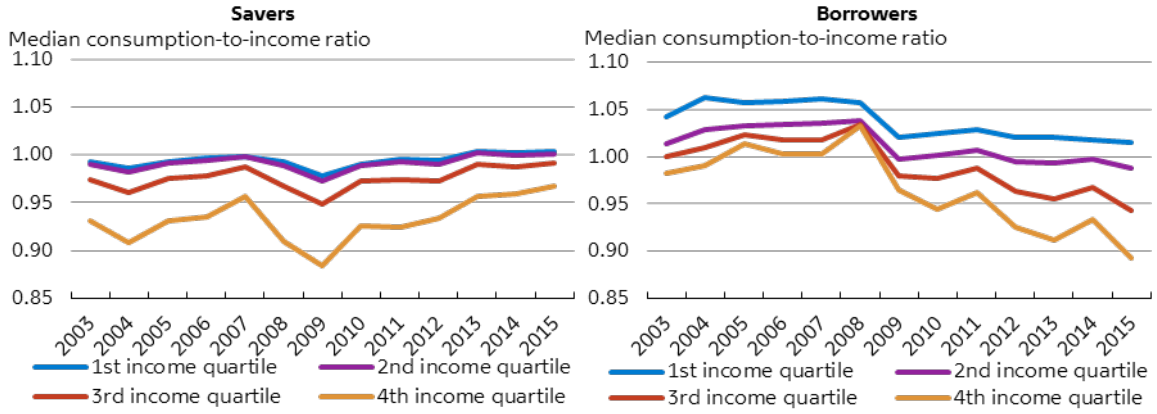


Figure 5: Consumption ratios – borrowers vs. savers

Note: Borrowers are defined as households whose financial liabilities exceed their financial assets (excl. pension savings) and vice versa for savers. Income quartiles are calculated within each group and year.

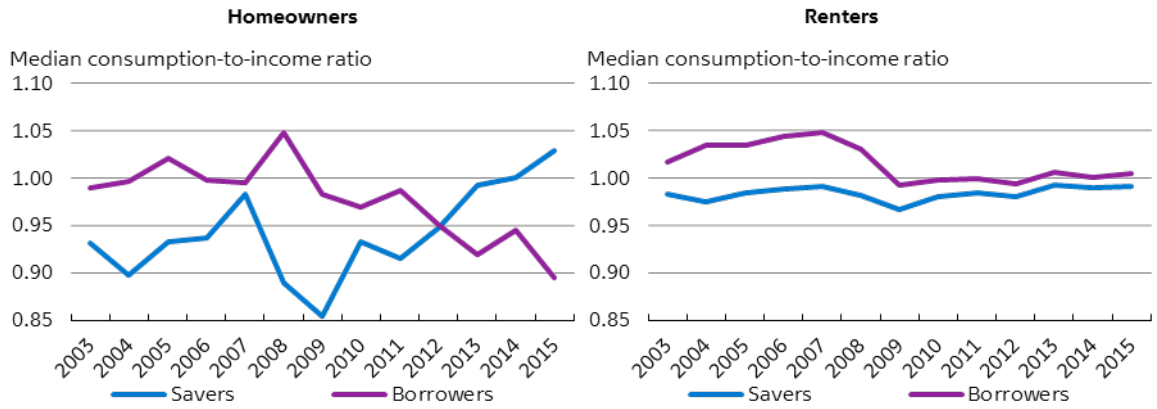


Figure 6: Consumption ratios – homeowners vs. renters

Note: Borrowers are defined as households whose financial liabilities exceed their financial assets (excl. pension savings) and vice versa for savers.

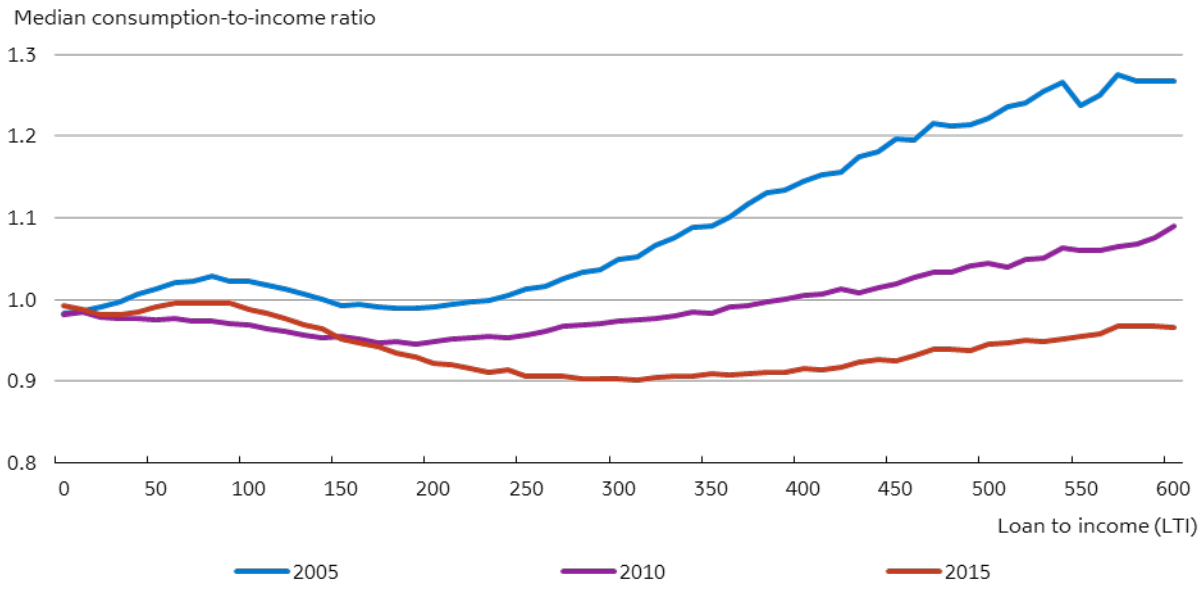


Figure 7: Median consumption ratios across loan to income (LTI) groups

ratios. The largest reduction in consumption ratios immediately after the beginning of the financial crisis was also found in the group of households with the largest leverage. This was also documented by Andersen et al. (2016), who tracked households with varying degrees of leverage over the years 2007-11. Considering the development from 2010 to 2015, again we see that it is households with the largest levels of gross debt which have reduced their consumption ratios the most. Households with debt-to-income ratios smaller than 150 per cent have increased their consumption ratio slightly in the same period.

In sum, during the most recent years of low interest rates, households with high gross debt have increased savings, while 'savers' with positive financial wealth have increased their consumption ratios. These results indicate that continued consolidation among households with high gross debt has played a substantial role for the low aggregate consumption ratios which have been observed throughout the period with very low and negative policy rates. Also, the share of outstanding interest-only mortgages has been falling recently. This may to some extent reflect such a willingness of households to reduce the size of their balance sheet. Fewer interest-only mortgages may both reflect that new loans are increasingly with amortization and that existing loans with an initially agreed interest-only period have to a smaller extent been refinanced when the interest-only period expired. The type of mortgage loan is important for household savings, since households with interest-only loans do not compensate fully for the lack of amortization by other forms of saving (Kuchler (2015)).

5 Empirical models of household consumption

To more formally assess the impact of low interest rates on consumption, we in this section estimate a range of empirical models of household consumption aimed at capturing different aspects of the distribution and dynamics of consumption. We estimate specifications in levels and in differences, as well as a specification aimed at recovering the marginal propensity to consume out of changes in housing wealth. A comprehensive reveiew of the related empirical literature can be found in Paiella (2009).

5.1 Consumption levels and dynamics

5.1.1 Econometric specification

First, we estimate a model of the consumption ratio of households based on a wide range of household characteristics. As noted previously, our consumption measure does not enable direct comparison between renters and homeowners. Therefore, we consider these two groups separately. We estimate the following specification for household i in year t:

$$\frac{C_{it}}{Y_{it}} = \alpha + \gamma \frac{1}{Y_{it}} + \theta \frac{NW_{it}}{Y_{it}} + \delta B_{it} + \beta x_{it} + \varepsilon_{it} \tag{5}$$

where Y_{it} denotes disposable income and NW_{it} net wealth.[3] We also include an indicator of whether the household is a net borrower or a net saver, B_{it}, since we found diverse consumption developments for these two groups in the descriptive analysis.[4] As control variables, we include a range of household characteristics, namely age, education, number of children, age of children, number of years lived at current address, municipality and year. Since we have a large number of observations, we allow for a fully flexible functional form for all control variables by estimating a satiated model.[5]

We estimate the model for 4 distinct periods, namely the period leading up to the crisis (2005-07), the period just after the beginning of the crisis (2008-10), the early recovery period (2011-12), as well as the subsequent period characterized by very low interest rates (2013-15). For the estimation, we winsorize the sample at the 5th and 95th percentile of the consumption ratio in each year due to potential measurement error as outlined in section 3.

Equation (5) is concerned with the consumption *level*. To evaluate the extent of changes in behavior instead of the determinants of consumption per se, it may be more informative to

[3] According to equation (2), the consumption ratio of a given households depends on the ratio of current to future (i.e. permanent) income. Since permanent income is unobservable, we assume that it is constant across households conditional on the covariates included in the regression. Therefore, we include $\frac{1}{Y_{it}}$ in the estimation equation. Results are not sensitive to this specific choice of functional form.

[4] Note that the split between borrowers and savers is done according to their net liquid financial wealth, not their net total wealth, in accordance with the theoretical discussion in section 2.

[5] That is, for each control variable, we include $s-1$ indicator variables, where s is the number of possible values which the variable can take.

consider consumption dynamics within households over time. Our next step is, therefore, to utilize the panel dimension of data and estimate a series of models aimed at explaining the *change* in the consumption ratio for a given household during separate periods before, during and after the crisis.

Specifically, we model the change in household i's consumption ratio as

$$\frac{C_{it+3}}{Y_{it+3}} - \frac{C_{it}}{Y_{it}} = \alpha + \gamma \frac{1}{Y_{it}} + \theta \frac{NW_{it}}{Y_{it}} + \delta B_{it} + \beta x_{it} + \varepsilon_{it} \tag{6}$$

In addition to the sample restrictions also imposed for the estimation of the model in levels, we only include families which have the same composition of adults (reference persons) in year t and $t+3$. We choose to track families over 3-year periods in order to minimize the influence of random variation from year to year, but also to minimize the non-random influence that dissolution of old families and creation of new families may have when tracing families for longer time horizons. To ensure that results are not driven by larger (e.g. durable) purchases in year t, we include in x_{it} the change in consumption from year $t-1$ to year t.

The descriptive analysis, as well as results from estimation of equations (5) and (6) which are presented below, indicate that the consumption behavior of borrowers and savers differed substantially over the sample period. The difference in the response to the crisis by borrowers and savers may arise because of their different balance sheet composition. In particular, the descriptive results pointed towards leverage as a potentially important factor in explaining the consumption development for borrowing homeowners. Next, we therefore separately consider the group of borrowing homeowners. To assess the importance of gross debt we include leverage as an explanatory variable, and estimate the following augmented versions of equations (5) and (6):

$$\frac{C_{it}}{Y_{it}} = \alpha + \gamma \frac{1}{Y_{it}} + \theta \frac{NW_{it}}{Y_{it}} + \sum_{l=100;200;...}^{500} \delta_l 1\left[LTI_{it} \in [l; l+100]\right] + \delta_{600} 1\left[LTI_{it} > 600\right] + \beta x_{it} + \varepsilon_{it} \tag{7}$$

$$\frac{C_{it+3}}{Y_{it+3}} - \frac{C_{it}}{Y_{it}} = \alpha + \gamma \frac{1}{Y_{it}} + \theta \frac{NW_{it}}{Y_{it}} + \sum_{l=100;200;...}^{500} \delta_l 1\left[LTI_{it} \in [l; l+100]\right] + \delta_{600} 1\left[LTI_{it} > 600\right] + \beta x_{it} + \varepsilon_{it} \tag{8}$$

where $1\,[]$ denotes the indicator function (taking a value of 1 if the expression in brackets is true, and 0 otherwise), and LTI_{it} is the loan to income ratio (in per cent) of household i at time t. Since the descriptive analysis pointed towards the effect of leverage being highly non-linear, we specify the effect of leverage on consumption as a series of indicator variables for various levels of leverage (loan-to-income).

Table 1: Results: Determinants of the consumption ratio

Panel A: Homeowners

Dep. var.: consumption ratio	2005-07	2008-10	2011-12	2013-15
$\frac{1}{Y_{it}}$	0.112***	0.102***	0.067***	0.051***
	(0.001)	(0.000)	(0.000)	(0.000)
$\frac{NW_{it}}{Y_{it}}$	-0.010***	-0.004***	-0.001***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
B_{it}	0.109***	0.137***	0.091***	-0.023***
	(0.001)	(0.001)	(0.001)	(0.001)
Observations	2,807,586	2,927,400	1,977,918	2,947,706
R-squared	0.054	0.091	0.064	0.074

Panel B: Renters

Dep. var.: consumption ratio	2005-07	2008-10	2011-12	2013-15
$\frac{1}{Y_{it}}$	0.045***	0.047***	0.042***	0.042***
	(0.000)	(0.000)	(0.000)	(0.000)
$\frac{NW_{it}}{Y_{it}}$	0.006***	0.004***	0.004***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)
B_{it}	0.127***	0.087***	0.061***	0.053***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2,931,616	2,989,624	2,051,873	3,201,396
R-squared	0.070	0.074	0.069	0.061

Note: Standard errors in parentheses. Coefficient estimates and standard errors for $\frac{1}{Y_{it}}$ have been scaled by average disposable income. *** p<0.01, ** p<0.05, * p<0.1. Control variables include indicators of age, education, number of children, age of children, number of years lived at current address, municipality and year.

5.1.2 Results

Results from estimation of equation (5) are presented in table 1. As would be expected, consumption ratios are decreasing with household income. The most striking result, however, is the difference between the development over time for savers and borrowers. Both homeowners and renters which had negative net financial wealth (borrowers) had high consumption ratios before the crisis. For renters, the difference between borrowers and savers is decreasing over time. Among homeowners, however, borrowers have actually had lower consumption ratios than savers in the most recent period 2013-15; a result which was also found unconditionally in figure 4.

To closer evaluate whether these results can be interpreted as changes in the behavior of individual households, we estimate equation (6) for selected time spans. Results for $t = \{2005; 2008; 2012\}$ are presented in table 2. Like in the levels specification, the most striking difference between renters and homeowners is the development in the coefficient estimates associated with the borrower-dummies. Both renters and owners, who were net borrowers, reduced their consumption more as an immediate response to the crisis in comparison to similar

Table 2: Determinants of change in consumption ratio

Panel A: Homeowners

Dep. var.: Change in consumption ratio	2005-08	2008-11	2012-15
$\frac{1}{Y_{it}}$	-0.015***	-0.031***	-0.036***
	(0.001)	(0.001)	(0.001)
$\frac{NW_{it}}{Y_{it}}$	0.002***	0.003***	0.004***
	(0.001)	(0.000)	(0.000)
B_{it}	-0.011***	-0.026***	-0.083***
	(0.001)	(0.001)	(0.001)
Observations	457,052	505,931	535,398
R-squared	0.084	0.075	0.100

Panel B: Renters

Dep. var.: Change in consumption ratio	2005-08	2008-11	2012-15
$\frac{1}{Y_{it}}$	-0.015***	-0.020***	-0.022***
	(0.000)	(0.000)	(0.000)
$\frac{NW_{it}}{Y_{it}}$	0.001***	-0.001***	-0.000
	(0.000)	(0.000)	(0.000)
B_{it}	-0.027***	-0.053***	-0.028***
	(0.001)	(0.001)	(0.000)
Observations	457,280	484,113	495,235
R-squared	0.063	0.072	0.068

Note: Standard errors in parentheses. Coefficient estimates and standard errors for $\frac{1}{Y_{it}}$ have been scaled by average disposable income. *** p<0.01, ** p<0.05, * p<0.1. Control variables include indicators of age, education, number of children, age of children, number of years lived at current address, municipality, and year; all measured in year t, as well as the change in consumption from year $t-1$ to year t scaled by income in year t.

households which were net savers (i.e. whose liquid financial wealth exceeded their liabilities). For renters who were net borrowers, the adjustment in consumption behavior was largest immediately after the beginning of the financial crisis. In contrast, homeowners which were net borrowers reduced their consumption ratio more from 2012 to 2015 than from 2008 to 2011. These results indicate that consolidation has been the main explanation for continued low levels of aggregate consumption ratios in more recent years.

To further quantify the role of leverage, next we focus on equation (7). Leverage was a very significant predictor of consumption levels before the crisis, cf. table 3. For example, households which had an LTI ratio between 4 and 5 had a consumption to income ratio more than 20 percentage points larger than households which had an LTI between 2 and 3 in the pre-crisis years. Note that this is after controlling for life cycle factors such as age and years lived at current address, as well as net wealth. This seems to indicate a substantial extent of debt-financed consumption before the crisis.

Leverage was a less important predictor of consumption ratios in the subsequent years, and in particular in 2013-15. This is in line with the result from figure 7. However, this should

Table 3: Determinants of the consumption ratio – borrowers

Dep. var.: consumption ratio	2005-07	2008-10	2011-12	2013-15
LTI 1-2	0.014***	0.016***	0.013***	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
LTI 2-3	0.088***	0.085***	0.059***	0.024***
	(0.001)	(0.001)	(0.001)	(0.001)
LTI 3-4	0.199***	0.160***	0.099***	0.047***
	(0.001)	(0.001)	(0.001)	(0.001)
LTI 4-5	0.320***	0.226***	0.135***	0.071***
	(0.002)	(0.001)	(0.001)	(0.001)
LTI 5-6	0.423***	0.283***	0.166***	0.091***
	(0.002)	(0.001)	(0.001)	(0.001)
LTI > 6	0.535***	0.350***	0.200***	0.115***
	(0.002)	(0.001)	(0.001)	(0.001)
$\frac{1}{Y_{it}}$	0.041***	0.045***	0.033***	0.034***
	(0.001)	(0.000)	(0.000)	(0.000)
$\frac{NW_{it}}{Y_{it}}$	-0.013***	-0.004***	-0.000***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2,194,835	2,314,609	1,550,371	2,292,150
R-squared	0.136	0.138	0.094	0.067

Note: Only borrowers (i.e. households whose liabilities exceed their liquid financial assets) who own their main residence are included in the estimation sample. The excluded (reference) category for LTI is LTI ≤ 1. Standard errors in parentheses. Coefficient estimates and standard errors for $\frac{1}{Y_{it}}$ have been scaled by average disposable income. *** p<0.01, ** p<0.05, * p<0.1. Control variables include indicators of age, education, number of children, age of children, number of years lived at current address, municipality and year.

not be interpreted as to imply that leverage has been less important for the consumption development during the more recent years. Rather, households with high leverage have reduced their consumption ratios to levels more comparable to other households, thereby reducing the coefficient estimates associated with the leverage indicators. Hence, the difference in consumption ratios between otherwise similar households with high and low leverage was smallest in 2013-15.

In order to verify that the smaller difference in consumption ratios across households with varying degrees of leverage is in fact mainly the result of changes in the consumption behavior of highly leveraged households, we consider equation (8). For our findings to be in line with this hypothesis, we would expect households with large leverage to have reacted most strongly in terms of reducing their consumption from the pre-crisis levels. Indeed, we see that households with large leverage adjusted their consumption the most in the wake of the financial crisis, cf. table 4. But not least important, an adjustment of close to similar magnitude has taken place from 2012 to 2015. Hence, through the years with negative policy rates, leveraged households have increased their speed of consolidation by decreasing their consumption ratio further than the initial adjustment which followed the outbreak of the crisis.

Table 4: Determinants of change in consumption ratios – homeowners with negative net liquid assets

Dep. var.: Change in consumption ratio	2005-08	2008-11	2012-15
LTI 1-2	-0.002	0.000	-0.006***
	(0.002)	(0.002)	(0.002)
LTI 2-3	-0.011***	-0.020***	-0.030***
	(0.002)	(0.002)	(0.002)
LTI 3-4	-0.025***	-0.053***	-0.052***
	(0.002)	(0.002)	(0.002)
LTI 4-5	-0.035***	-0.081***	-0.067***
	(0.002)	(0.002)	(0.002)
LTI 5-6	-0.026***	-0.099***	-0.077***
	(0.003)	(0.002)	(0.002)
LTI > 6	-0.031***	-0.106***	-0.077***
	(0.004)	-0.003	(0.002)
$\frac{1}{Y_{it}}$	-0.012***	-0.014***	-0.021***
	(0.001)	(0.001)	(0.001)
$\frac{NW_{it}}{Y_{it}}$	0.003***	0.004***	0.004***
	(0.000)	(0.000)	(0.000)
Observations	353,848	400,474	429,556
R-squared	0.094	0.085	0.100

Note: Only borrowers (i.e. households whose liabilities exceed their liquid financial assets) who own their main residence are included in the estimation sample. The excluded (reference) category for LTI is LTI ≤ 1. Standard errors in parentheses. Coefficient estimates and standard errors for $\frac{1}{Y_{it}}$ have been scaled by average disposable income. *** p<0.01, ** p<0.05, * p<0.1. Control variables include indicators of age, education, number of children, age of children, number of years lived at current address, municipality, and year; all measured in year t, as well as the change in consumption from year $t-1$ to year t scaled by income in year t.

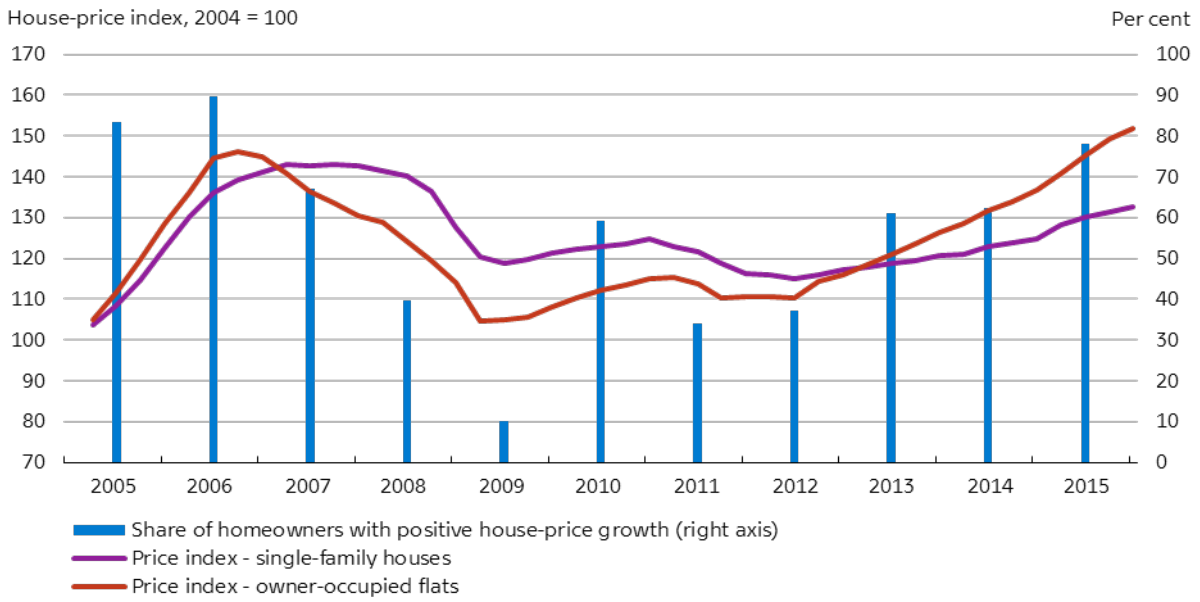


Figure 8: House prices and share of households with positive house price growth

Source: Statistics Denmark and own calculations.

5.2 Housing wealth and consumption

House prices grew rapidly before the financial crisis, and were subsequently subject to a relatively large correction, cf. figure 8. House-price growth have in some parts of the country accelerated again over the years with negative policy rates. The development in housing wealth in combination with in particular the introduction of interest-only mortgage loans is also likely to have played a role for the development in consumption over the decade in which our data spans. We therefore consider in greater detail the propensity of households to consume out of changes in housing wealth.

The specification used in the previous section is aimed at identifying changes in behavior of different groups of households over time. To assess the extent to which housing wealth played a role for the consumption decisions of households, we estimate a different specification aimed at capturing the marginal propensity to consume out of changes in housing wealth (as well as income). Specifically, we estimate

$$\frac{\Delta C_{it}}{Y_{it}} = \alpha + \gamma \frac{\Delta HE_{it-1}}{Y_{it}} + \delta \frac{\Delta Y_{it}}{Y_{it}} + \beta x_{it} + \varepsilon_{it} \tag{9}$$

where ΔC_{it} is the nominal change in consumption from year t to $t+1$, ΔHE_{it-1} is the nominal change in housing equity from year $t-1$ to t, ΔY_{it} is the nominal change in income from year t to $t+1$, and x_{it} is a vector of control variables similar to those used in the previous specifications, including the ratio of liquid assets to income. Based on this regression, γ is an estimate of the marginal propensity to consume (MPC) out of changes in housing wealth. To allow for an asymmetric response of households to positive and negative house price shocks, we estimate

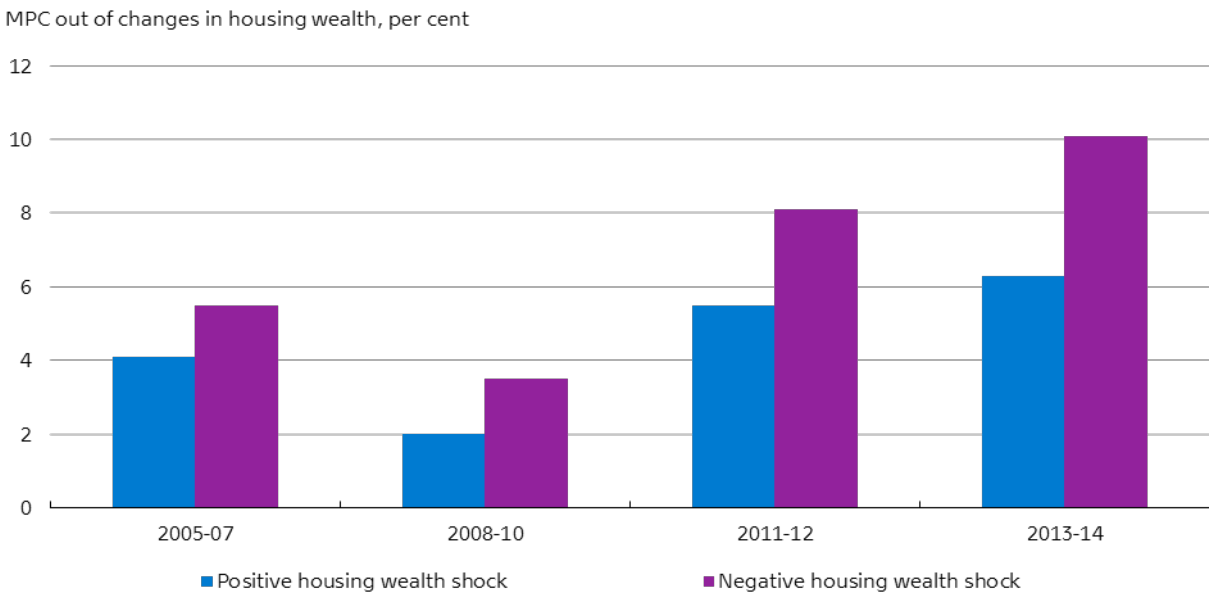


Figure 9: Marginal propensity to consume out of housing wealth shocks

Note: The MPC out of housing wealth is the point estimate of γ from estimation of equation (9) for the groups of households having experienced a positive and a negative housing wealth shock, respectively. Owing to the large number of observations, standard errors associated with the coefficient estimates are in all cases $\leq$0.1 percentage points.

equation (9) separately for households that experience increases and decreases in housing wealth during the given years.

Our estimates of γ are shown in figure 9.[6] The MPC out of increasing housing wealth over one year has been around 4-6 per cent, except in 2008-10 where it was lower, at around 2 per cent. Further, we find an asymmetric MPC out of housing wealth. Households that experienced a negative housing wealth shock reacted more strongly in terms of adjusting their consumption than did households that experienced a positive housing wealth shock. The difference is present throughout the sample period, but it has been stronger in the years with negative policy rates.

To get an indication of whether the MPC out of housing wealth is due to a 'pure' wealth effect or whether collateral effects also play a role, we interact the change in housing equity with indicators of leverage and age. We find a stronger MPC out of both positive and negative house price shocks for more indebted households, cf. figure 10, and younger households, cf. figure 11. The stronger consumption response to increasing house prices by more indebted households may indicate that collateral constraints play a role. This is further underlined by the finding that the most indebted households respond less strongly than those with LTI between 300 and 500 per cent to both increases and decreases in house prices. Those highly indebted households may find it more difficult to obtain additional credit even in the event of wealth increases. At the same time, a stronger consumption response to decreasing housing wealth by more indebted households may indicate deleveraging.

In terms of the possible impacts of negative policy rates, we see that the MPC out of housing

[6] All estimates are statistically significant at the 1 per cent level.

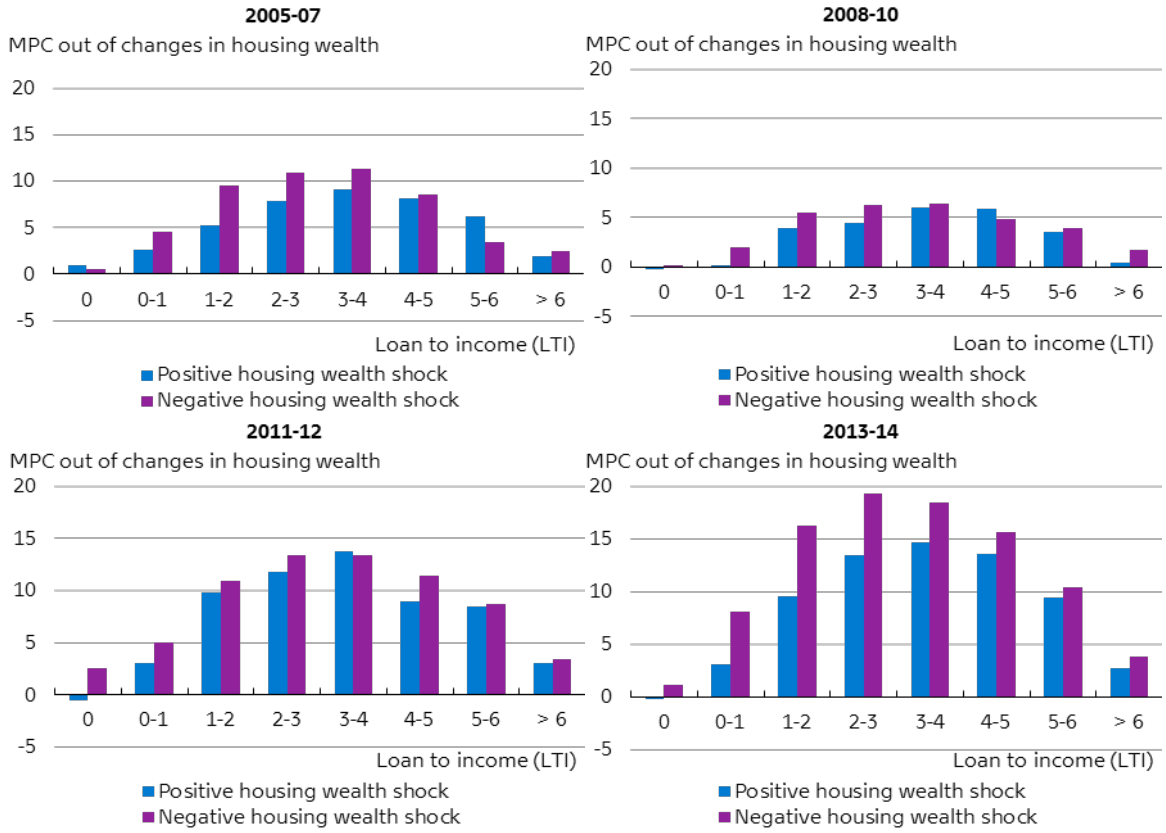


Figure 10: Marginal propensity to consume out of changes in housing wealth, LTI groups

Note: The MPC out of housing wealth changes is estimated from equation (9), with added interaction terms between leverage indicators and $\frac{\Delta HE_{it-1}}{Y_{it}}$.

wealth decreases has been larger during 2013-15 than during previous periods, whereas the MPC out of housing wealth increases has been more in line with the previous period. This confirm that in particular more leveraged households which have experienced negative housing wealth shocks have accelerated their deleveraging over the period with negative policy rates. In sum, our results indicate that debt and an efficient financial system allowing easy withdrawal of housing equity may increase the sensitivity of consumption to house-price fluctuations. Overall, these findings are in line with the theoretical findings of Guerrieri and Iacoviello (2017).

5.3 Counterfactuals and general discussion

As the results demonstrate, Danish households have been through a relatively long consolidation process following the financial crisis. Rather than increasing their borrowing, they have to a large extent taken advantage of the low interest rates to increase debt repayment and savings in liquid assets. The non-decreasing trend in aggregate nominal debt is likely to be a result of e.g. higher house prices, to a larger extent than by increased borrowing by already leveraged homeowners.

Figure 11: Marginal propensity to consume out of changes in housing wealth, age groups

Note: The MPC out of housing wealth is estimated from equation (9), with added interaction terms between age group indicators and $\frac{\Delta HE_{it-1}}{Y_{it}}$. *Age refers to the eldest member of the household.*

It has been argued both historically (Keynes (1919)) as well as by others more recently[7] that increased inequality and aging may have contributed to decreasing aggregate consumption ratios. The reasoning is based on the finding, which is also present in our results, that families with high wealth and/or income as well as older working-age households have lower propensities to consume out of income than the average household. Hence, if those households over time increase their share of total wealth or income, overall consumption ratios would tend to decline.

To assess the medium-term implications of changes in distributions and demographic characteristics vs. changes in behavior, we perform a counterfactual exercise as follows. First, we estimate the model described in equation (7) for each year in the sample period, and predict the consumption ratio for all households. Next, for each year, we predict the consumption ratio using the covariates (i.e. the characteristics of each household) from 2007. That is, we predict how the consumption ratio of each of the households observed in 2007 would have developed if their background characteristics were unchanged, but behavior changed according to the estimated models for each year. Finally, we use the two predictions, the actual and counterfactual consumption ratio, to estimate total consumption at the household level in each of the two scenarios. These estimates of household-level consumption are then aggregated across the whole sample to obtain estimates of the macroeconomic consumption ratio in the two scenarios. We use the aggregate in stead of the mean consumption ratio in order to also take into account any development over time in the concentration of wealth and income, which will not be reflected in an unweighted mean. The counterfactual consumption ratio can therefore be interpreted as the consumption ratio which would have been observed had there been no changes in household characteristics from 2007, but only changes in behavior.

The difference between the actual consumption development and the counterfactual development assuming that household characteristics were unchanged from their 2007 values is insignificant, cf. figure 12. The explanation for the change in consumption ratios over the sample period is therefore one of changes in behavior, not in distributions or demographic characteristics. Our findings do not preclude the existence of an effect of changes in distributions or demographics, but such effects are likely to work in the longer term and seem not to be not important in explaining the development over the decade which our data spans.

The process of consolidation has extended well into a period of economic recovery. Consumption ratios are still lower than what could be expected in the beginning of an economic upturn because of continued deleveraging. The finding that adjustments in credit and in household balance sheets extend over longer time than a typical length of a downturn is consistent with (and may be one of the explanations of) medium term co-movements in house prices, credit and GDP (Drehmann et al. (2012)).

[7] Summers (2015) points out income inequality as one of potential factors driving secular stagnation.

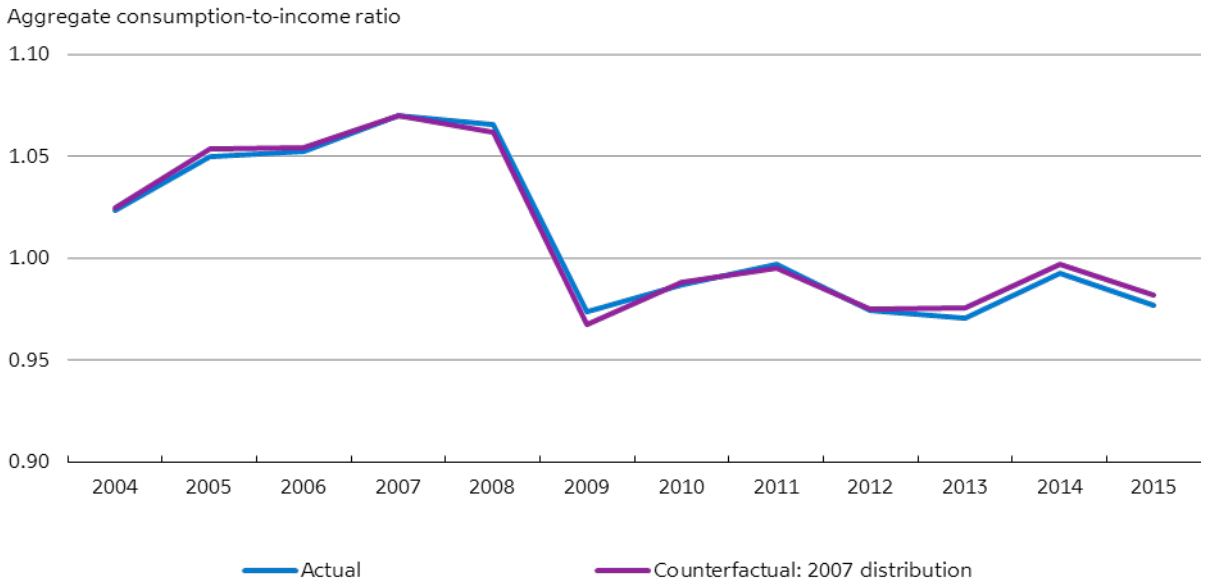


Figure 12: Actual and counterfactual consumption ratios

Note: The actual development is the predicted aggregate consumption ratio estimated by annual models. The counterfactual development is the predicted aggregate consumption ratio for the population in 2007 and covariates fixed at 2007 values, using parameter estimates from annual models. Hence, the counterfactual is an estimate of how the aggregate consumption ratio would have evolved if there has been no changes in household characteristics and distributions since 2007, but only changes in behavior.

6 Increasing interest rates: Assessing the importance of the cash-flow channel

While the previous sections have highlighted the role of debt for the development in consumption during the financial crisis and in the subsequent recovery, this section is concerned with the potential direct impact on consumption of increasing interest rates going forward. We focus here on the cash-flow channel, i.e. the impact on consumption of changed flows of interest payments on debt and bank deposits.

To be more specific, we simulate the impact of a 100 basis points increase in interest rates on debt and bank deposits. First, we calculate the changes in interest payments on both assets and liabilities. Then, we recalculate tax payments to take into account the taxational consequences of changes in interest paid or received.[8] These calculations are performed at the individual level before aggregation to the household level. Since the individual household mortgage information is available, we calculate the change in interest payments from the increase in the borrowing rate on the debt service, ΔIP, as

$$\Delta IP = \Delta r * P_{ARM} + \alpha * \Delta r * P_{FRM} \tag{10}$$

[8]Tax payments are calculated subject to an assumption that married couples with total interest expenses exceeding DKK 100,000 split interest payments equally, e.g. by having equal owner shares of their total real estate stock.

where P_{ARM} and P_{FRM} are the outstanding principal of any adjustable- and fixed-rate mortgages of the household in the given year, respectively; and Δr is the change in interest rates on loans, here assumed to be 1 percentage point (0.01). α is a passthrough coefficient to model the effect of the higher borrowing rates on future refinancing of fixed-rate mortgages and the uptake of new mortgages to finance e.g. equity withdrawal, housing investment, or new house purchases. In what follows, unless otherwise noted, we assume that $\alpha = 0.25$. As we are interested in the medium-term effects, we assume in the simulations that all adjustable-rate mortgages have been refinanced. Hence, we do not utilize the information on the precise refinancing dates on the loans.

It may be reasonable to assume that interest-rate increases would not be mirrored on deposit rates one-to-one, especially after the years of deposit rates being at or close to 0 despite negative policy rates. An exception is, however, deposits that are linked to loan accounts which carry the same rate as the loan. Such deposits constitute a significant share of total deposits, but they cannot be separately identified in our dataset. As a result, we present the results both including and excluding the effect of increased interest received, ΔIR, defined as

$$\Delta IR = \Delta r * D \tag{11}$$

where D is the stock of deposits. The two sets of results are meant to serve as range of estimates for the true impact of rising rates on consumption.

The results are reported as the change in disposable income as a share of consumption. Therefore it is straightforward to convert to consumption using an estimate of the households' marginal propensity to consume. For instance, a marginal propensity to consume equal to 1 would imply a one-to-one passthrough from disposable income to consumption, which would serve as an upper bound of the consumption response. Reasonable estimates for the average marginal propensity to consume range from 0.4 to 0.8.[9] But given that our consumption data refer to total consumption, which include autonomous consumption (such as fixed spending in utilities, housing expenditures and more), high values for the marginal propensity to consume may be more realistic.

The median sensitivity of household consumption to rising rates is modest. A 100 basis points (bps) increase of the borrowing rate decreases disposable income as a share of consumption by 15 bps for the median overall household when allowing for interest income effects from bank deposits (Table 5). This implies a relatively small hit to consumption, but, as argued above, when rates increase from the current very low rates, it is likely that banks will be slow to raise deposit rates given the long period of negative policy rates. In that case, if we ignore interest income effects, the impact of the 100 bps increase of the borrowing rate is a decrease in disposable income as a share of consumption by 32 basis points for the median overall household. When

[9] Jorgensen and Kuchler (2017) have recently estimated the average marginal propensity to consume out of a temporary increase in liquid assets to be 0.49 for Danish households but with significant heterogeneity across the income and wealth distribution.

Table 5: The effect of an interest-rate increase of 1 percentage point

Interest on deposits modeled?	Yes				No	
	$\alpha = 0$		$\alpha = 0.25$		$\alpha = 0.25$	
Households	With debt	All	With debt	All	With debt	All
Aggregate reduction	1.13	0.79	1.25	0.89	1.58	1.29
Mean reduction	1.11	0.69	1.23	0.78	1.55	1.17
1st decile	-0.47	-0.82	-0.31	-0.74	0.01	0.00
1st quartile	-0.04	-0.22	0.01	-0.16	0.17	0.00
Median	0.38	0.08	0.50	0.15	0.74	0.32
3rd quartile	1.62	1.09	1.74	1.23	2.04	1.50
9th decile	3.38	2.88	3.49	2.98	3.80	3.25

Note: The table shows the reduction in disposable income as a percentage of consumption following an increase in interest rates of 1 percentage point.

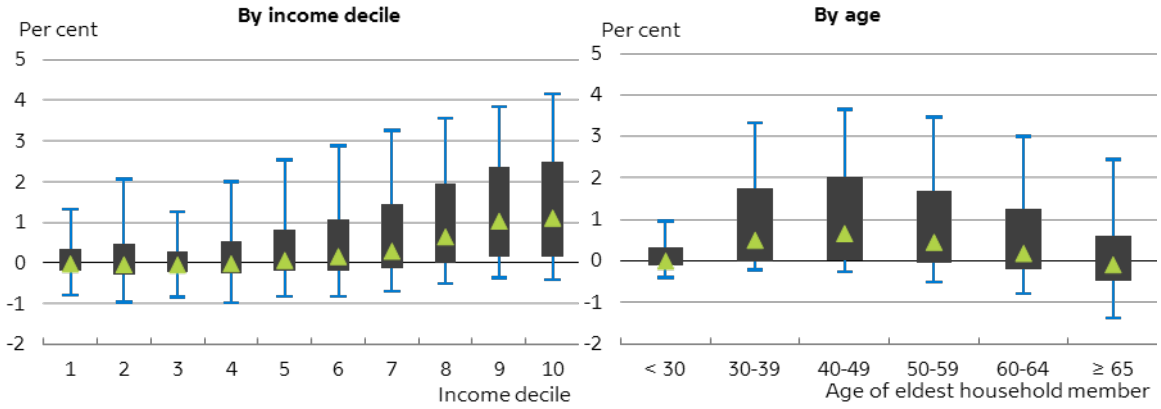


Figure 13: The cash-flow effect of a 1 percentage point increase in interest rates by income decile and age

Note: Graphs show the reduction in disposable income induced by a 1 percentage point increase in interest rates on loans and deposits as a ratio of household consumption. Blue lines indicate 9th and 1st decile, black boxes indicate 3rd and 1st quartile and green triangles indicate the median.

considering the effect of the rate rise only on households with debt, the sensitivity increases to 50 basis points (including interest income effects) or 74 basis points (excluding interest income effects; see table 5). The mean reduction for all households is 78 basis points factoring in bank deposits, and it increases to 123 basis points for the households with outstanding debt. Similarly, when the effect of bank deposits is excluded, the effect is a lot stronger: 117 basis points for all households, and 155 basis points among households with debt.

The sensitivity of consumption to interest-rate rises increases considerably for groups at-risk. The simulation results presented in figures 13 and 14 (which include the interest income channel and are therefore lower bound estimates for the impact on consumption) suggest that the interest rate sensitivity of consumption is modest for most households, but non-negligible for some. The sensitivity of consumption with respect to interest rates generally increases with income, which is due to higher income households having higher leverage in general. The dispersion of the

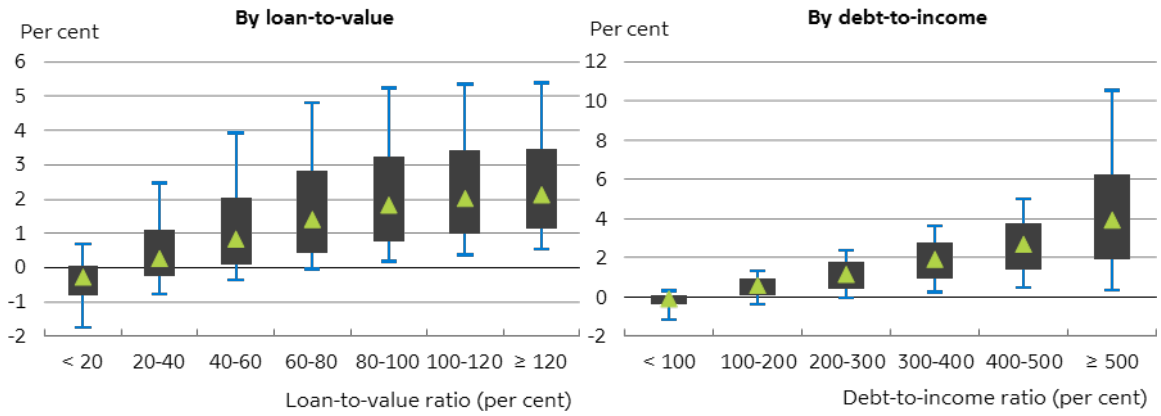


Figure 14: The cash-flow effect of a 1 percentage point increase in interest rates by loan-to-value and debt-to-income

Note: Graphs show the reduction in disposable income induced by a 1 percentage point increase in interest rates on loans and deposits as a ratio of household consumption. Blue lines indicate 9th and 1st decile, black boxes indicate 3rd and 1st quartile and green triangles indicate the median. For the purposes of calculation of loan-to-value, all debt, also debt which is not secured by real estate, is included in the nominator; whereas only the value of real estate is included in the denominator. Only homeowners are included in the left graph.

sensitivity to increasing rates is also larger for higher-income households. Also, households with their eldest family member in prime working ages (30-59) have relatively higher sensitivity to consumption from a rise in interest rates, as expected, but, older households (greater than 65 years old by age of eldest household member) appear to have low sensitivity to rising rates, given their smaller debt loads and higher savings.

Higher leverage, as measured by loan-to-value (LTV), or the outstanding debt in relation to the value of the property, increases the sensitivity of consumption with respect to rates, with the median sensitivity greater than 100 basis points for households with LTV above 60 per cent. Similarly, the median consumption decline for households with debt-to-income (DTI) above 200 per cent is over 100 basis points, with the highly-indebted households (DTI greater than 500 per cent) being very vulnerable to interest-rate increases.

7 Concluding remarks

This paper analyzes savings and consumption decisions over different parts of the business cycle; before and during the financial crisis as well as in the more recent period characterized by negative policy rates. We find that during the most recent years, households with high gross debt have increased savings, while 'savers' with positive financial wealth have increased their consumption ratios to pre-crisis levels. These results indicate that consolidation among households with high gross debt still played a significant role for the economy-wide consumption ratio 7-8 years after the onset of the financial crisis. Households with large leverage have to a substantial extent utilized the low interest rates to increase debt repayment or savings in other forms. The reasons for this consolidation may include a more realistic risk assessment

compared to that of the pre-crisis period, as well as lower perceived permanent income or a larger uncertainty around the permanent income level. In a counterfactual exercise, we find that changes in distributions (e.g. of income and wealth) as well as in demographic characteristics did not play a significant role for the consumption development over the decade which our data spans.

Furthermore, we estimate the MPC out of changes in housing wealth using the panel dimension of data. We estimate an MPC out of positive shocks to housing wealth at around 4-6 per cent, except during the crisis years 2008-10 where it was lower, at around 2 per cent. Further, we find that the MPC out of housing wealth is asymmetric. Households that experienced a negative housing wealth shock reacted more strongly in terms of adjusting their consumption than did households that experienced a positive housing wealth shock. The difference is present throughout the sample period, but it has been stronger in the years with negative policy rates. In addition, the MPC out of housing wealth is higher for households with debt and younger households. The stronger consumption response to increasing housing wealth by more indebted households may indicate the presence of collateral constraints, whereas the stronger consumption response to decreasing housing wealth by more indebted households may indicate deleveraging.

Overall, our results indicate that the low level of interest rates in more recent years may have countered an even larger drop in private consumption than what has actually been observed. The MPC out of a positive housing wealth shock was around 6 per cent in 2013-14, which was similar to or somewhat higher than in the years leading up to the financial crisis. In the coming years, therefore, the current strong house price growth may contribute towards a normalization of consumption ratios.

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Appendix: Robustness

The most uncertain part of the imputed consumption measure is savings. As noted in section 3, savings are approximated by changes in assets and liabilities, and while we do as much as possible to improve the imputation, the imputed savings is still a noisy measure of actual savings. One known issue, which we can do something about for a part of the estimation period, is related to debt. While changes in outstanding bank debt is a good measure of repayments, the same is not true for mortgage debt.

The issue is, that all we observe is the market value of mortgage debt at the end of each year. All loans from mortgage banks in Denmark are financed by the issuance of bonds, and loans are issued with an option to pay back the loan by purchasing bonds equivalent to the notional loan amount. Borrowers with fixed-rate loans in addition have the option to purchase bonds at par in order to repay their loan. The problem of only observing the market value of mortgage debt is, that in periods with falling interest rates, the market value of outstanding debt is increasing. Thereby, we would underestimate savings and overestimate consumption for households which do not refinance their loans in a given year. The size of this effect is increasing in the stock of mortgage debt.

From 2009 and onwards, we have information from the mortgage banks, which we can utilize to improve the measure of savings and thereby consumption. We use the detailed information on mortgage loan characteristics to separate repayments from revaluations by computing the repayment profile of each loan. The annual repayments from this calculation are then used in the measure of savings in stead of the change in the market value of outstanding debt. This is likely to increase the quality of the consumption measure but since we only have the information on mortgage loans from 2009 and onwards, we cannot use this better measure to compare the situation before, during and after the crisis. Therefore, we only use the improved measure as a robustness check.

All results from the models presented in section 5, which we are able to recalculate using the improved consumption measure, carry through qualitatively. Table 6 presents the most important of these robustness calculations.

Table 6: Selected robustness results

Dep. var. in				
Level or difference	Level	Level	Difference	Difference
Year	2011-12	2013-15	2012-15	2012-15
$\frac{1}{Y_{it}}$	0.054***	0.039***	-0.007***	-0.010***
	(0.000)	(0.000)	(0.000)	(0.000)
$\frac{NW_{it}}{Y_{it}}$	0.001***	0.003***	0.001***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
B_{it}	0.054***	-0.017***		-0.031***
	(0.001)	(0.000)		(0.000)
LTI 1-2				-0.013***
				(0.001)
LTI 2-3				-0.016***
				(0.001)
LTI 3-4				-0.026***
				(0.001)
LTI 4-5				-0.035***
				(0.001)
LTI 5-6				-0.042***
				(0.001)
LTI > 6				-0.041***
				(0.001)
Sample	All	All	All	Borrowers
Observations	1,965,051	2,876,161	851,945	1,351,238
R-squared	0.058	0.062	0.011	0.011

Note: Dependent variable is either level of consumption ratio, or change in consumption ratio over the period specified. Standard errors in parentheses. Coefficient estimates and standard errors for $\frac{1}{Y_{it}}$ have been scaled by average disposable income. *** p<0.01, ** p<0.05, * p<0.1. Control variables include indicators of age, education, number of children, age of children, number of years lived at current address, municipality and year.