

Financial Innovation, House Prices and Consumption

Claes Bäckman and Natalia Khorunzhina*

June 26, 2017

Abstract

We use detailed household-level data and mortgage market reform in Denmark to show how an increasing share of interest-only mortgages can create a strong link between house prices and consumption. Consumption expenditure and house price growth are uncorrelated prior to the introduction of interest-only mortgages in 2003. As interest-only mortgages grows towards half of outstanding mortgages, house price, consumption expenditure and home equity borrowing expand rapidly in areas where these new products were more popular. Our results are consistent with financial innovation causing both house prices and consumption to increase.

*Bäckman: Department of Economics and Knut Wiksell Center for Financial Studies, Lund University, Tycho Brahes väg 1, 223 63 Lund, Sweden. Email: claes.backman@nek.lu.se. Khorunzhina: Copenhagen Business School, Department of Economics. Porceløshaven 16a, 2000 Frederiksberg, Denmark. Email: nk.eco@cbs.dk. We would like to thank Marcus Asplund, João Cocco, Fane Groes, Ralf Wilkes, and Søren Leth-Petersen for helpful comments.

1 Introduction

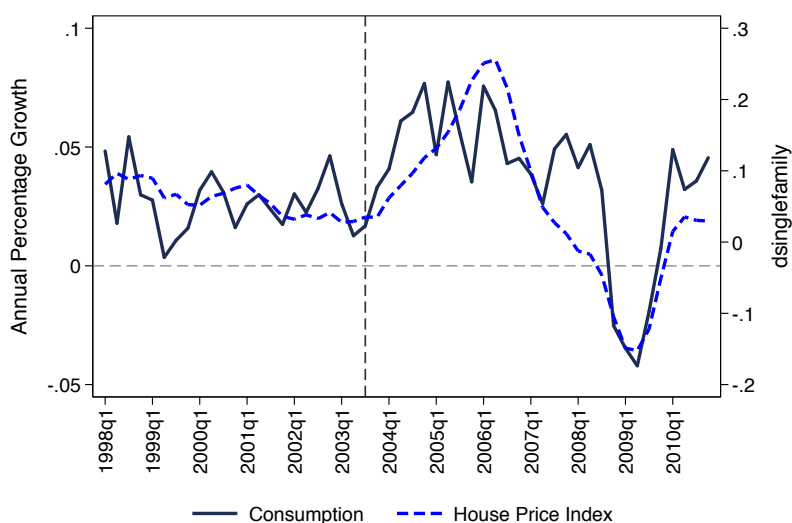
An expanding empirical and theoretical literature maintains that house price growth is correlated with growth in household consumption ([Mian and Sufi, 2011](#); [Mian et al., 2013](#); [Kaplan et al., 2015](#)). While several studies conclude that house price changes strongly affected household consumption during the Great Recession, this period is also characterized by a growing popularity of mortgage products that were primarily designed to allow the borrower to reduce savings by removing amortization requirements ([Cocco, 2013](#)). These new mortgage products, broadly defined as *alternative mortgage products*, are especially valuable for households that cannot smooth consumption fully due to liquidity constraints.¹

Even though alternative mortgage products were a defining feature of the housing boom, accounting for up to 61 percent of all outstanding mortgage contracts in certain areas in the United States ([Barlevy and Fisher, 2012](#)), their effect on consumption dynamics has not yet been studied as extensively. In this paper, we provide evidence that strongly suggests that an increasing share of interest-only loans can affect both house prices and consumption expenditure simultaneously. We use the introduction of interest-only mortgages in Denmark in 2003 to show that house price growth was uncorrelated to consumption growth prior to their introduction, but that the two economic series became strongly correlated after interest-only mortgages were introduced. [Figure 1](#) documents that house prices and consumption expenditure grew rapidly (top panel) as interest-only mortgages went from zero to 40 percent of outstanding mortgages (bottom panel) between late 2003 and 2007.

How can interest-only mortgages affect the interpretation of the correlation between house prices and consumption? Amortization payments are calculated as a fraction of outstanding mortgage debt, implying that the value of an interest-only mortgage is directly related to the level of mortgage debt. Following the mortgage reform in Denmark,

¹[Gorea and Midrigan \(2017\)](#) find that 75 percent of US homeowners are liquidity constrained, whereas [Kaplan et al. \(2014\)](#) find that between 20 and 40 percent of households in the United States are hand-to-mouth, of which two thirds are homeowners.

House Prices and Consumption



Outstanding Mortgage Debt

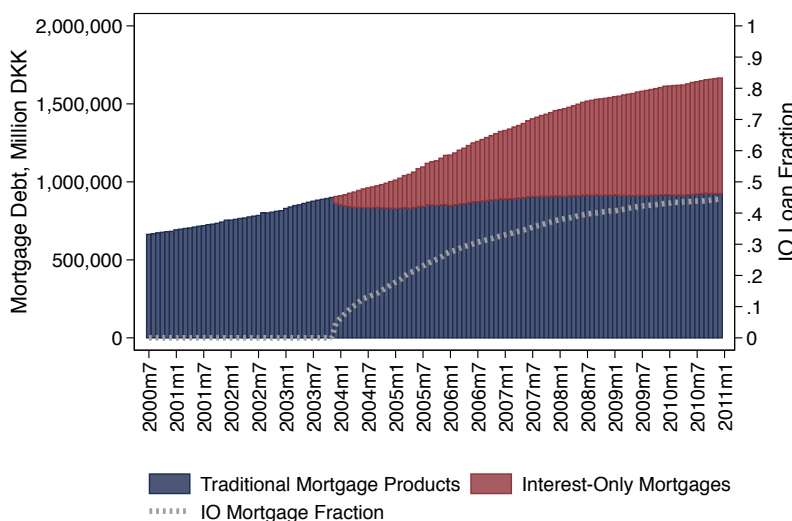


Figure 1: House Prices, Consumption and Mortgage Debt in Denmark

Notes: The top figure plots the year-over-year growth rate in total consumption from Eurostat along with the year-over-year growth rate in house prices from Denmark Statistics. The bottom figure plots outstanding mortgage debt in DKK divided into traditional amortizing mortgages and interest-only mortgages, from Nationalbanken. The grey line plots the fraction of all outstanding interest-only mortgages.

Sources: Eurostat, Denmark Statistics, Nationalbanken,

house prices increased dramatically in areas characterized by high levels of mortgage debt, constrained housing supply and generally high house price levels.² This pattern is reminiscent of house price developments in the United States, where Saiz (2010) shows

²See Bäckman and Lutz (2016).

that house price growth was higher in areas with constrained housing supply and higher price levels.

Moreover, the increase in consumption expenditure is likely higher in these same areas for two reasons. First, the fraction of households with an interest-only mortgage is higher in areas that experienced higher house price growth (the extensive margin). Second, the potential increase in consumption expenditure from choosing an interest-only mortgage is larger in areas that experienced high house price growth because the initial mortgage balance was higher in these areas (intensive margin). To see this, take two otherwise identical households that differ in their level of mortgage debt. If both switch to an interest-only mortgage, the reduction in amortization payments will be higher for the households with higher initial level of mortgage debt, as amortization payments are a percentage of initial mortgage debt. Because of the intensive and extensive margin of interest-only mortgage use, consumption expenditure will increase more in high growth areas, creating a correlation between house price and growth in consumption expenditure.

In the empirical exercise we focus on existing home-owners who do not purchase more housing. We use detailed household-level data on the full Danish population to show that house prices are uncorrelated with consumption expenditure prior to the introduction of interest-only mortgages, but that there is a strong correlation in the years when the usage of interest-only mortgages goes from zero to approximately fifty percent of the mortgage market share. The finding that house prices are uncorrelated with consumption expenditure before 2003 and after 2005 is robust for various subgroups of the population, most notably liquidity and borrowing constrained households, and equally applies to home equity borrowing. We control for household-level income changes and year-specific regional shocks, which moderate concerns that income expectations are the driving factor behind the relation between house prices and consumption expenditure. More specifically, we find that the elasticity of consumption expenditure with respect to house prices is 0.21 in the period from 2003 to 2005, but that the elasticity is close to zero for the periods prior to and after this period. While we do not have individual data on the types of mortgage

contract, house price growth and consumption expenditure growth are larger in areas with a higher fractions of interest-only mortgages as of 2011. A conservative assumption that amortization payments on average are 2 percent of mortgage value suggests that amortization payments were approximately 3,500 DKK higher in high growth areas in 2003-2005. Our estimates suggest that consumption expenditure increased by 5,000 DKK (\$775) per year in high house price growth areas during 2003-2005. Combining this finding with the higher prevalence of interest-only mortgages in high house price growth areas, we can conclude that most of the increase in consumption normally attributed to house price growth can be explained by the expansion of interest-only mortgages. We control for household-level income changes and year-specific regional shocks, which moderate concerns that income expectations are the driving factor behind the relation between house prices and consumption expenditure.

There are two reasons why interest-only mortgages can cause an increase in consumption expenditure. First, switching to an interest-only mortgages allows for a one-time increase towards a higher consumption levels through reduced savings. Second, because interest-only mortgages reduce the disutility of debt, a household may optimally choose to increase their debt levels by borrowing against home equity when interest-only mortgages become available. We separate the effect of reducing savings from increasing borrowing by removing any household that extracts equity from the sample and evaluating the results for those who do not borrow against their home equity. We find a somewhat reduced elasticity of 0.14 in 2003-2005, but no effect in any other year. Moreover, we find that borrowing against home equity is uncorrelated with house price growth prior to the introduction of interest-only mortgages in 2003. Following the reform, households in high house-price-growth areas aggressively liquefied their home equity, borrowing substantial amounts of mortgage debt (see also [Mian and Sufi, 2011](#)). Areas with a higher fraction of equity extraction also had a higher interest-only mortgage penetration, again suggesting that interest-only mortgages can influence the choice to extract equity.³ Com-

³An alternative explanation is that households took advantage of available home equity when they chose to refinance to a new mortgage product.

pared to households who do not refinance, households who refinance do not face higher subsequent growth in income and do not have a lower economically significant chance of becoming unemployed, suggesting that income expectations is not the main driver behind the decision to extract equity.

We do not find that extracted funds on average are used to reduce other types of debt, invest in other assets or to fund consumption expenditure for more than one year. We show that while there is a large increase in consumption expenditure in the year that the household decides to borrow against home equity, consumption expenditures returns to the previous level soon in subsequent years (see also [Andersen et al., 2016](#)). We observe this pattern in all years for households who extract equity. One interpretation of this pattern is that equity extraction is used for durable consumption expenditure or to cover a large one-time expense.⁴

It is important to note that it is not the availability of alternative mortgage products that create the boom in consumption, but rather their increasing share of outstanding mortgage debt. Our results indicate that a large number of households switching to an interest-only mortgages can have a substantial impact on consumption expenditure. In other words, interest-only mortgages do not represent a common factor affecting both consumption and house prices in countries where their share is constant, but they do represent a common factor if the share increases. In the United States, for example, interest-only mortgages became increasingly prevalent over the course of the housing boom ([Barlevy and Fisher, 2012](#); [Brueckner et al., 2016](#)), which suggests that the increasing share of alternative mortgage products at least partly explain the rise in consumption expenditure during this period.

Finally, the Danish institutional framework for mortgage financing helps us to rule

⁴Two alternative explanations are possible. The first explanation is that a shift in credit supply allowed for access to credit for certain households in the year when they refinance, but these households likely were not able to access credit in the years after. This can lead to an increase and subsequent decrease in consumption expenditure. The second explanation is that the households who extracted equity had optimistic income expectations and increased their consumption, but became less optimistic in the years after they extracted equity. Both of these explanations are difficult to reconcile with the fact that we observe the effect throughout our sample period.

out several confounding factors. Importantly, throughout the housing boom and bust lending standards remained constant. [Bäckman and Lutz \(2016\)](#) conduct an analysis of credit supply shifts in Denmark during this time period, and find no support for lowered lending standards or shifts towards riskier borrowing. Danish mortgage banks are legally required to evaluate the income and house value for each borrower to assess whether the borrower can repay a standard 30-year fixed rate mortgage product even in the face of increasing interest rates. Mortgage banks have a strong incentive to comply with this requirement as they are legally required to retain all credit risks associated with the lending [Campbell \(2013\)](#). The specific requirements faced by the borrowers did not change over our sample period, and households were limited to an 80 percent loan to value ratio. Additionally, borrowers have a strong incentive to conform to these limits and not overextend themselves. All debt in Denmark is full recourse, and the mortgage banks can both repossess the collateral and garnish wages until the outstanding debt is repaid in the case of a household default. This implies that household debt is considerably riskier for borrowers in Denmark than in the United States, with corresponding incentive effects not to speculate on rising prices.

The next section provides a conceptual framework for how house prices, consumption and interest-only mortgages are related. [Section 3](#) gives an overview of the Danish mortgage market and the introduction of interest-only mortgages. [Section 4](#) describes the data, the sample selection and the empirical strategy. [Section 5](#) presents the results, discusses the impact that interest-only mortgages have on consumption and house prices, and examines the relative importance of reductions in savings and increases in home equity borrowing. [Section 6](#) provides evidence on alternative channels. [Section 7](#) concludes.

2 Conceptual Framework

The previous literature has focused on two causal and one non-causal explanations for the correlation between house prices and consumption expenditure. The causal channels are commonly denoted as the *wealth effect* and the *collateral effect*. [Bostic et al. \(2009\)](#) surveys the literature on housing wealth effect and reports that the elasticities of consumption with respect to house prices range from around 0.03 to 0.20, an effect that includes both the collateral and wealth channel. The estimated elasticity is often higher than what a standard life-cycle model would predict ([Campbell and Cocco, 2007](#)), and is typically higher than the estimated wealth effect from stock market gains. The non-causal explanation is related to common factors that simultaneously influence both house prices and consumption expenditure, for example income expectations or in our case, the introduction of interest-only mortgages.

The wealth effect implies that households adjust their consumption when the expected life-time wealth changes. Within a life-cycle framework an increase in house prices increases life-time wealth, and in the absence of credit constraints and substitution effects, households smooth the increase in wealth over their remaining life-cycle.⁵ The literature often suggests that the aggregate housing wealth effect is limited ([Campbell and Cocco, 2007](#); [Berger et al., 2015](#)), because the positive effect for certain households is offset by a negative effect for others. Similarly, [Sinai and Souleles \(2005\)](#) show that the implicit cost of consuming housing services rises at the same rate as house prices, which eliminates any wealth effect. The collateral channel implies that housing can be used as a collateral for borrowing. Under rising house prices, previously credit constrained households can increase borrowing to smooth their consumption over time.⁶

A common factor is an unobserved variable that causes both house prices and consumption to increase, for example, rising income expectations through productivity shocks.

⁵Studies supporting the wealth hypothesis include [Case et al. \(2005\)](#), [Aron et al. \(2006\)](#), [Campbell and Cocco \(2007\)](#), [Bostic et al. \(2009\)](#), [Disney et al. \(2010\)](#), [Gan \(2010\)](#), [Carroll et al. \(2011\)](#) and [Paiella and Pistaferri \(2014\)](#).

⁶Studies supporting the collateral channel include [Leth-Petersen \(2010\)](#), [Cooper \(2013\)](#), [Mian and Sufi \(2011, 2014\)](#), [Mian et al. \(2013\)](#), and [DeFusco \(2015\)](#).

Expectations about higher productivity in the future increase consumption today via the mechanism of consumption smoothing over time, an argument that similarly applies to housing. Productivity shocks may increase consumption either through a reduction in savings or through an increase in borrowing. Studies that emphasize the role of a common factor include [King \(1990\)](#), [Pagano \(1990\)](#) and [Attanasio et al. \(2009\)](#).

Interest-Only Mortgages As a Common Factor

If interest-only mortgages are valuable to both home buyers and current homeowners, the introduction of interest-only mortgages can have a simultaneous effect on house price growth and consumption expenditure (a non-causal common factor). Interest-only mortgages are valuable for homeowners with mortgage debt for several reasons. First, as amortization payments limit diversification and come with a low expected return, an interest-only mortgage may increase household utility by allowing for shifting savings towards other types of investment, such as stocks or bonds. Second, an interest-only mortgage is attractive for tax reasons, as it can be used to maintain higher debt levels with higher mortgage interest deductions. Third, with an interest-only mortgage the household can pay down higher interest debt instead of the lower interest secured mortgage debt. Fourth, and most importantly, an interest-only mortgage allows credit constrained households to better align current consumption with permanent income ([Cocco, 2013](#)) in the spirit of the permanent income hypothesis of [Friedman \(1957\)](#). With traditional mortgage products, the household trades off the benefit from having mortgage debt and the cost in utility from not fully smoothing consumption (a similar logic is presented in [Kaplan et al., 2014](#)). This is especially relevant for households with high expected future income, for whom forced savings represent a larger utility loss ([Cocco, 2013](#); [Piskorski and Tchisty, 2010](#)). As these households are liquidity constrained, interest-only mortgages are valuable as a means to relieve binding liquidity or savings constraints (this is especially relevant for households who have a high marginal utility of consumption today, or households with higher income growth in the future, see [Piskorski and Tchisty, 2010](#)).

Additionally, interest-only mortgage may raise the level of debt that a household chose to hold for the reasons described above.⁷ Removing amortization requirement lowers the disutility of debt for the reasons mentioned above, and as a result, households may choose to hold higher levels of mortgage debt.

The potential benefit from choosing an interest-only mortgage is directly related to how large amortization payments are, which in turn is related to household mortgage debt. An interest-only mortgage is more valuable for a household where amortization payments are 20 percent of income than for a household where amortization payments are 2 percent of income. Indeed, the benefit is related to how constraining amortization payments are, and whether the household is consuming and saving optimally, or if they are constrained in their choices.

The fraction of households who face such binding constraints is likely not trivial. [Gorea and Midrigan \(2017\)](#) find that 75 percent of US homeowners are liquidity constrained. The authors also point out that an interest-only mortgage can alleviate liquidity constraints. [Kaplan et al. \(2014\)](#) and [Kaplan and Violante \(2014\)](#) argue that a large fraction of homeowners act as hand-to-mouth households and hold low levels of liquid assets. These households are not smoothing consumption fully across periods, and would like to consume more in the current period. By choosing an interest-only mortgage, hand-to-mouth households can achieve a higher consumption level and move closer to full consumption smoothing. This one-time adjustment in consumption implies that the growth rate in consumption will be high for one period.

The benefit of choosing an interest-only mortgages varies by household. Households with higher mortgage debt with consequently larger amortization payments benefit more from choosing an interest-only mortgage. Households with a larger consumption smoothing incentive would benefit more from reducing their savings and moving closer to full

⁷Alternatively, households may misunderstand the cost of choosing an IO mortgage. While the total cost for the loan over 30 years is higher with an IO loan because of lower principal repayments in the beginning, the first year expenditure on mortgage payments is lower because of reduced amortization payments. However, Danish households report being well informed about the consequences of choosing an IO mortgage, both in terms of the higher cost and the higher risk ([Association of Danish Mortgage Credit Banks, 2011](#)).

consumption smoothing. More importantly, the potential benefit varies geographically. Areas where price levels are high require households to borrow larger amounts to purchase a property, implying that mortgage debt and amortization payments would be larger on average and that interest-only mortgages are more valuable in these areas. This reasoning applies to households who purchase a property, for whom the utility cost of debt has been reduced, and to current homeowners, who can choose to increase their consumption through reduced amortization payments. For property buyers, the reduced disutility of having to amortize should translate into a higher willingness to pay for housing, which should increase house prices. Once interest-only mortgages are introduced, the increase in house price should be proportional to the increase in utility from choosing an interest-only mortgage, i.e. in areas where house price levels and mortgage debt is high.

For current home-owners who do not purchase housing, refinancing to an interest-only mortgages allow for an increase in consumption. By the reasoning above, the expectation is that more household in areas with high house price levels will choose to refinance to an interest-only mortgage (the extensive margin), as it is more likely that amortization payments are constraining in these areas. Furthermore, the potential increase in consumption is larger in these areas, as initial mortgage debt is higher on average (the intensive margin). Both the intensive and extensive margin thus suggests that interest-only mortgages will have a larger effect on consumption in areas where house price levels and mortgage debt is higher. Since these are also the areas where house price growth will expand following the reform, both consumption expenditure and house price growth will be increase in the same locations because of interest-only mortgages, creating a common factor that affects both house price growth and consumption expenditure growth.

3 Mortgage Market Design

The Danish mortgage market consists of seven mortgage credit banks that provide mortgage loans to households and sell bonds to investors using the payments from the mortgage

loans.⁸ The mortgage system operates according to a “matched funding” principle, where each mortgage loan is matched by a mortgage bond sold to investors. There is no government intervention in the mortgage market, neither through direct ownership of mortgage debt nor through government insurance of mortgage debt. Moreover, financial innovation and new mortgage products are limited by institutional design. Changes to the mortgage market are approved by the Danish parliament, and mortgage banks themselves are restrained from implementing new products without regulatory and parliamentary approval.

Historically the predominant mortgage contract in Denmark has been the 30 year fixed rate mortgage contract, which made up over 90 percent of outstanding mortgages in the early 2000s. Variable-rate mortgage was introduced in 1997, and has become increasingly popular. Similar to the United States, there is no pre-payment penalty, and borrowers can refinance freely without compensating the lender for lost income. There is no requirement on positive equity while refinancing to a lower interest rate. In other words, there is no lock-in effect of housing equity for mortgage rates. Borrowers are allowed to borrow up to 80 percent of their house value, and are evaluated on their ability to afford a standard 30-year fixed rate mortgage regardless of the mortgage contract they choose. This requirement was enforced throughout our sample period for all types of mortgages ([Ministry of Economic and Business Affairs, 2007](#)). The interest rate on mortgages is decided by investors in mortgage bonds, not by the mortgage bank itself. The cost for refinancing is approximately 10,000 DKK (\$1,500) ([Andersen et al., 2015](#)). Households can also refinance to extract home equity up to the maximum loan-to-value limit of 80 percent. Danish mortgage debt is full recourse, and in the case of a borrower default a mortgage bank can enact a forced sale of the collateralized property. If the proceeds from the sale are insufficient to cover the outstanding debt, the mortgage bank can garnish the incomes of the borrower until the debt is repaid.

Mortgage credit banks originate mortgage loans to households and issue mortgage-

⁸A more comprehensive overview can be found in [Association of Danish Mortgage Credit Banks \(2009\)](#), [Danske Bank Markets \(2013\)](#) and [Campbell \(2013, p. 28\)](#).

backed bonds to investors. Mortgage banks receive fees from borrowers but do not receive interest income or mortgage repayments, which instead accrue to the bond investor. To limit moral hazard all mortgage credit banks are legally required to retain all credit risk on their balance sheets. If a borrower defaults, the mortgage bank who issued the bond has to replace the defaulting mortgage with a bond with equivalent interest rate and maturity. Investors therefore bear all refinancing and interest-rate risks, but face no credit risk. This system operates without government intervention or direct guarantees.

Mortgage banks are legally limited in the type of mortgage products that they are allowed to offer, and new mortgages have to be approved by the parliament. Interest-only mortgage was introduced in October 2003. The reform was implemented following a political process that aimed towards helping households who were temporarily cash-constrained, such as families on maternity/paternity leave.

Although commonly referred to as interest-only mortgages, these loans are more correctly called deferred amortization mortgages. The structure of the mortgage allows a borrower to postpone amortization payments for up to ten years, but the loan has to be repaid within maximum of 30 years. While there is an initial period where total payments (interest and amortization) are lower than a standard 30-year mortgage loan, the total interest payments over the full loan span will be higher.

4 Data, Methodology and Empirical Framework

In the first part of this section, we present the data used in the empirical estimation and describe the construction of consumption expenditure and other variables. In the second part, we discuss the empirical strategy.

4.1 Data

We construct a dataset containing consumption expenditure, income, financial wealth, homeownership, leverage, house prices, and demographic characteristics for all homeown-

ers in Denmark from 1996 to 2010. We collect individual data on income, financial assets and liabilities through the Danish Tax and Customs Administration (SKAT). Detailed demographic data is provided by population records. Individual information is aggregated to the household level using a family identification number.

We use property transaction records collected from the Danish Official Gazette (Statstidende) to keep track of homeowners and their housing assets, and to construct a municipality-level house price index. We have access to the information about homeownership for all households in Denmark. Further, we observe all housing transactions, and we can therefore pinpoint households who passively benefit from house price changes, i.e. those who do not make an active decision to transact in the housing market.

Consumption Expenditure

We follow a procedure of [Browning and Leth-Petersen \(2003\)](#) in constructing consumption expenditure on the level of households. [Browning and Leth-Petersen \(2003\)](#) construct total consumption expenditure as disposable income minus the change in net wealth. This method of imputing consumption is frequently adopted for administrative data ([Leth-Petersen, 2010](#); [Browning et al., 2013](#); [Koijen et al., 2015](#); [Andersen et al., 2016](#)), and for survey data ([Ziliak, 1998](#); [Cooper, 2013](#); [Khorunzhina, 2013](#)).

To construct the measure of consumption expenditure, we collect information on disposable income, financial assets and liabilities. Disposable income is a sum of income after taxes, interest payments, rental value of owned properties, alimony payments and repaid social benefits. Financial assets consist of individual holdings of stocks, bonds and bank deposits. Liabilities include separate categories for bank debt and mortgage debt. All values are deflated to a base of 2006 using the consumer price index from Statistics Denmark.

The main concern with imputed consumption is that only active savings should be considered, and that changes in observed asset values that derive from capital gains (passive savings) should be excluded. We can control for passive and active savings in

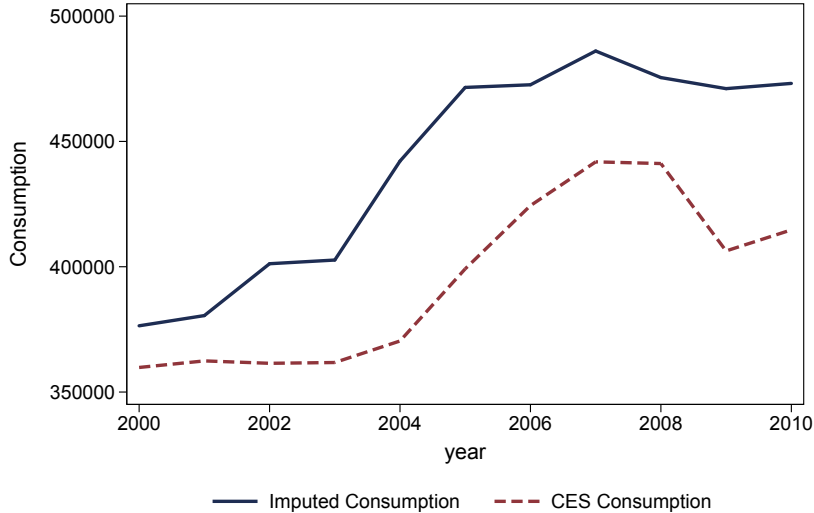


Figure 2: Imputed and Survey Consumption

Notes: Solid line is data from the Danish Expenditure Survey for total consumption of two adult households with children. Dashed line is imputed consumption from the registry data. All values deflated to a base of 2006 using the consumer price index.

housing assets, as we observe all property transactions and any observed change in the value of housing assets for those who do not buy or sell is due to capital gains. We therefore remove all households who are buying or selling in the housing market, and exclude changes in housing wealth from the imputation. We also remove households who buy or sell housing in $t - 1$ because their consumption decisions may be different in the year before the purchase.

It is important to account for portfolio returns when imputing consumption expenditures from data on income and net wealth (Kojien et al., 2015). Since we do not observe the exact type of assets in the stock portfolio, we approximate capital gains on stock portfolios with the market portfolio return. Specifically, we multiply the value of stock holdings at the beginning of the year with the over-the-year growth in the Copenhagen Stock Exchange (OMX) C20 index, and calculate active savings as the end-of-year holdings minus stock holdings at the beginning of the year adjusted for the capital-gains.⁹

Figure 2 shows that both imputed and survey-based consumption closely match in levels and growth rates, consistent with the findings in Browning and Leth-Petersen

⁹A robustness check confirms that our results are not unduly impacted by this procedure.

(2003). The average annual total household consumption expenditure over the sample years is 428,000 DKK (\$66,000). This amount is close to the value reported by the Danish Consumer Expenditure Survey for two-person households with children.

Sample Construction

We select all two-adult households between ages 22 and 55 years old (either married or cohabiting) who own housing assets. We remove households where at least one member is an entrepreneur, because income and wealth characteristics are less accurately reported for entrepreneurs. We also remove three small island municipalities as their housing and financial situation is likely different from the rest of Denmark.¹⁰ As explained above, we also remove households who buy or sell housing assets in year t and $t - 1$.

Browning and Leth-Petersen (2003) find that imputed consumption corresponds well to the self-reported consumption on average, but that outlier values can be problematic.¹¹ We remove outliers in consumption expenditure by excluding observations where the growth in imputed consumption expenditure is above the 99th percentile or below the 1st percentile, any observations with negative imputed consumption, and a small number of households who have no housing wealth but who have positive mortgage debt.

The final data sample consists of approximately 4.6 million homeowner-year observations from 1996 to 2010, which amounts to approximately 500,000 households per year. A full sample selection table is available in table 10 in the appendix.

Variable Description

The registry data contains information on demographic characteristics, income, and disaggregated wealth variables for all households. Demographic characteristics on individual level include marital status, number of children, years of education, age, and area of residence. We define household level education as the level achieved by the most educated spouse, and household age as the age of the oldest spouse. We define a household as an

¹⁰The municipalities in question are Christiansø, Bornholm and Ærø.

¹¹Koijen et al. (2015) point to a similar issue for imputed consumption in Swedish administrative data.

owner if his/her registered housing wealth is positive. To measure housing wealth and leverage we use an official property valuation from SKAT, adjusted by a scaling factor to approximate market values.¹²

We construct two variables related to credit constraints. First, we construct a measure of liquidity constraint as liquid assets divided by disposable income. Liquid assets consist of the sum of the market value for bonds, stocks and bank deposits. Second, we construct a measure of borrowing constraint as value of outstanding mortgage debt divided by housing wealth, which we refer to as leverage. For each year, we split the sample of households into decile based on each measure, which we later use to examine heterogeneity in the response to house price changes. We also construct indicators for borrowing-constraints and liquidity-constraints. Specifically, we define a household as borrowing-constrained if mortgage value is more than 50 percent of his/her housing wealth, and we define a household as being liquidity-constrained if the value of his/her liquid assets is lower than 1.5 months of disposable income.

We examine whether household's nominal mortgage balances increased by more than 10 percent year-over-year and interpret this as an indicator that a household likely extracted equity in the given year. [Andersen et al. \(2015\)](#) briefly discuss equity extraction in Danish data, and chose a 10 percent threshold to remove households who withdraw equity.¹³

We construct house price indices on the level of municipalities.¹⁴ After cleaning the

¹²The scaling factor is calculated as the sales price divided by the tax valuation for all sold properties, for each municipality, year and property type (single-family houses and apartments). A similar scaling factor is provided by Denmark Statistics for the years before 2006. For the years after the Danish municipality reform of 2006 we calculate this factor ourselves. We do not find substantial differences between the scaling factor that we calculate and the one provided by Denmark Statistics for the data directly comparable before and after the reform. See [Andersen et al. \(2016\)](#) for a similar calculation of housing wealth.

¹³[Bhutta and Keys \(2016\)](#) chose a 5 percent threshold. We chose a higher threshold because mortgage debt is measured in market values in the data, which fluctuates year-over-year depending on interest rates.

¹⁴Constructing municipality-specific house price indices and geographical controls is complicated by a Danish municipality reform in 2006 that created new municipalities and divided Denmark into five regions based on these new municipalities. To ensure that regions and municipalities are geographically consistent over time, we match households to the new municipalities based on a unique geographical match provided by Denmark Statistics, and assign each municipality to the new region.

transaction data, we use the average square meter price of traded single-family houses and apartments for each municipality as our municipality-level house price index. More details on the house price index can be found in Appendix A.

4.2 Empirical Framework

Our empirical framework consists of regressing the change in consumption at the household level on changes in house prices, while controlling for changes in income, demographics and for changes in the aggregate and local economy:

$$\Delta Consumption_{ikt} = \alpha_0 + \alpha_1(HPgrowth_{kt}) + \alpha_3(\Delta Income_{ikt}) \quad (1)$$

$$+ \alpha_2(r_{ikt}) + \mathbf{X}_{it}\mathbf{\Gamma} + \lambda_{zt} + \lambda_z + \lambda_t + \epsilon_{ikt}, \quad (2)$$

for household i in municipality k and period t . In the above equation $\Delta Consumption_{ikt}$ is the log-difference in total consumption expenditure between period t and $t-1$, $HPgrowth_{kt}$ is the log-difference in house prices between periods $t-1$ and t for municipality k . $\Delta Income_{ikt}$ is the log-difference in disposable income, and r_{ikt} is the inter-temporal interest rate between periods $t-1$ and t . The vector $\mathbf{X}_{it}\mathbf{\Gamma}$ include changes in demographic characteristics between periods $t-1$ and t . We include a set of region (λ_z), year (λ_t), and region-year (λ_{zt}) fixed effects to account for aggregate effects. When we explore heterogeneity in the response to house price changes, for example over liquidity or leverage, we interact all variables with the variable of interest.

The collateral channel suggests that rising house prices enable consumption smoothing for constrained households through borrowing against home equity, whereas the wealth effect implies that households increase their consumption without resorting to borrowing. To disentangle the wealth and collateral effects we exclude households who borrow against their home-equity in the current year, as this is the key element of the collateral channel. We also remove households who extracted equity in the past year, as their consumption

expenditure in the previous year is abnormally high due to the equity extraction.¹⁵

We examine the collateral channel in the following regression framework, where we estimate how the probability of home equity borrowing is affected by rising house prices. We estimate the following equation:

$$EquityExtraction_{ikt} = \alpha_0 + \alpha_1(HPgrowth_{kt}) + \alpha_3(\Delta Income_{ikt}) \quad (3)$$

$$+ \alpha_2(r_{ikt}) + \mathbf{X}_{it}\mathbf{\Gamma} + \lambda_{zt} + \lambda_z + \lambda_t + \epsilon_{ikt}, \quad (4)$$

where the dependent variable, $EquityExtraction_{ikt}$, is a binary variable equal to one if the household chose to extract equity in the current year, and all other variables are as specified above.

This framework is standard in the literature on housing wealth effect, where identification of the wealth effect relies on variation in house price growth across geographical areas. If interest-only mortgage leads to an increase in consumption and house prices simultaneously, the coefficient on house price growth does not represent a causal relationship (Pagano, 1990). Interest-only mortgage increases consumption if the household faces binding savings commitment in the form of amortization payments. Amortization payments are more likely to present a binding savings constraint if mortgage debt is high, which empirically is observed in areas where house prices are high and supply is constrained (Saiz, 2010). Bäckman and Lutz (2016) find that interest-only mortgages are more popular in high house price growth areas and have a larger impact on house prices in areas with higher house price levels and more constrained housing supply. This suggests that both consumption and house prices could be simultaneously affected by an increasing adoption of alternative mortgage products.

Attanasio et al. (2009) argue that changes in house prices and consumption may be driven by a common factor. Common factors may also affect the household's willingness to borrow against home equity. For example, looser credit conditions can induce households

¹⁵Not doing so would bias our estimates down, as consumption expenditure increases around the time of refinancing but declines in the next period as consumption expenditure normalizes.

to borrow larger amounts against their home equity, and can simultaneously raise house prices. Looser credit conditions is not a concern in our study, because, as explained above, lending standards did not change and the maximum loan-to-value ratio remained constant at 80% over the entire sample period. However, shocks to income expectations caused by productivity shocks are still a concern (King, 1990; Pagano, 1990; Muellbauer and Murphy, 1997; Attanasio et al., 2009). We address concerns over income expectations by including an extensive set of interaction variables to control for aggregate factors that may affect households in a given year and region, and household-level income growth and changes in demographic characteristics to proxy for changes in individual-level income expectations. Note that we are including controls for region-year effects, but use house prices on the municipality level. Denmark is not a large country, therefore, the regions are small enough to capture local labor market conditions, but large enough so that there is still variation in house price growth.¹⁶ Year, region and year-region indicators capture changing macro-economic environment on a national and regional levels, as well as lower interest rates and credit conditions by year or region. We also provide supporting evidence that households who extract equity do not experience different labor market outcome from households who do extract equity.

5 Results

This section contains the main results of the paper. We begin by providing some summary statistics detailing how the housing market and consumption expenditure evolved during our time period, and proceed with estimating equation (1) for the full sample of households. We show that the correlation between house prices and consumption expenditure is the strongest between 2003 and 2005, and that the correlation between house price changes and consumption expenditure is lower once we remove households who refinance to extract home equity, but still significant in 2003 to 2005. Further, we find that equity

¹⁶To use an analogy to the United States, we are controlling for MSA-year (city-year) effects and using county-level variation in house price growth.

extraction is related to house price growth, and that it is likely used to finance durable consumption.

5.1 Summary Statistics

The Danish housing market underwent a period of substantial volatility during the 2000s. As we showed previously in figure 1, house price growth started to increase following the introduction of interest-only mortgages in October 2003. House prices increased by 62 percent between 2003Q3 and the peak of the house price boom is in 2007Q3, but plateaued already in 2006Q3, after which growth in house prices is low until house prices start declining in late 2007. Overall, house prices increased by 58 percent in 3 years, stayed at a high level for one year, and declined by 16 percent until finally bottoming out in 2009Q4. This national pattern contains considerable heterogeneity across municipalities, with the largest increases occurring in the areas around Copenhagen and the larger cities. Figure 3 shows the median annual house price growth between 1998 and 2010 along with the distribution across municipalities. The difference between the 25th and 75th percentile in house price growth is especially high during the housing boom, when house price growth was particularly high in areas with constrained housing supply and high price levels.

These are the areas where interest-only mortgages are most valuable for households, as figure 4 shows. The figure plots the percentage growth in house prices between 2003 and 2005 across municipalities (top panel) and the fraction of households in each municipality that had an interest-only mortgage (middle panel) using data from 2011 published in a newspaper article ([Politiken, 2012](#)). House price growth between 2003 and 2005 was high in the areas where interest-only mortgages later were prominent - the correlation is 0.54. As the figure shows, the same areas that experienced large increases in house prices had a larger share of interest-only mortgages in 2011.

Table 1 provides summary statistics based on house price growth during the housing boom. The first four columns divides municipalities into four groups based on growth between 2003 and 2006, when house prices were still rising nationally (in certain munic-

Table 1: Summary Statistics

	Lowest Growth	2	3	Highest Growth	T-test of (4) - (1)
Housing Market Characteristics					
House Price Growth 2003-2006	18.62 (4.37)	28.97 (3.35)	45.19 (5.43)	59.26 (5.10)	40.63*** [6,629.70]
Housing Supply	0.01 (0.00)	0.04 (0.15)	0.07 (0.10)	0.41 (0.38)	0.41*** [1,207.91]
House Price per Square Meter	6,321.57 (857.50)	8,274.11 (1,846.64)	11,070.50 (3,074.23)	14,883.28 (2,933.12)	9,967.12*** [2,197.15]
Household Demographic Characteristics					
Age	42.81 (7.87)	42.99 (7.83)	43.18 (7.72)	43.43 (7.57)	0.43*** [43.62]
Education Length	14.38 (1.97)	14.61 (2.02)	14.92 (2.05)	15.38 (2.13)	1.06*** [397.27]
Total number of people in the household	3.49 (1.09)	3.40 (1.05)	3.39 (1.02)	3.37 (1.00)	-0.09*** [-68.74]
Employment Ratio during the Year	0.97 (0.08)	0.97 (0.08)	0.98 (0.07)	0.98 (0.07)	0.01*** [105.85]
Household Financial Characteristics					
Consumption	367,716 (224,454)	385,341 (275,118)	425,932 (286,646)	459,423 (264,763)	91,707*** [82]
Disposable Income	363,468 (118,116)	378,360 (173,550)	413,228 (161,795)	447,512 (201,578)	84,044*** [114]
Mortgage Debt	732,390 (792,872)	800,659 (685,153)	931,150 (640,345)	1,012,562 (667,708)	280,172*** [83]
Housing Wealth (Adjusted)	1,148,318 (978,923)	1,306,809 (891,990)	1,644,791 (911,814)	1,929,613 (922,224)	781,295*** [177]
Sum of Liquid Assets	117,931 (387,086)	125,072 (391,540)	146,212 (483,993)	177,561 (559,964)	59,630*** [28]
Interest Payments	56,302 (31,629)	61,575 (33,113)	69,304 (38,284)	73,545 (40,334)	17,243*** [105]
Consumption to Disposable Income	1.01 (0.37)	1.02 (0.36)	1.03 (0.36)	1.03 (0.36)	0.02*** [14.72]
Liquid Assets to Disposable Income	0.28 (0.44)	0.29 (0.44)	0.30 (0.45)	0.33 (0.47)	0.05*** [25.74]
Mortgage to Disposable Income	1.90 (1.11)	2.07 (1.13)	2.26 (1.21)	2.32 (1.30)	0.42*** [76.85]
Equity Extraction	0.14 (0.34)	0.16 (0.37)	0.19 (0.39)	0.19 (0.39)	0.05*** [30.23]
Mortgage Rate	0.06 (0.03)	0.06 (0.03)	0.06 (0.03)	0.06 (0.03)	-0.00*** [-17.10]
Liquidity Constrained	0.70 (0.46)	0.69 (0.46)	0.66 (0.47)	0.62 (0.49)	-0.08*** [-36.35]
Borrowing Constrained	0.46 (0.50)	0.42 (0.49)	0.34 (0.47)	0.27 (0.44)	-0.19*** [-87.68]
Observations	105089	111575	95097	88581	193670

Notes: Average values in 2002. Municipalities are divided into quartiles based on house price growth between 2003 and 2006. Housing wealth is the tax value adjusted by the scaling factor. Debt is the sum of mortgage debt, bank debt and the value of mortgage deeds. Liquid assets consists of stocks, bonds and bank deposits. Consumption is defined in section 4. Mortgage rate is calculated as the interest payments in DKK divided by mortgage value. Equity withdrawal, Borrowing Constrained and Liquidity Constrained are defined in section 4.

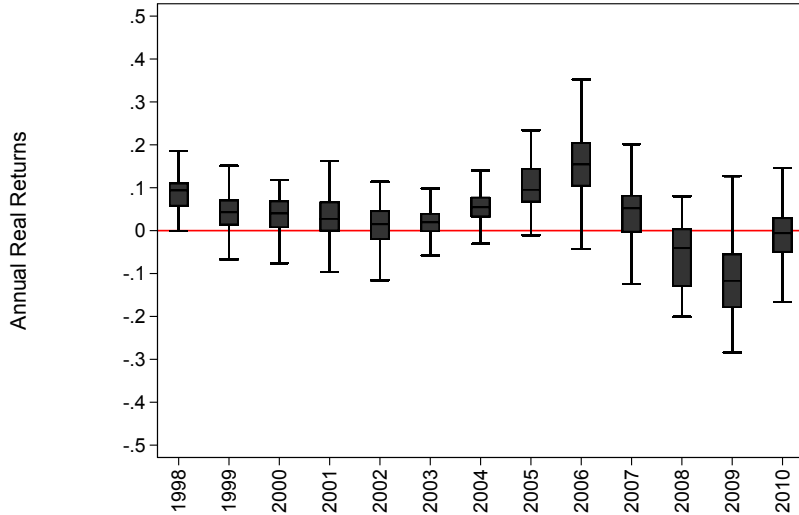


Figure 3: Distribution of House Price Growth Within Each Year

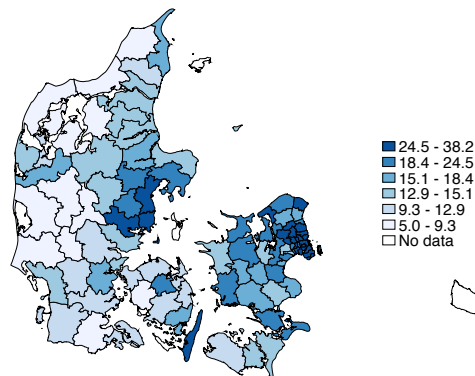
Notes: The figure plots the median, 25th and 75th percentiles of house price growth within each year for 98 municipalities. The black box plots the house price growth for the 25th and 75th percentile respectively, with the median house price marked by a black line within the box. The whiskers indicates the maximum and minimum values excluding outliers, respectively.

ipalities house price growth was negative in 2007). The fifth column tests for differences between the areas with the highest and lowest growth. Municipalities in column 1 (the low growth group) experienced an 18 percent increase in house prices during the boom, whereas municipalities with the highest house price growth experienced a 60 percent increase in prices. Furthermore, the areas with the highest growth have more constrained housing supply, measured as the percentage of the land covered by buildings, and has a substantially higher per square meter prices.

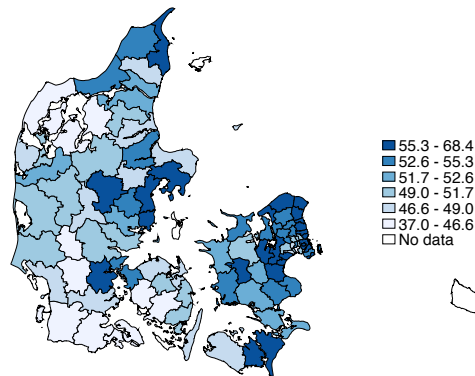
The second part of the table provides summary statistics for households living in each group in 2002, prior to the increase in house prices and prior to the introduction of interest-only mortgages. Households in high growth areas are on average slightly older and have more education compared to households in low growth areas. Furthermore, these households have higher income levels and higher consumption. Importantly, mortgage debt is significantly higher in high growth areas, and interest-only mortgages are subsequently more valuable.

Table 7 in the appendix presents summary statistics for households in different time

House Price Growth, 2003-2005



Interest-Only Mortgage Penetration, 2011



Equity Extraction, 2003-2005

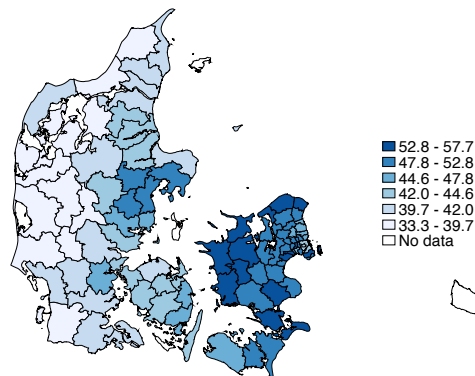


Figure 4: Equity Extraction Share and Interest-Only Mortgage Penetration

Notes: The top figure plots the house price growth from 2003 to 2005 for each municipality in Denmark. The middle figure plots the fraction of households in each municipality who extracted equity at least once between 2003 and 2005. The bottom figure plots the fraction of households with a mortgage in each municipality that holds an interest-only mortgage, using data from Politiken (2012).

periods. Column 1 presents statistics for the full sample, and columns 2-4 split the sample into different time periods. The average consumption expenditure is increasing over time, and closely tracks disposable income. Liquid assets are approximately 170,000 DKK

(\$26,000), but the standard deviation is large. Over 60 percent of the sample hold less than 1.5 months of liquid assets in income and are thereby defined as liquidity constrained. Even so, housing wealth is approximately four times the disposable income, and mortgage debt is approximately two times the disposable income. Many households therefore have considerable wealth that they can access through refinancing. A high fraction of Danish households therefore hold low levels of liquid assets combined with sizeable amounts of housing wealth, meaning that they resemble the wealthy hand-to-mouth households described in [Kaplan et al. \(2014\)](#); [Kaplan and Violante \(2014\)](#). Wealthy hand-to-mouth households trade off the benefit of owning an illiquid asset with having not fully smoothed consumption, which causes a strong marginal propensity to consume out of liquidity. Interest-only mortgage represents an opportunity to reduce savings and increase liquidity, therefore this type of households is expected to refinance to interest-only mortgage to increase consumption.

5.2 The Effect of House Prices on Consumption Expenditure

The first set of regression results is presented in [Table 2](#). The first column estimates the baseline equation for the full sample of households without any controls. All standard errors are clustered on the year-municipality level. The estimated elasticity of consumption with respect to house price growth is 0.147, and is highly significant. When we control for income growth, demographic characteristics and year-region fixed effects, the coefficient is reduced to 0.063.¹⁷

Columns 3-5 provide the results for different time periods, and show that consumption is uncorrelated with house price growth in years before and after the housing boom. [Figure 5](#) shows the year-by-year results from a single regression, with very similar results. The estimate in column 3 for 1998-2002 is 0.040, but it is not statistically different from

¹⁷All results are robust to excluding stock and bond holders, which may contain some measurement error due to imputation of stock holdings, and are robust to only including households who stay in the panel for more than 7 years. The results are also robust to normalizing consumption expenditure by disposable income.

Table 2: Baseline Results

Dependent Variable:	(1)	(2)	(3)	(4)	(5)
$\Delta Consumption_{ikt}$	All Years	All years	1998-2002	2003-2005	2006-2010
$HPgrowth_{kt}$	0.147*** (0.017)	0.063*** (0.015)	0.040 (0.024)	0.213*** (0.038)	0.035 (0.018)
$\Delta Income_{ikt}$		0.326*** (0.005)	0.253*** (0.008)	0.332*** (0.010)	0.385*** (0.006)
Demographic Controls	No	Yes	Yes	Yes	Yes
Region-Year Interactions	No	Yes	Yes	Yes	Yes
Observations	4,964,963	4,964,963	2,021,114	1,132,848	1,811,001

Notes: *, **, *** denote statistical significance at the 5%, 1% and 0.1% level. Standard errors clustered on year-municipality in parentheses. Dependent variable is the change in log consumption, $\Delta Consumption_{ikt}$. ΔHPI_{kt} is the change in log square meter price between $t - 1$ and t for municipality k . Δy_{it} is the change in log disposable income between $t - 1$ and t . Regressions in column 2-5 include controls for age, education level, change in number of children, a household-specific individual return, and with region, year and region-year effects.

zero. During this period house price growth was relatively modest and there were no instances of serious financial innovations. The elasticity is close in magnitude to what is reported in [Browning et al. \(2013\)](#), who estimate an equation similar to (1) for the period from 1987 to 1996. In contrast, the estimated coefficient of 0.213 in column 4 is substantially larger than in column 3 or 5. Column 5 shows that consumption expenditure is uncorrelated with house price changes in years when house prices decline. These results suggest that the correlation between house prices and consumption expenditure is driven by a few years with high house price growth that followed the introduction and increased use of interest-only mortgages. If the adoption of interest-only mortgage results in the increase in both consumption and house prices, the higher coefficients in column 4 represents the increased importance of new mortgage products, not a causal effect of house prices on consumption. As we will show, interest-only mortgages were more popular in areas that experienced larger increases in house prices during the housing boom.

An elasticity of 0.213 corresponds to a marginal propensity to consume (MPC) out of housing of approximately 0.05 (or 5% of the increase in house value), or an annual increase in consumption of 5,719 DKK (\$886).¹⁸ While this is on the lower end of the empirical

¹⁸The marginal propensity to consume is calculated as: $MPC = \text{Elasticity} * \text{Consumption Expenditure} / \text{Housing Wealth}$, using only the sample included in the regression.

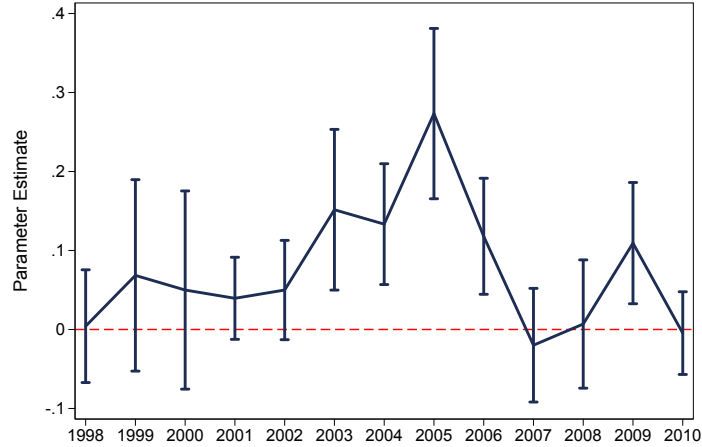


Figure 5: Year-by-Year Estimates

Note: The figure plots the coefficients on $HPgrowth_{kt}$ interacted with year. Dependent variable is the change in log consumption. Regressions are estimated using controls for changes in income, demographic controls for age, education, change in family size, and region fixed effects. Standard errors clustered on municipality-year level.

findings (see [Bostic et al., 2009](#)), [Gan \(2010\)](#) points out that international comparison of MPC is not always easily interpretable. Institutional differences in mortgage and financial markets imply that the consumption-housing value ratio varies widely across countries, making direct comparisons difficult. Nonetheless, the MPC is relatively high compared to other studies that use household-level data ([Disney et al., 2010](#); [Gan, 2010](#); [Browning et al., 2013](#)), but comparable to recent studies of the financial crisis ([Mian and Sufi, 2011](#); [Mian et al., 2013](#); [DeFusco, 2015](#); [Kaplan et al., 2016](#)).

If rising house prices alleviate credit constraints, the estimated effects ought to be larger for households that were constrained. Unfortunately, these are also the households that are most likely to benefit from choosing an interest-only mortgage. A stronger effect for credit constrained households does not imply that these households are reacting to house price changes, but could instead mean that they are choosing an interest-only mortgage to a larger extent. This applies to both liquidity-constrained and borrowing-constrained households. For liquidity constrained households, an interest-only mortgage allows for a better consumption smoothing. For a borrowing constrained household, the larger amount of mortgage debt implies that the value of an interest-only mortgage is higher.

We investigate liquidity and borrowing constraints in Table 9 in the appendix. We divide the population into deciles based on leverage and liquid wealth for each year, and show the coefficient estimates for each group separately. As the table shows, the coefficient on the interaction of house price growth and liquidity indicator is only marginally significant for the households in the tenth decile of liquidity in column 1. For all other households, consumption is uncorrelated with house price growth during this period. In column 2 all groups have positive and significant coefficients on house price growth, but the pattern does not suggest that households with less liquidity respond stronger. The same pattern occurs in column 3 as in column 1. In contrast to the previous literature, we do not find that a low level of liquidity is associated with a larger response to house price changes (see e.g. [Mian and Sufi, 2011, 2014](#), who finds that the housing wealth effect is primarily driven by households with low levels of liquidity). In column 4, the only group that responds strongly to house price growth is the group with the highest leverage. In column 5 households that are more borrowing constrained respond more strongly to house price growth, consistent with either loosening of the binding borrowing constraints or with a higher value of an interest-only mortgage. Households with higher leverage are likely more constrained, but are also more likely to benefit from choosing an interest-only mortgage. Indeed, an increase in consumption from choosing an interest-only mortgage is directly related to how much mortgage debt a household has.

The above results point towards the significance of the boom in house prices that followed the introduction of interest-only mortgages. The stronger results for borrowing constrained households can be interpreted as evidence for binding credit constraints, but may also be due to larger benefits from choosing an interest-only mortgage. It is striking that house prices are uncorrelated with consumption in all other periods, even though house prices grow significantly during these periods as well. As amortization payments are substantial for most households, the shift towards interest-only mortgages can potentially explain a large fraction of the increase in consumption. The estimated elasticity of 0.14 suggest that households increased their consumption by 3,500 DKK per

year because of rising house prices. Given that interest-only mortgages are correlated with house prices and that their use is higher in areas with constrained supply and high debt levels, lower amortization payment could explain the part of the increase in consumption. For households in column 3, the average imputed amortization payments are 18,500 DKK in municipalities in the highest quartile of house price growth and 15,300 in municipalities in the lowest quartile of house price growth. If all households equally chose to refinance to an interest-only mortgage, the increase in consumption would be approximately 3,000 DKK higher in areas with high house price growth. Moreover, since the benefit of choosing an interest-only mortgage is directly related to average mortgage debt and the fraction of constrained households, the fraction of households who chose an interest-only mortgage is higher in areas that experienced larger increases in house prices, as Figure 4 shows. This suggests that interest-only mortgages can explain the large consumption expenditure response that we observe in the period where these loans become prominent.

5.3 Changing Consumption Without Home Equity Withdrawal

The above results include both reductions in savings and increases in borrowing. To separate between borrowing and reductions in savings, we limit our sample to households who do not borrow against home equity. If the correlation between house prices and consumption is driven entirely by borrowing against home equity, as for example [Cooper \(2013\)](#) argues, then the estimated coefficient on house prices will be zero if we remove these households from the sample. We test this hypothesis and find that the estimated elasticity is lower, but that it is still positive and significant during the Danish housing boom, but not for any other period.

Table 3 estimates the same regression as in Table 2, but excludes households who extract equity in the current and subsequent years.¹⁹ The coefficient on house price

¹⁹As we will see later, equity extraction is associated with a one-time increase in consumption. If we only exclude the year of extraction we will remove the increase, but retain the decrease in consumption following the one-time increase.

Table 3: Estimated Effects Without Equity Withdrawal

Dependent Variable:	(1)	(2)	(3)	(4)
$\Delta Consumption_{ikt}$	All Years	1998-2002	2003-2005	2006-2010
$HPgrowth_{kt}$	0.027 (0.014)	0.035 (0.028)	0.145*** (0.030)	-0.008 (0.018)
$\Delta Income_{ikt}$	0.385*** (0.005)	0.322*** (0.010)	0.403*** (0.011)	0.425*** (0.007)
Demographic Controls	Yes	Yes	Yes	Yes
Region-Year Interactions	Yes	Yes	Yes	Yes
Observations	3,651,336	1,202,567	758,423	1,406,828

Notes: *, **, *** denote statistical significance at the 5%, 1% and 0.1% level. Standard errors clustered on year-municipality in parentheses. Sample is limited to households who did not extract equity. Dependent variable is the change in log consumption, $\Delta Consumption_{ikt}$. ΔHPI_{kt} is the change in log square meter price between $t-1$ and t for municipality k . Δy_{it} is the change in log disposable income between $t-1$ and t . All regressions include controls for age, education level, change in number of children, a household-specific individual return, and with region, year and region-year effects.

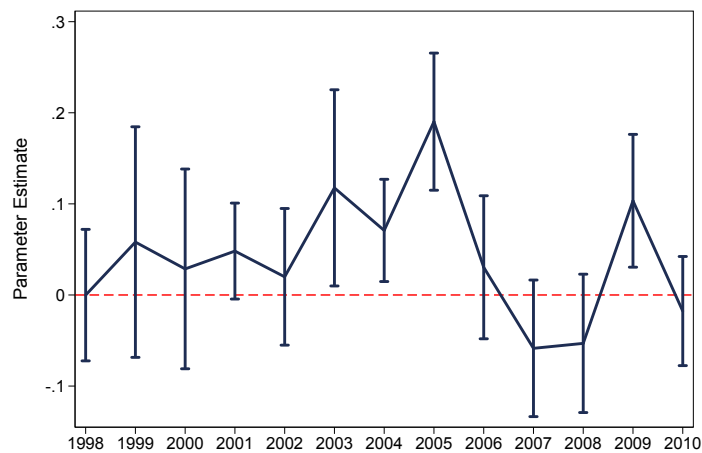


Figure 6: Year-over-Year Effects Without Equity-Withdrawal

Note: The figure plots the coefficients on $HPgrowth_{kt}$ interacted with year where we have excluded households who extracted equity. Regressions are estimated using controls for changes in income, demographic controls for age, education, change in family size, and region fixed effects. Standard errors clustered on municipality-year level.

growth is 0.027 when we use the full sample, and it is not significantly different from zero. However, the elasticity of consumption with respect to house prices are positive in 2003-2005, although its magnitude is reduced by a third. Figure 6 shows this result in a single regression. The estimated elasticity is the largest in 2005, and is the strongest in the years following the introduction of interest-only mortgages in 2003.

Table 4: Equity Extraction and House Price Growth

Dependent Variable:	(1)	(2)	(3)	(4)	(5)
$EquityExtraction_{ikt}$	All Years	All Years	1998-2002	2003-2005	2006-2010
$HPgrowth_{kt}$	0.342*** (0.016)	0.138*** (0.020)	0.050 (0.028)	0.332*** (0.065)	0.138*** (0.019)
$\Delta Income_{ikt}$		-0.080*** (0.002)	-0.101*** (0.003)	-0.089*** (0.003)	-0.060*** (0.002)
Education Length		-0.003*** (0.000)	-0.004*** (0.000)	-0.003*** (0.000)	-0.003*** (0.000)
Change in Number of Children		-0.003*** (0.000)	-0.003*** (0.001)	-0.003** (0.001)	-0.002*** (0.001)
r_{ikt}		-0.071*** (0.012)	-0.051 (0.031)	-0.457*** (0.012)	0.001 (0.009)
Apartment		-0.032*** (0.001)	-0.027*** (0.002)	-0.035*** (0.003)	-0.038*** (0.001)
Age Dummies	No	Yes	Yes	Yes	Yes
Region-Year Interactions	No	Yes	Yes	Yes	Yes
Observations	4,964,963	4,964,963	1,620,772	1,132,848	1,811,001

Notes: *, **, *** denote statistical significance at the 5%, 1% and 0.1% level. Standard errors clustered on year-municipality in parentheses. Dependent variable is Equity Extraction. ΔHPI_{kt} is the change in log square meter price between $t-1$ and t for municipality k . Δy_{it} is the change in log disposable income between $t-1$ and t . Column 2-5 include controls for age, education level, change in number of children, a household-specific individual return, and region-year interactions.

5.4 Equity Extraction and House Price Growth

Table 4 examines equity extraction and house price growth. The dependent variable is equal to one if nominal mortgage debt increased by more than 10 percent between $t-1$ and t . The independent variables and controls are the same as in Table 2. The baseline coefficient is 0.342 when we do not include any controls in column 1, and is reduced to 0.138 in column 2 when we include a full set of control variables. Similar to our previous findings, house price growth was not significantly related to equity extraction in 1998-2002, but is strongly related to equity extraction during the Danish housing boom in 2003-2005. Contrary to the results in table 2, the coefficient on house price growth in 2006-2010 is positive and statistically significant. However, the positive coefficient mainly reflects increasing equity extraction in 2006, when house price growth was still high. Figure 7 shows that equity extraction is positively related to house price growth

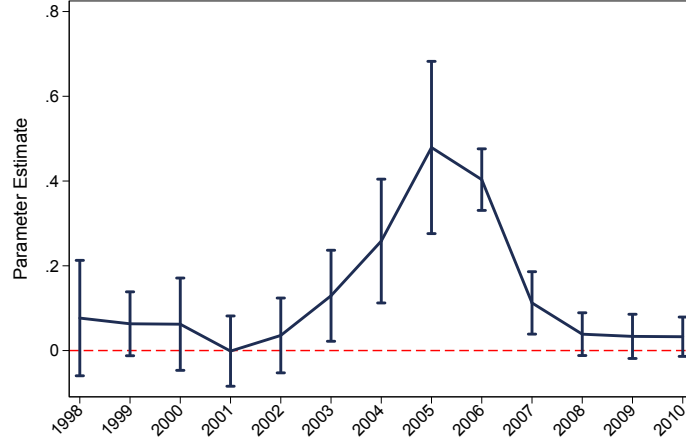


Figure 7: Year-over-Year Effects for Equity Extraction

Note: The figure plots the coefficients on $HPgrowth_{kt}$ interacted with year. The dependent variable is $EquityExtraction$. Regressions are estimated using controls for changes in income, demographic controls for age, education, change in family size, and region fixed effects. Standard errors cluster on municipality-year level.

up until 2007, but unrelated for the years 2008 - 2010. During these years house price growth is negative or flat.

The increase in equity extraction after the introduction of interest-only mortgage suggests that households may have chosen to extract additional equity when refinancing to a new mortgage product. As we argue in the section 2, interest-only mortgages may cause an increase in the optimal debt level because the disutility of amortization payments is smaller. Figure 4 shows that the fraction of households who extracted equity at least once in 2003-2005 (bottom panel) is again highly correlated with the fraction of homeowners with an interest-only mortgage. The correlation between equity extraction in 2003-2005 and interest-only fraction is 0.45. Equity extraction and interest-only mortgages are prominent in the same areas of Denmark, and as these are also the areas that experienced high house price growth, the increasing popularity of new mortgage products over this time period confounds estimates of how house price growth affects equity extraction.

We further examine the use of extracted funds. Table 5 shows that equity extraction is associated with a one-time increase in consumption expenditure by regressing the log first difference in consumption in different time horizons on equity extraction at time t , controlling for changes in income, changes in house prices, demographic characteristics

Table 5: Equity Extraction and Consumption Growth

Dependent Variable: Growth in Consumption at:	Full Sample			2003-2005		
	t	t+1	t+2	t	t+1	t+2
Panel A: All Households						
Equity Extraction	0.302*** (0.002)	-0.227*** (0.002)	-0.035*** (0.001)	0.292*** (0.002)	-0.217*** (0.002)	-0.035*** (0.002)
Observations	3,004,681	3,004,681	3,004,681	1,028,040	1,028,040	1,028,040
Panel B: Borrowing Constrained						
Equity Extraction	0.345*** (0.002)	-0.200*** (0.002)	-0.048*** (0.001)	0.324*** (0.002)	-0.189*** (0.002)	-0.043*** (0.002)
Observations	870,059	870,059	870,059	339,352	339,352	339,352
Panel C: Liquidity Constrained						
Equity Extraction	0.314*** (0.002)	-0.274*** (0.002)	0.003* (0.001)	0.307*** (0.002)	-0.268*** (0.003)	0.007** (0.002)
Observations	1,942,571	1,942,571	1,942,571	624,596	624,596	624,596

Notes: *, **, *** denote statistical significance at the 5%, 1% and 0.1% level. Standard errors clustered on year-municipality in parentheses. Dependent variable is the change in log consumption. Column 1-3 uses observations for all years, and column 4-6 uses observations in 2003, 2004, 2005 and 2006. The sample in Panel A includes all households, Panel B limits the sample to borrowing constrained households, and Panel C limits the sample to liquidity constrained households. All regressions include controls for ΔHPI_{kt} , Δy_{it} , age, education level, change in number of children, a household-specific individual return, and with region, year and region-year effects.

and region-year effects.²⁰ Equity extraction leads to an increase in consumption growth in the current year followed by a decrease in consumption in the subsequent two years. Columns 1-3 show the results for the full sample, and columns 4-6 limit the sample to households who extracted equity in 2004-2006. Equity extraction leads to a 30 percent increase in consumption in the current year, which is followed by a 22.7 and 3.5 percent decline in consumption in year $t + 1$ and $t + 2$ respectively. The net effect is close to zero already after one year.²¹ These results are robust to different time periods (columns 4-6), to only including households who are borrowing constrained (Panel B) and liquidity constrained (Panel C). This spike in consumption expenditure would not show up if extracted funds were used to re-balance the debt portfolio or to invest in alternative assets. In that case, there would be a change in both mortgage debt and debt/other

²⁰We limit the sample to the households who we observe for all periods to ensure that survivorship bias does not affect the results.

²¹Net effect after 1 year: $(1 + 0,302) \times (1 - 0,227) = 1,006$.

assets, which would cancel out given our measure of consumption expenditure. These results are consistent with [Bhutta and Keys \(2016\)](#), who examine the refinancing behavior of US households and find that extracted funds were not used to repay higher interest debt. The pattern in [table 5](#) suggests that extracted funds are used to fund a large durable consumption expenditure, for example a home renovation or a car purchase. Previous studies on US data suggest that equity extraction is often used to fund durable consumption purchases. [Brady et al. \(2000\)](#) report that 40 percent of respondents in the 1999 Survey of Consumers from the University of Michigan cite home renovations as a reason for home equity extraction, and that 39 percent cite consumption expenditure.²² [Canner et al. \(2002\)](#) and [Mian and Sufi \(2011\)](#) find similar evidence.

6 Alternative Hypotheses

In this section, we examine some alternative explanations for the increase in consumption following house price increases. As we show that the correlation between house prices and consumption is driven a few years, we need to show that there is no other factor that is driving both house prices and equity extraction during this time period. For example, house price growth, equity extraction and consumption growth could be explained by rising income expectations ([Attanasio et al., 2009](#)).

However, the evidence suggest that income expectations are not likely a key driver of the decision to extract equity. We examine the income growth of households before and after their decision to extract equity in [Figure 9](#). There is little difference in either level of income growth between households who refinance and those who do not in 2004, 2005 and 2006. The formal evidence for this result is presented in [table 6](#). The table investigates two outcomes - future income growth and unemployment. The first three columns examine outcomes in $t + 1$, $t + 2$ and $t + 3$, respectively. Since the previous result highlighted the importance of a few selected years, we also provide results for

²²The survey design allowed for multiple use of funds.

Table 6: Equity Extraction and Labor Market Outcomes

	Full Sample			2003-2006		
	t+1	t+2	t+3	t+1	t+2	t+3
Dependent Variable: Income Growth						
Equity Extraction	-0.003*** (0.000)	0.001*** (0.000)	0.001*** (0.000)	-0.002** (0.001)	-0.002*** (0.000)	-0.001 (0.000)
Observations	3,857,087	3,017,372	2,493,344	1,228,787	1,031,928	941,695
Dependent Variable: Unemployment Dummy						
Equity Extraction	-0.001* (0.000)	-0.001** (0.000)	-0.001** (0.000)	-0.001* (0.000)	-0.002*** (0.000)	-0.001** (0.000)
Observations	3,857,087	3,017,372	2,493,344	1,228,787	1,031,928	941,695

Notes: *, **, *** denote statistical significance at the 5%, 1% and 0.1% level. Standard errors clustered on year-municipality in parentheses. Dependent variable is log first difference in disposable income in Panel A, and a dummy equal to one if one or two members of the households is unemployed in Panel B. The number of periods ahead is listed in the column headings. Column 1-3 uses observations for all years, and column 4-6 uses observations in 2003, 2004, 2005 and 2006. All regressions include controls for Δy_{it} , age, education level, change in number of children, a household-specific individual return, and with region, year and region-year effects.

equity extraction in 2003-2006 in columns 4-6. All regressions include the same controls used previously. The dependent variable in the first panel is the log first difference in disposable income one year ahead. The prediction is that if income expectations are causing households to extract equity and thereby increase their consumption, we should see higher income growth in the future. In column 1 we have the opposite result, namely that equity extraction predicts lower income growth one year ahead. Column 2 and 3 show that equity extraction does predict 0.001 percent higher income growth two and three years ahead. However, the effect is small, and is reversed in column 5 and 6 when we only include the boom years. The second panel investigates another aspect of expected income, the chance of becoming unemployed. The coefficients show that equity extraction predicts a lower unemployment rate, but that the effect size is again small.

7 Conclusion

In this paper we investigate how changes in housing wealth affect consumption. We find the increased prevalence of interest-only mortgages provides a new common factor that in-

fluences both consumption expenditure and house prices. House prices and consumption expenditure are correlated only during the period when interest-only mortgages became increasingly popular. This channel has previously not been emphasized in the literature, but has important implications for the policy debate in the aftermath of the financial crisis.

Our results suggest that changing amortization requirements can have large impacts on both consumption and on housing markets. The reason why interest-only mortgage have such a large impact on consumption is because households can make a one-time adjustment to their consumption level. If a large enough number of households choose to refinance at the same time, this one-time adjustment will have a substantial impact on aggregate consumption. However, this suggests that after the initial shock to consumption has expired, the presence of interest-only mortgages as an option will not affect aggregate consumption dynamics. It is precisely the introduction and increased popularity of these mortgages that created a boom in house prices and consumption in Denmark, not the availability of these mortgages.

References

- Andersen, Asger Lau, Duus, Charlotte, and Jensen, Thais Lærkholm. 2016. Household debt and spending during the financial crisis: Evidence from Danish micro data. *European Economic Review*, **89**, 96–115.
- Andersen, Steffen, Campbell, John Y., Nielsen, Kasper Meisner, and Ramadorai, Tarun. 2015. *Inattention and Inertia in Household Finance: Evidence from the Danish Mortgage Market*. NBER Working Paper 21386.
- Aron, Janine, Muellbauer, John, and Murphy, Anthony. 2006. Housing wealth, credit conditions and consumption. 00065.
- Association of Danish Mortgage Credit Banks. 2009. *The Traditional Danish Mortgage Model*.
- Association of Danish Mortgage Credit Banks. 2011. *Boligejerne har styr på deres afdragsfrie realkreditlån*.
- Attanasio, Orazio P., Blow, Laura, Hamilton, Robert, and Leicester, Andrew. 2009. Booms and busts: Consumption, house prices and expectations. *Economica*, **76**(301), 20–50.
- Bäckman, Claes, and Lutz, Chandler. 2016. Prime Borrowers and Financial Innovation in the Housing Boom and Bust.
- Barlevy, Gadi, and Fisher, Jonas DM. 2012. Mortgage choices and housing speculation.
- Berger, David, Guerrieri, Veronica, Lorenzoni, Guido, and Vavra, Joseph. 2015. *House Prices and Consumer Spending*. NBER Working Paper 21667.
- Bhutta, Neil, and Keys, Benjamin J. 2016. Interest Rates and Equity Extraction During the Housing Boom. *American Economic Review*, **106**(7), 1742–1774.

- Bostic, Raphael, Gabriel, Stuart, and Painter, Gary. 2009. Housing wealth, financial wealth, and consumption: New evidence from micro data. *Regional Science and Urban Economics*, **39**(1), 79–89.
- Brady, Peter J., Canner, Glenn B., and Maki, Dean M. 2000. The effects of recent mortgage refinancing. *Federal Reserve Bulletin*, **86**(7), 441–450.
- Browning, Martin, and Leth-Petersen, Søren. 2003. Imputing consumption from income and wealth information*. *The Economic Journal*, **113**(488), F282–F301.
- Browning, Martin, Gørtz, Mette, and Leth-Petersen, Søren. 2013. Housing Wealth and Consumption: A Micro Panel Study. *The Economic Journal*, **123**(568), 401–428.
- Brueckner, Jan K, Calem, Paul S, and Nakamura, Leonard I. 2016. House-Price Expectations, Alternative Mortgage Products, and Default. *Journal of Money, Credit and Banking*, **48**(1), 81–112.
- Campbell, J. Y. 2013. Mortgage Market Design. *Review of Finance*, **17**(1), 1–33.
- Campbell, John Y., and Cocco, João F. 2007. How do house prices affect consumption? Evidence from micro data. *Journal of Monetary Economics*, **54**(3), 591–621.
- Canner, Glenn, Dynan, Karen, and Passmore, Wayne. 2002. Mortgage refinancing in 2001 and early 2002. *Federal Reserve Bulletin*, **88**(12), 469–481.
- Carroll, Christopher D., Otsuka, Misuzu, and Slacalek, Jiri. 2011. How large are housing and financial wealth effects? A new approach. *Journal of Money, Credit and Banking*, **43**(1), 55–79.
- Case, Karl, Quigley, John M., and Shiller, Robert. 2005. Comparing Wealth Effects: The Stock Market versus the Housing Market. *Advances in Macroeconomics*, **5**(1), 1–34.
- Cocco, Joao F. 2013. Evidence on the benefits of alternative mortgage products. *The Journal of Finance*, **68**(4), 1663–1690.

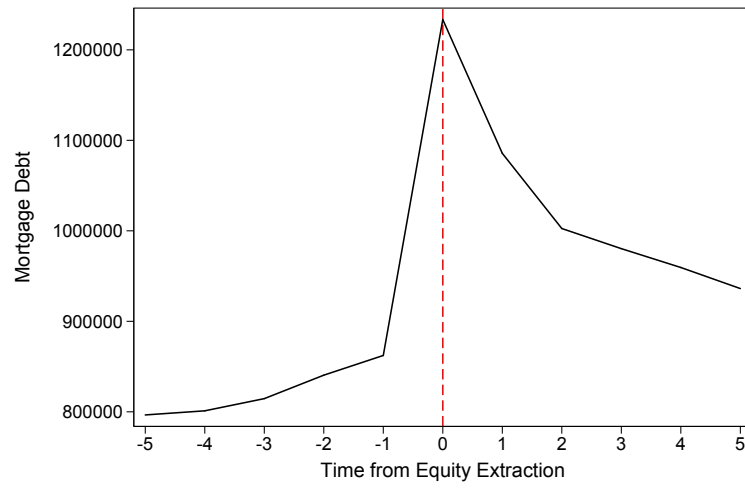
- Cooper, Daniel. 2013. House price fluctuations: the role of housing wealth as borrowing collateral. *Review of Economics and Statistics*, **95**(4), 1183–1197.
- Danske Bank Markets. 2013. *Danish Covered Bond Handbook*.
- DeFusco, Anthony A. 2015. Homeowner borrowing and housing collateral: New evidence from expiring price controls. *Available at SSRN*.
- Disney, Richard, Gathergood, John, and Henley, Andrew. 2010. House Price Shocks, Negative Equity, And Household Consumption In The United Kingdom. *Journal of the European Economic Association*, **8**(6), 1179–1207.
- Friedman, Milton. 1957. A Theory of the Consumption Function. *Pages 1–6 of: A theory of the consumption function*. Princeton University Press.
- Gan, Jie. 2010. Housing Wealth and Consumption Growth: Evidence from a Large Panel of Households. *Review of Financial Studies*, **23**(6), 2229–2267.
- Gorea, Denis, and Midrigan, Virgiliu. 2017. *Liquidity constraints in the us housing market*. Working paper.
- Kaplan, Greg, and Violante, Giovanni L. 2014. A model of the consumption response to fiscal stimulus payments. *Econometrica*, **82**(4), 1199–1239.
- Kaplan, Greg, Violante, Giovanni L, and Weidner, Justin. 2014. The wealthy hand-to-mouth. *Brookings Papers on Economic Activity*, 121–154.
- Kaplan, Greg, Mitman, Kurt, and Violante, Gianluca. 2015. Consumption and house prices in the Great Recession: Model meets evidence.
- Kaplan, Greg, Mitman, Kurt, and Violante, Giovanni L. 2016. *Non-durable Consumption and Housing Net Worth in the Great Recession: Evidence from Easily Accessible Data*. Working Paper 22232.

- Khorunzhina, Natalia. 2013. Structural estimation of stock market participation costs. *Journal of Economic Dynamics and Control*, **37**(12), 2928 – 2942.
- King, Mervyn. 1990. Discussion. *Economic Policy* 11, **11**(3), 383–387.
- Koijen, Ralph, van Nieuwerburgh, Stijn, and Vestman, Roine. 2015. Judging the Quality of Survey Data by Comparison with “Truth” as Measured By Administrative Records: evidence From Sweden. In: Carroll, Christopher, Crossley, Thomas, and Sabelhaus, John (eds), *Improving the Measurement of Consumer Expenditures*. University of Chicago Press.
- Leth-Petersen, Søren. 2010. Intertemporal consumption and credit constraints: Does total expenditure respond to an exogenous shock to credit? *The American Economic Review*, 1080–1103.
- Mian, A., Rao, K., and Sufi, A. 2013. Household Balance Sheets, Consumption, and the Economic Slump. *The Quarterly Journal of Economics*, **128**(4), 1687–1726.
- Mian, Atif, and Sufi, Amir. 2011. House Prices, Home Equity–Based Borrowing, and the US Household Leverage Crisis. *American Economic Review*, **101**(5), 2132–2156.
- Mian, Atif, and Sufi, Amir. 2014. *House Price Gains and US Household Spending from 2002 to 2006*. Working paper.
- Ministry of Economic and Business Affairs. 2007 (Jan). *Nye tider på boligmarkedet*. Working paper.
- Muellbauer, John, and Murphy, Anthony. 1997. Booms and Busts in the UK Housing Market. *The Economic Journal*, **107**(445), 1701–1727.
- Pagano, Marco. 1990. Discussion. *Economic Policy* 11, **11**(3), 387–390.
- Paiella, Monica, and Pistaferri, Luigi. 2014. Decomposing the wealth effect on consumption. *Review of Economics and Statistics*.

- Piskorski, Tomasz, and Tchisty, Alexei. 2010. Optimal mortgage design. *Review of Financial Studies*, **23**(8), 3098–3140.
- Politiken. 2012. Se hvor mange der har afgragsfrie lan og flekslan i din kommune. 6 December. Last accessed: 7 August 2015.
- Saiz, Albert. 2010. The geographic determinants of housing supply. *The Quarterly Journal of Economics*, **125**(3), 1253–1296.
- Sinai, Todd, and Souleles, Nicholas S. 2005. Owner-occupied housing as a hedge against rent risk. *The Quarterly Journal of Economics*, **120**(2), 763–789.
- Ziliak, James P. 1998. Does the Choice of Consumption Measure Matter? An Application to the Permanent-Income Hypothesis. *Journal of Monetary Economics*, **41**(1), 201–216.

8 Figures

Figure 8: Mortgage Debt Around Equity Extraction



Notes: The figure plots mortgage debt in the year preceding and following equity extraction. The year of equity extraction is normalized to zero.

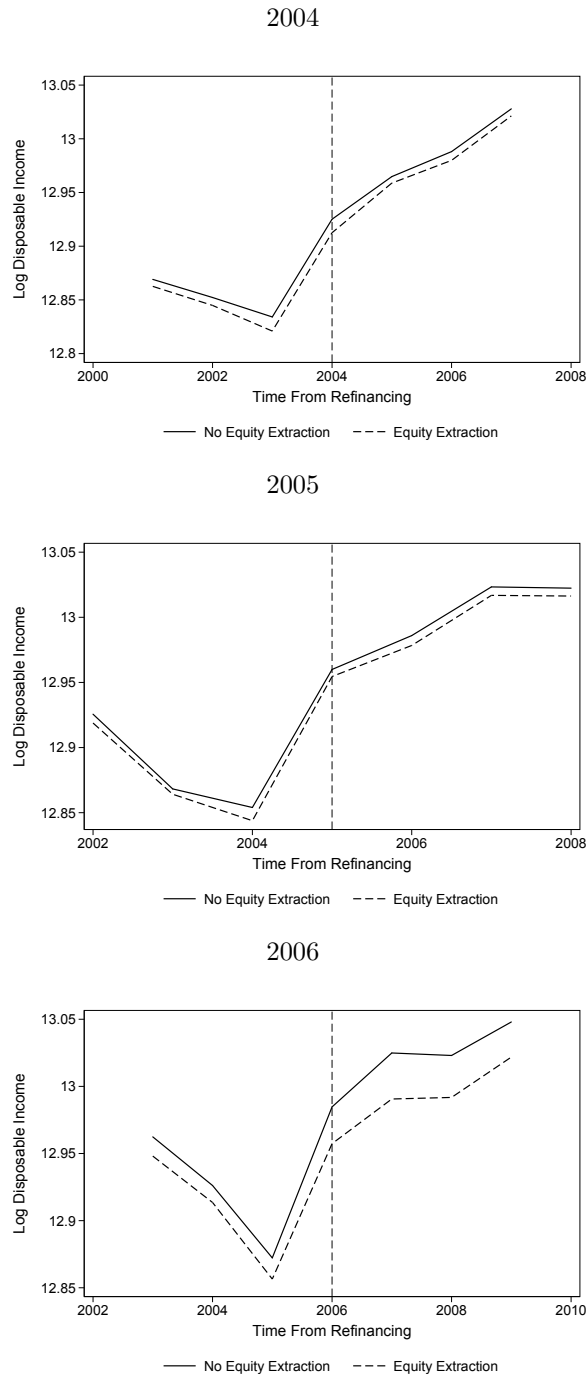


Figure 9: Log Disposable Income for Equity Extractors and Other Households

Notes: The figure plots log disposable income for households who choose to refinance (dashed line) and for households who did not refinance (solid line) in the year indicated above the graph.

9 Tables

Table 7: Summary Statistics

	(1) Full Sample	(2) 1998-2002	(3) 2003-2005	(4) 2006-2010
Panel A: Demographic Characteristics				
Age	43.15	43.09	43.10	43.25
	7.63	7.84	7.57	7.44
Number of Children	1.45	1.38	1.46	1.52
	1.03	1.03	1.04	1.03
Length of Education	14.91	14.66	14.92	15.19
	2.08	2.15	2.03	1.99
Panel B: Financial Characteristics				
Consumption	436,528	386,634	444,695	487,101
	317,775	309,014	277,304	341,755
Disposable Income	427,373	385,208	425,068	475,871
	221,634	171,698	184,231	276,040
Net Wealth	486,559	389,228	438,815	625,046
	1,223,040	961,655	1,133,473	1,494,650
Housing Wealth	1,822,905	1,487,224	1,810,008	2,205,598
	1,425,949	982,683	1,461,855	1,699,322
Liquid Assets	170,648	139,289	172,618	204,414
	580,692	538,067	597,064	613,287
Mortgage Debt	957,712	773,843	960,439	1,161,208
	807,907	625,693	804,430	931,989
Interest Payments	66,001	66,096	58,447	70,620
	40,214	37,826	32,965	45,825
Consumption / Disposable	1.02	1.01	1.05	1.03
	0.39	0.36	0.40	0.40
Liquid Assets to Income	0.34	0.30	0.35	0.37
	0.48	0.46	0.49	0.50
Mortgage to Income	2.25	2.04	2.27	2.48
	1.40	1.26	1.35	1.53
Equity Withdrawal	0.14	0.14	0.19	0.11
	0.35	0.35	0.39	0.31
Mortgage Rate	0.06	0.07	0.05	0.05
	0.03	0.03	0.03	0.02
Interest Payments to Income	0.16	0.18	0.14	0.16
	0.09	0.10	0.08	0.09
Liquidity Constrained	0.63	0.67	0.61	0.59
	0.48	0.47	0.49	0.49
Borrowing Constrained	0.31	0.28	0.35	0.33
	0.46	0.45	0.48	0.47
Observations	4,964,963	2,021,114	1,132,848	1,811,001

Notes: Average values for each variable from year 1998 to 2010. Net wealth is defined as assets minus liabilities. Housing wealth is the tax value adjusted by the scaling factor. Debt is the sum of mortgage debt, bank debt and the value of mortgage deeds. Liquid assets consists of stocks, bonds and bank deposits. Consumption is defined in section 4. Mortgage rate is calculated as the interest payments in DKK divided by mortgage value. Equity withdrawal, Borrowing Constrained and Liquidity Constrained are defined in section 4.

Table 8: Equity Extraction Summary Statistics

	Full Sample		1998-2002		2003-2005		2006-2010	
	No EE	EE	No EE	EE	No EE	EE	No EE	EE
Panel A: Demographic Characteristics								
Age	43.25	42.57	43.21	42.33	43.18	42.76	43.32	42.72
	7.67	7.41	7.87	7.60	7.62	7.36	7.47	7.16
Number of Children	1.43	1.55	1.36	1.50	1.44	1.54	1.51	1.65
	1.04	1.02	1.03	1.02	1.04	1.02	1.03	1.01
Length of Education	14.93	14.82	14.67	14.59	14.93	14.89	15.21	15.08
	2.09	2.01	2.16	2.08	2.04	1.97	2.00	1.92
Panel B: Financial Characteristics								
Consumption	415,502	564,325	369,489	490,953	415,716	566,028	464,891	668,293
	298,113	394,420	307,699	296,227	234,625	387,481	311,572	490,731
Disposable Income	430,311	409,513	387,484	371,362	426,865	417,545	478,346	455,679
	231,785	144,124	179,232	114,757	193,043	141,244	286,370	168,359
Net Wealth	534,715	193,849	433,370	120,641	491,165	219,626	668,446	270,992
	1,250,986	987,826	993,644	678,387	1,182,739	864,557	1,500,212	1,399,068
Housing Wealth	1,820,759	1,835,948	1,486,488	1,491,701	1,788,962	1,898,132	2,198,453	2,263,894
	1,418,385	1,471,023	977,001	1,016,557	1,485,423	1,355,204	1,666,027	1,948,845
Liquid Assets	171,470	165,653	142,188	121,652	170,225	182,638	203,684	210,374
	610,893	344,138	569,476	278,369	642,873	344,296	633,329	415,048
Mortgage Debt	907,362	1,263,757	729,771	1,042,005	887,786	1,264,638	1,109,543	1,582,692
	772,734	938,920	587,945	765,844	759,733	908,405	896,619	1,093,997
Interest Payments	64,461	75,362	64,228	77,461	56,534	66,454	69,204	82,172
	40,340	38,123	37,672	36,762	32,927	31,900	45,836	44,062
Consumption / Disposable	0.97	1.34	0.96	1.31	0.98	1.32	0.98	1.41
	0.33	0.52	0.32	0.47	0.33	0.52	0.35	0.59
Liquid Assets to Income	0.33	0.37	0.30	0.30	0.34	0.40	0.36	0.42
	0.48	0.48	0.47	0.41	0.48	0.51	0.50	0.53
Mortgage to Income	2.13	3.01	1.92	2.76	2.10	2.97	2.36	3.43
	1.36	1.38	1.22	1.26	1.30	1.35	1.50	1.47
Mortgage Rate	0.06	0.05	0.07	0.06	0.05	0.05	0.05	0.04
	0.03	0.02	0.04	0.02	0.03	0.02	0.02	0.01
Interest Payments to Income	0.16	0.19	0.17	0.21	0.14	0.17	0.15	0.19
	0.09	0.09	0.10	0.09	0.08	0.08	0.09	0.09
Liquidity Constrained	0.64	0.57	0.68	0.63	0.63	0.53	0.60	0.52
	0.48	0.50	0.47	0.48	0.48	0.50	0.49	0.50
Borrowing Constrained	0.28	0.55	0.23	0.57	0.30	0.52	0.30	0.55
	0.45	0.50	0.42	0.50	0.46	0.50	0.46	0.50
Observations	4,263,529	701,434	1,735,832	285,282	914,447	218,401	1,613,250	197,751

Notes: Average values for each variable from year 1998 to 2010 for households who extracted equity and households who did not extract equity. Net wealth is defined as assets minus liabilities. Housing wealth is the tax value adjusted by the scaling factor. Debt is the sum of mortgage debt, bank debt and the value of mortgage deeds. Liquid assets consists of stocks, bonds and bank deposits. Consumption is defined in section 4. Mortgage rate is calculated as the interest payments in DKK divided by mortgage value. Equity withdrawal, Borrowing Constrained and Liquidity Constrained are defined in section 4.

Table 9: Consumption and House Price Growth for Constrained and Unconstrained Households

Interaction Variable: $HPgrowth_{kt}$	Liquidity Constraints			Borrowing Constraints		
	(1) 1998-2002	(2) 2003-2005	(3) 2006-2010	(4) 1998-2002	(5) 2003-2005	(6) 2006-2010
First Decile, Liquidity	0.021 (0.047)	0.189** (0.064)	0.087* (0.036)			
Second Decile, Liquidity	0.031 (0.036)	0.158** (0.053)	0.045 (0.031)			
Third Decile, Liquidity	0.033 (0.047)	0.220** (0.072)	0.035 (0.033)			
Fourth Decile, Liquidity	0.034 (0.036)	0.188*** (0.049)	0.036 (0.030)			
Fifth Decile, Liquidity	0.004 (0.037)	0.140** (0.050)	0.015 (0.026)			
Sixth Decile, Liquidity	0.051 (0.035)	0.224*** (0.043)	0.028 (0.026)			
Seventh Decile, Liquidity	0.039 (0.035)	0.167*** (0.050)	0.019 (0.028)			
Eight Decile, Liquidity	0.048 (0.034)	0.217*** (0.053)	0.039 (0.030)			
Ninth Decile, Liquidity	-0.019 (0.036)	0.233*** (0.055)	0.054 (0.039)			
Tenth Decile, , Liquidity	0.124* (0.054)	0.269* (0.106)	0.044 (0.058)			
First Decile, Leverage				0.035 (0.034)	0.077 (0.061)	0.041 (0.035)
Second Decile, Leverage				0.019 (0.033)	0.234*** (0.047)	-0.010 (0.031)
Third Decile, Leverage				0.004 (0.033)	0.168*** (0.045)	-0.069* (0.031)
Fourth Decile, Leverage				-0.011 (0.035)	0.039 (0.046)	-0.009 (0.029)
Fifth Decile, Leverage				-0.041 (0.037)	0.171* (0.073)	-0.018 (0.029)
Sixth Decile, Leverage				-0.063 (0.043)	0.400*** (0.092)	-0.041 (0.031)
Seventh Decile, Leverage				-0.024 (0.040)	0.377*** (0.079)	0.032 (0.035)
Eight Decile, Leverage				0.097* (0.040)	0.441*** (0.080)	0.124** (0.039)
Ninth Decile, Leverage				0.066 (0.045)	0.594*** (0.109)	0.233*** (0.049)
Tenth Decile, Leverage				0.170*** (0.051)	0.824*** (0.150)	0.313*** (0.059)
Observations	2,021,114	1,132,848	1,811,001	2,021,114	1,132,848	1,811,001

Notes: *, **, *** denote statistical significance at the 5%, 1% and 0.1% level. Standard errors clustered on year-municipality in parentheses. Column 1-3 include results for Liquidity Constrained households, and column 4-6 include results for Borrowing Constrained households. Dependent variable is the change in log consumption, $\Delta Consumption_{ikt}$. ΔHPI_{kt} is the change in log square meter price between $t-1$ and t for municipality k . Δy_{it} is the change in log disposable income between $t-1$ and t . All regressions include controls for age, education level, change in number of children, a household-specific individual return, and with region, year and region-year effects.

Appendix: Tables

Table 10: Sample Selection

	Dropped	Remaining
Demographics		
Initial Number of Observations		40,230,677
Single-adult households	20,249,851	19,980,826
Age 18-21	107,646	19,873,180
Age 55+	7,092,939	12,780,241
Entrepreneur	846,285	11,933,956
Small municipalities	339,088	11,594,868
House Traders and Consumption		
Remaining Observations		11,594,868
Property traders	2,339,239	9,255,629
Renters with mortgage debt	15,75	9,239,879
High/low consumption growth	37,43	9,202,449
Consumption below 0	141,779	9,060,672
Estimation Sample Selection		
Renters	2,361,589	6,699,083
No Demographics	641,957	6,057,126
No House Type	6,599	6,050,527
No Income Change	404,711	5,645,816
No Consumption Change	673,128	4,972,688
Final Estimation Sample		4,972,688

A Appendix

A.1 Municipality-Level Price Index

We construct a municipality level house price index using data on all transactions in Denmark. The data is from The Danish Gazette (*Statstidende*), and covers the universe of Danish property transactions as a part of the judicial process of transferring ownership. We combine the data on property sales with data on individual property characteristics from the Housing Register (*Bygnings- og Boligregister*, BBR). Further, we collect data on property ownership to identify trades between spouses and family members, and to identify trades that occur due to the death of a spouse or due to divorce. These trades are removed from the final sample, as they are less likely to be sold at market prices.²³

After collecting the data on all property transactions, we connect each house and apartment to the Housing Register (BBR) to find the property type (apartment, single-family house or summer house). We further drop outliers in the sales price by removing the top and bottom 1 percent in the sales price distribution, and by removing any transactions where the transaction price is listed as zero. The resulting sample of households are then used to calculate the average square meter price for traded properties in all municipalities.

²³Removing family trades and similar non-market transactions are common in the construction of real estate indices. See e.g. the S&PCase-Shiller index methodology: <http://us.spindices.com/index-family/real-estate/sp-case-shiller>).