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# How do Interest-only Mortgages Affect Consumption and Saving over the Life Cycle?

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**Abstract**

Using a unique data set with detailed information on Danish households and their mortgages, we show that young and old households are more likely to use IO mortgages compared to middle-aged households. Young households use IO mortgages because they expect higher future income, old households because IO mortgages allow them to circumvent an otherwise binding liquidity constraint. Through different channels, IO mortgages thus facilitate consumption smoothing for young and old households. Our detailed data also allow us to examine how households with IO mortgages differ from households with repayment mortgages in terms of leverage, debt and asset composition, and pension contributions.

**Keywords:** Interest-only mortgages; micro data; consumption and savings pattern; life-cycle planning; financial constraints

**JEL subject codes**: G11

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## 1 Introduction

Interest-only (IO) mortgages and other non-conventional loans were—together with lenders' lax underwriting standards—heavily criticized in the debate following the financial crisis that erupted in 2007.[1] Mortgages with no or even negative amortization were issued on a large scale in 2004–2006 in the US and many other countries. When home prices plummeted, many homeowners went underwater and default rates spiked with severe macroeconomic ramifications. A substantial literature on IO mortgages has subsequently emerged, examining who use them (Cocco, 2013; Cox, Brounen, and Neuteboom, 2015; Gathergood and Weber, 2017; Amromin, Huang, Sialm, and Zhong, 2018), how IO mortgages impact financial stability (Campbell, Clara, and Cocco, 2021), whether IO mortgages lure households into excessive leverage and consumption (Laibson (1997) and references in footnote 1), and whether IO mortgages help facilitate rational households' life-cycle planning by offering greater financial flexibility (Cocco, 2013). In spite of significant progress in our understanding of households' use of IO mortgages, important gaps remain. In particular, it is not fully clear *which* households use IO mortgages, and *how* households use IO mortgages in conjunction with their consumption and investment decisions over the life cycle. For the debate about the benefits versus costs of IO mortgages, it is obviously important to know how IO mortgages are used by households. This paper makes progress on these questions using a comprehensive panel data set from Denmark.

The time-span of our data allows us to take a life-cycle perspective on how IO mortgages are used. We find that both young and old households are more likely to use IO mortgages than middle-aged homeowners, also after controlling for differences in, e.g., income, education, and debt-to-assets. Interestingly, young and old households with an IO mortgage are net-borrowers, whereas middle-aged homeowners with an IO mortgage are net-savers. This pattern indicates consumption smoothing over the life cycle. On the other hand, homeowners with a repayment mortgage are net-savers over the entire life-cycle.

We provide new evidence explaining why old households choose IO mortgages. Retirees receiving a low pension and little other income might want to reduce net wealth in order to sustain their consumption level, and thus continued saving through mortgage amortization is suboptimal.[2] This motivation applies in particular to liquidity-constrained retired homeowners for whom the home equity is the dominant part of their net wealth. An IO mortgage allows such homeowners to maintain a reasonable level of consumption while staying in their home and thus avoiding the stressful and costly process of selling which

[1] See, e.g., Baily, Litan, and Johnson (2008), Mayer, Pence, and Sherlund (2009), Bernanke (2010), Acharya, Richardson, van Nieuwerburgh, and White (2011), Demyanyk and van Hemert (2011), and United States Senate (2011).

[2] A reverse mortgage may be an alternative to an IO mortgage, but reverse mortgages are not standard products in the Danish market.

is the alternative way of liquefying housing wealth. In a difference-in-difference estimation, we show that the consumption of liquidity-constrained, near-retirement households increased approximately 8% after the introduction of IO mortgages in Denmark in 2003, compared to the consumption of similar unconstrained households. Hence, the access to IO mortgages has significantly improved the welfare of constrained older households. We argue that these positive effects do not arise because of a general credit-supply shock to the economy, but are due to the greater financial flexibility that IO mortgages provide.

Consistent with life-cycle consumption smoothing, we show that the likelihood of a young household having an IO mortgage increases considerably with expected income growth. This observation is in accordance with Cocco (2013) who documents a positive relation between income growth and IO mortgages in a sample of UK households of age 20-60. We refine his conclusion by showing that the relation is strongly positive for young households but decreases with age and turns negative so that among older households IO mortgages are taken more frequently by households expecting lower income growth.[3]

How do households use the extra liquidity that IO mortgages offer? Recent papers based on US data relate mortgage-payment reductions and consumption/saving decisions, see Di Maggio, Kermani, Keys, Piskorski, Ramcharan, Seru, and Yao (2017), Agarwal, Amromin, Chomsisengphet, Landvoigt, Piskorski, Seru, and Yao (2017), and Abel and Fuster (2021). They show that the reduction in mortgage payments leads to lower mortgage default rates, increases in car purchases—measured using auto loans—and increases in voluntary mortgage repayments. These findings advance our understanding of how mortgages with reduced payments influence parts of households' consumption (car purchases) and parts of their debt (mortgage debt), but they do not address the broader questions of whether households with non-conventional mortgages increase their overall consumption, debt, and savings, and how reduced-payment mortgages influence the composition of total debt and savings. Using our comprehensive data, we can do so.

We show that, at any age level, both the total debt and the debt-to-asset, loan-to-income, and consumption-to-income ratios tend to be larger for households with IO mortgages than households with repayment mortgages. Our rich data offers a more detailed picture of how IO mortgages correlate with debt and savings. First, access to IO mortgages can reduce life-time borrowing costs since IO borrowers can pay down other, more expensive, debt earlier. Indeed, IO borrowers above age 40 have a smaller fraction of their debt as non-mortgage debt than borrowers with repayment mortgages. Second, we document how mortgage choice is related to stock and bond investments. For example,

[3]We have data on both labor income and consumption, whereas Cocco (2013) only has income data. While Cocco (2013) considers a sample combining all households of age 20-60, we study the relation between mortgage choice, income, and consumption across nine age groups that also include households of age 60 and above, which gives additional insights into life-cycle patterns.

the stock market participation rate for middle-aged and old households is five percentage points higher among IO borrowers than among borrowers with an amortizing mortgage. Interestingly, among young households, the stock market participation rate is lower for IO borrowers. Hence, if participation reflects risk tolerance, our results question the conclusion of Cox et al. (2015) that risk tolerance is a key driver of mortgage choice. Among homeowners older than 50 years, IO borrowers make larger contributions to private pension plans, maybe to exploit a tax-arbitrage opportunity as suggested by Amromin, Huang, and Sialm (2007).[4] Overall, we find that IO borrowers replace, at least to some extent, the reduced savings in real estate by investments in other assets, leading to a better diversified asset portfolio.[5] Notably, default rates are very low in our data even for IO borrowers and during the financial crisis, but this may partly be due to specifics of the Danish setting.

Households choose the type of their mortgage jointly with consumption and investment decisions, including the decision to purchase a house. The correlations between mortgage type and household characteristics we identify are consistent with the view that many households include the IO/repayment choice in their overall life-cycle decision problem in a rational way. Of course, both the IO/repayment choice and the decisions regarding house purchases, consumption, saving, and financial asset holdings can be affected by unobservable variables, such as the underlying preferences of the household. IO mortgages (in particular those with an adjustable rate) seem more risky than repayment mortgages (in particular those with a fixed rate), which suggests that more risk-tolerant households would tend to choose IO mortgages. At the same time, they would, among other things, tend to save less and investment more in stocks. On the other hand, an adjustable-rate IO may be the rational choice also for risk-averse households facing a labor income which is relatively risky and positively correlated with the adjustable mortgage rate, so that the household typically pays only a low interest rate should their income drop. As mentioned above, the relation we identify between mortgage type and stock market participation questions the hypothesis that risk aversion drives the IO/repayment choice. Numerous studies find that individuals' risk aversion increases with age (Bakshi and Chen, 1994; Albert and Duffy, 2012) but, if this is so, our overall finding that IO take-up is U-shaped in age also questions the view that risk aversion is a main determinant of mortgage type.

To sum up, we offer a number of contributions relative to the current literature on IO

[4]Institutional differences between the Danish and US tax and pension systems imply that the tax-arbitrage strategy in a Danish setting is somewhat different from that suggested by Amromin et al. (2007) and only available to some households close to retirement, cf. the discussion in Section 4.3.

[5]In addition to these effects, a young household may purchase its long-term preferred residence right away by using an IO mortgage, instead of a smaller starter home with subsequent steps up the housing ladder. This could reduce total housing transactions costs over the life cycle. However, given the time span of our data, we cannot detect significant differences in the transaction frequency of IO borrowers compared to borrowers choosing conventional mortgages.

mortgages. First, other papers do not take the life-cycle perspective we do. Our paper, thus, offers a richer description of how young, middle-aged, and old households use IO mortgages. Our finding that older households benefit from access to IO mortgages, as they relax an otherwise binding liquidity constraint, is particularly noteworthy. Furthermore, we are able to study how IO mortgages influence other financial decisions of households (stock market investments, pension contributions, etc.), something that is difficult to do without comprehensive data on household portfolios over the life cycle.

There are considerable challenges involved in conducting an empirical analysis of which and how households use IO mortgages. First, one must have data for a large representative sample of households who use IO mortgages and a sample using repayment mortgages, such that the two groups can be contrasted. Second, for both groups, one needs data that allow for a calculation of consumption and savings at the household level. Third, to say something meaningful about saving decisions, information about the composition of households' portfolios is required, i.e., their holdings of bonds, stocks, etc. Finally, one needs exogenous variation in the availability of IO mortgages. With few exceptions, previous research has studied IO mortgages and other alternative mortgage products using US or UK data. US data sets do not typically include both households using IO mortgages and households using repayment mortgages, and lack detailed information about portfolio composition at the household level. Moreover, exogenous variation in the access to alternative mortgage products is typically unavailable.

To overcome these challenges, we use a comprehensive panel data set from Denmark with detailed information on the mortgages of more than 400,000 households in the period 2001–2015 coupled with register-based data on, e.g., household wealth and income from which we can infer the household's consumption. The Danish mortgage system is renowned for its stability, efficiency, and transparency, cf. Campbell (2013) and Section 2 below. While sharing many features of the US market, the Danish mortgage market was less affected by the financial crisis, and the share of IO mortgages has remained high in Denmark. Importantly, our data span the sudden, exogenous introduction of IO mortgages in Denmark in 2003, allowing us to address the question of causality from IO mortgages to consumption and saving decisions. Furthermore, we have comprehensive data on users of IO mortgages and repayment mortgages, as well as information about the financial portfolios of households. Finally, we have information about income, education, geographical location, etc., that allows us to control for confounding effects when investigating life-cycle patterns in saving-consumption decisions of households with different mortgage types.

In addition to the literature already mentioned, a number of papers examine related aspects of households' mortgage decisions. Several papers investigate the choice between an FRM (fixed-rate mortgage) and an ARM (adjustable-rate mortgage) in life-

cycle models (Campbell and Cocco, 2003; Koijen, van Hemert, and van Nieuwerburgh, 2009; van Hemert, 2010), while ignoring the IO/repayment decision. In a more simplistic modeling framework, Chiang and Sa-Aadu (2014) study mortgage choice with a menu of contracts including the pay-option ARM that can be seen as a combination of an IO mortgage and an equity line of credit. In a stylized dynamic contracting model, Piskorski and Tchistyi (2010) find that the optimal mortgage contract resembles such an option ARM, and that the gains from taking the non-conventional optimal mortgage are largest for homeowners who face more volatile income, buy more expensive homes given their income level, and who make no or a small down payment. Koijen et al. (2009) and Badarinza, Campbell, and Ramadorai (2018) show empirically that households' choice between FRMs and ARMs is affected by the FRM-ARM rate spread and expectations about future ARM rates. Andersen, Campbell, Meisner-Nielsen, and Ramadorai (2020b) study the 2009–2011 refinancing behavior of Danish households with a focus on how the refinancing activity varies with household characteristics such as age, educational level, income, and wealth.

Bäckman and Khorunzhina (2018) investigate the effect of IO mortgages on consumption and borrowing in Denmark, but do not address life-cycle patterns or the impact on households' other financial decisions. Refinancing from a repayment mortgage to an IO mortgage might help a homeowner facing temporary financial hardship by freeing up liquidity. Using Danish microdata, Andersen, Jensen, Johannesen, Kreiner, Leth-Petersen, and Sheridan (2020a) indeed find that individuals hit by unemployment shocks to a small degree increase their use of IO mortgages.[6]

Another line of research investigates the relation between house prices and household consumption, e.g. Campbell and Cocco (2007) using UK data, Mian, Rao, and Sufi (2013) and Kaplan, Mitman, and Violante (2020) using US data, and Browning, Gørtz, and Leth-Petersen (2013) using Danish data. A central discussion is whether the house price boom leading up to the Great Recession was primarily due to an increase in credit supply through relaxed lending standards (Mian and Sufi, 2017) or a demand increase through households' expectations of future price changes (Adelino, Schoar, and Severino, 2016).

The remainder of the paper is organized as follows. Section 2 provides a short introduction to the Danish mortgage market, describes our data set and the key variables in our analysis, and presents summary statistics. Section 3 examines which types of households are more likely to use IO mortgages and how labor income and liquidity constraints influence households' decision to use IO mortgages. Section 4 documents how households with IO mortgages differ from households with repayment mortgages in terms of debt and asset composition and pension contributions. Finally, Section 5 concludes.

[6]The modest effect found in Andersen et al. (2020a) is consistent with Defusco and Mondragon (2020) showing that unemployed might demand mortgage refinancing but are constrained.

## 2 Data

### 2.1 Main data sources and features

In Denmark, residential mortgage loans are offered by specialized mortgage banks who act as intermediaries between households and investors. We have detailed data on more than 980,000 loans issued by a major mortgage bank during the period 2001–2015. The name of the bank must be kept anonymous, but it has a market share of over 20% of the Danish mortgage market and lends out in all geographic areas of Denmark and to all types of customers. The data contain the personal identification number of borrowers and mortgage characteristics such as a unique mortgage identification number, the loan amount, the time to maturity, and the mortgage type specifying whether the mortgage includes a repayment commitment or not, and whether the interest rate is fixed or adjustable. The time span of the data set covers both the financial crisis and the introduction of IO mortgages in 2003. A related data set covering all Danish mortgage banks from 2009 and onwards is made available by Finance Denmark (an interest organization for financial institutions) and Danmarks Nationalbank (the central bank of Denmark) and is accessed through Statistics Denmark. This data set is used by Andersen et al. (2020b) and others but does not cover the IO introduction or the financial crisis that we use as exogenous shocks. However, we use the larger post-2009 data set in case a given household changes mortgage bank after 2009 allowing us to follow the given household for a longer period.[7]

Given the borrowers' personal identification number, Statistics Denmark supplies a number of relevant socioeconomic variables such as the educational history and, on an annual basis, the labor income, bank debt and deposits, holdings of stocks and bonds, as well as contributions paid to pension saving schemes. We have this information for all households in Denmark in the full period from 2001–2015.

### 2.2 The Danish mortgage market

First, we describe the Danish mortgage system; see also Gyntelberg, Kjeldsen, Nielsen, and Persson (2011) and Danske Bank (2017). The Danish mortgage system dates back to 1797 and has been regulated by law since 1850 with the key objective of providing homeowners with inexpensive low-risk funding. Mortgage banks form large pools of geographically diversified mortgages having identical terms (different loan sizes, though) and then issue a series of identical covered bonds receiving payments that closely match the incoming payments from borrowers on the mortgages in the pool. The Danish mortgage-backed bond market is the largest European covered bond market (see the Internet Ap-

[7] Danish households are very loyal to their mortgage bank. In the 2004-2015 period only about 3% of all households changed mortgage bank per year (Danish Competition and Consumer Authority, 2017).

pendix). While the interest rate paid on the mortgage matches the coupon rate of the associated bond, borrowers have to make additional contribution payments proportional to their outstanding debt to cover the mortgage bank's expenses and maintain its reserves.[8] Due to relatively strict regulation, an 80% maximum residential loan-to-value ratio, and conservative underwriting standards, the system has exhibited a remarkable stability even through financial crises and thus received considerable international attention (Campbell, 2013). When a borrower defaults on a mortgage, the corresponding bonds are paid out of the reserves of the issuing mortgage bank, and not a single bond default has been recorded in the more than 220-year long history of the system.

As in the US, the predominant mortgage in Denmark has traditionally been a 30-year annuity-style FRM with a penalty-free prepayment option. However, all Danish mortgages are recourse loans, allowing the borrower to settle his debt by delivering corresponding bonds purchased at market value to the issuing mortgage bank, and can be taken over by the new owner when the underlying property is sold. ARMs were introduced in Denmark in 1996 and are offered with various rate reset frequencies.

IO mortgages were introduced in Denmark in 2003 and several observations indicate that the introduction can be seen as an exogenous shock. First, the law introducing IOs was passed relatively fast. Discussions about introducing IOs started in the Danish financial sector in late 2002, the bill was first discussed in parliament in Spring 2003 and eventually passed on June 1, and IO mortgages became available from October 1, 2003. Second, and most important, if the IO introduction had been expected, we should not have seen the significant increase in house prices shortly after the introduction, cf. Figure IA.2 in the Internet Appendix. Dam, Hvolbøl, Pedersen, Sørensen, and Thamsborg (2011) estimate that Danish house prices would have been 15-20% lower at their peak in 2007, had IOs not been introduced in 2003.[9]

An IO mortgage gives the borrower up to 10 years in which no repayment of debt has to be made so that only interest payments (and the above-mentioned contributions) are needed. Some mortgage banks require that the interest-only period is a continuous period starting at the initiation of the loan, whereas others grant the borrower the option to select shorter interest-only periods (totaling at most 10 years) along the way. The vast majority of IO mortgages, however, are issued with a 30-year maturity and have only interest payments in the first 10 years. Whether the IO period is a continuous 10-year period or consists of shorter IO periods, the loan has to be paid back within the full 30-year period. For this reason, the interest rate on an IO mortgage is not significantly different from

[8] Until 2011 the contribution rate was around 0.5% for all mortgage types. Since then the mortgage institutions have increased contribution rates on loans with IO, ARM, and high loan-to-value (LTV).

[9] Also, in a US context Barlevy and Fisher (2021) show that the share of IOs is tightly correlated with the rate of house price growth in a city even after controlling for other mortgage characteristics.

the interest rate on a repayment mortgage. Given the embedded penalty-free prepayment option (subject to transaction costs, though), a borrower might decide to refinance into a new IO mortgage after the end of the 10-year IO period—and thus extending the IO period—provided that the loan-to-value ratio of the new loan is still below the 80% limit. Both FRMs and ARMs can have an IO feature so four main mortgage types exist: IO-FRMs, repayment FRMs, IO-ARMs, and repayment ARMs.

Regulation stipulates that mortgage banks are only allowed to grant a mortgage with an interest-only period or an adjustable rate or both if the borrower can afford a conventional 30-year FRM. Based on the learnings from the financial crisis, the Danish FSA in December 2014 introduced the so-called Supervisory Diamond for mortgage banks which sets a number of benchmarks with associated limits for when a Danish mortgage bank is considered to be too risky in its lending. One limit restricts the amount of IO mortgages a mortgage bank can issue. This change in regulation occurred at the very end of our sample period and is thus unlikely to affect our results.

Figure 1 shows that the share of IO mortgages started out around 14% in 2004, hit 40% in 2007 and 50% in 2009, and peaked at 56% in 2012–2013 after which it dropped to 52% in December 2015. In that month approximately 23% of the IO loans were issued with a fixed rate, 77% with an adjustable rate. Figure 1 also shows that the nominal value of outstanding FRMs has remained fairly stable in the 2003–2015 period, whereas the ARM market has grown substantially from around 30% of all mortgages in 2003 to 63% in 2015, a small decline from the 67-68% peak in 2012–2013.

[Figure 1 about here.]

Figure 2 depicts the average short-term and long-term yields on Danish mortgage-backed bonds over the period 2000–2014. The interest rates on ARMs [FRMs] typically follow the short-term [long-term] bond yields. Yields fell before the financial crisis, rose during it, and have fallen substantially since 2009 with short-term yields even turning negative in 2015. The increased gap between the long and short rate affects the incentive to choose ARMs over FRMs, and may also indirectly affect the incentives to choose an IO over a repayment mortgage, and hence explain the increased interest of IO mortgages with an adjustable rate. As discussed by Foà, Gambacorta, Guiso, and Mistrulli (2019), lenders could have incentives to supply more of one type of mortgage than other types. However, in the main part of the time-span in our study, the fees banks earn on different types of mortgages are flat and equal across different mortgage types (The Danish Ministry of Industry, Business, and Financial Affairs, 2016, Figure C), so we do not believe that the mortgage banks preferred issuing IO mortgages instead of repayment mortgages.

[Figure 2 about here.]

Section IA.1 of the Internet Appendix provides additional background. There we document that the homeownership rate has been stable from 2001 to 2015 except for the youngest households (maybe due to increasing market entry prices) and the oldest households (maybe related to the introduction of IO mortgages). Moreover, we show that across the five regions of Denmark, house and apartment prices increased significantly from 2001 up to around 2007 after which prices generally declined until 2012 and then went up again. In our regressions we control for the regional differences in price changes.

### 2.3 Details of our data set

In our data from a major mortgage bank we focus on the 86.9% of mortgages issued on residential property and thus exclude commercial mortgage loans. We exclude the mortgages issued before 1970 (only 0.5% of all mortgages) because of a major change in mortgage regulation that year which, among other things, reduced the maximum loan-to-value ratio and the maximum maturity.

We link individual mortgages to the household characteristics of borrowers. We define a household as one or two adults living at the same postal address. In cases where only one of the adults in the household holds the mortgage, we also include the second adult's contribution to economic variables such as income, debt holding, stock holdings, etc., but omit the contribution from children in the household unless they are registered as one of the borrowers of the mortgage.

Almost 30% of the households have more than one mortgage; the average is 1.2 mortgages per household. To obtain a direct link between mortgage choice and household characteristics we use only one mortgage per household. This *dominant mortgage* is the mortgage with the highest loan amount. If the household has several mortgages with the same loan amount, the dominant mortgage is defined as the one with the highest outstanding debt. Households sharing mortgages with other households are excluded (e.g. divorced couples still owning a house together) to avoid having special family arrangements influencing the results. In total and after exclusions, we have data on 983,822 mortgages issued to 733,222 individuals in 443,600 households over the period 2001–2015.

### 2.4 Key variables in our analysis

#### 2.4.1 Mortgage-specific variables

The *household loan amount (outstanding debt)* is the total loan amount (outstanding debt) of all mortgages held by the household. *LTI* is the ratio of the loan amount to the annual household income. The *nominal interest rate* is the nominal rate paid on the dominant mortgage and is presented in percent. *FRM* takes a value of 1 for a fixed-rate

mortgage and 0 for an adjustable-rate mortgage. Likewise, *IO mortgage* takes a value of 1 for an IO mortgage, i.e. a mortgage without a required repayment in the year in question, and 0 for a mortgage with a mandatory repayment. The *actual IO period* takes a value of 1 if no repayment on the loan is made at the given point in time, either by default or because the borrower exercises an option not to repay. Finally, the variable *at least one IO mortgage* is a dummy variable for households having at least one IO mortgage.

### 2.4.2 Household-specific variables

The *age* of the household is defined as the average age of the borrowers of the mortgage. From Statistics Denmark we have annual observations of various financial variables of each individual, which we aggregate to the household level. *Household total debt* is the sum of the mortgage debt, bank debt, and all other types of debt registered for the household. *Household income* is the disposable income of the household defined as its total income less interest payments and tax payments. Total income consists of labor income, social welfare, unemployment benefits, child benefits, pension payouts, capital income, and inheritance. The *debt to asset ratio* is defined as total debt over total assets, where the latter includes cash, stock and bond holdings, as well as the public property value of all properties owned by the household.[10]

Statistics Denmark reports for each individual an *education level* from 1 to 4. Level 1 represents primary school or less, level 2 secondary school or vocational education, level 3 is short-, medium-, or long-term higher education, and level 4 means PhD or similar. We include the relatively few individuals with level 4 education in level 3 in our analysis. The *education level* of the household is defined as the highest education level in the household. *Household type* corresponds to either 'Single,' 'Couple,' or 'Several families' where in the latter case the household's adults belong to different families. The geographical dimension is represented by which of the five administrative regions of Denmark (*Copenhagen, Zealand, Southern Denmark, Central Jutland, Northern Jutland*) the property is located in. When analysing regressions involving consumption patterns we use regional trends in house prices instead of just regional and time dummies. Finally, the variable *Male* takes the value of 1 if the mortgage has a male borrower and 0 otherwise.

[10]The public property value is the tax authorities' assessment of the value of the property, based among other things on recent transaction prices in the neighborhood. The value is used for calculating the property taxes to be paid by the homeowner and is typically significantly lower than the potential market value of the property.

### 2.4.3 Consumption

We impute the household-level annual consumption from the income and wealth data supplied by Statistics Denmark, as done by Leth-Petersen (2010) and others.[11] Let $c_t$ denote consumption and $y_t$ disposable income in year $t$. Let $A_t$ denote the value of the household's liquid assets (bank deposits including the balance of private pension schemes), $M_t$ mortgage debt, and $D_t$ bank debt and other debt at the end of year $t$. Based on the household budget constraint, total consumption is then imputed as

$$c_t = y_t - \Delta A_t + \Delta M_t + \Delta D_t, \tag{1}$$

where $\Delta A_t = A_t - A_{t-1}$ is the increase in liquid assets plus private pension contributions in year $t$, $\Delta M_t = M_t - M_{t-1}$ is the increase in mortgage debt, and $\Delta D_t = D_t - D_{t-1}$ the increase in bank debt and other debt.[12] The household's net savings in year $t$ are $\Delta A_t - \Delta M_t - \Delta D_t$. Hence, consumption is simply income less net savings. Note that $\Delta M_t = 0$ for a household paying only interest on the mortgage, whereas $\Delta M_t < 0$ in case of a repayment mortgage. Therefore, an interest-only paying household must either consume more, increase assets, or reduce bank and other debt—or a combination hereof—compared to the case where the household has a repayment mortgage of the same size.

We do not include stock and bond holdings in the household's liquid assets. Including them would make imputed consumption of the (relatively few) households with significant positions excessively volatile in years with large movements in stock prices as seen around the financial crisis.[13] Another challenge is that the actual value of the home is unobservable between transactions. Consequently, in years where the household buys or sells real estate, the imputed consumption can severely misrepresent actual consumption as only the debt side is taken into account. For example, in a year where an individual sells a house worth DKK 1.5mn and buys another worth DKK 2.0mn and finances the difference by increasing the mortgage by DKK 0.5mn, this would show up on the right-hand side of Eq. (1) only as

[11] The quality of this imputation is investigated by Browning and Leth-Petersen (2003). They compare data from a Danish Expenditure Survey to administrative data for the years around the survey and conclude that the imputed consumption measure gives a good match with households' self-reported total expenditures. Koijen, van Nieuwerburgh, and Vestman (2015) find substantial reporting errors in Swedish consumption survey data and argue for the use of imputed register-based consumption. Baker, Kueng, Meyer, and Pagel (2022) document a potential measurement error arising when retail investors buy and sell assets within a year as that moves imputed consumption. Since only a small proportion of Danish households invest on their own, this issue is unlikely to significantly affect our results.

[12] When calculating disposable income, voluntary private pension contributions are deducted from gross salaries). Pension contributions are considered as an increase in liquid assets and are thus included in $\Delta A_t$.

[13] We cannot distinguish between changes in asset values due to active investment decisions of the household and changes due to unrealized gains and losses caused by market movements, where the latter might have little relation to consumption decisions. We find that consumption imputed without stock and bond holdings align well with survey-based consumption data, whereas imputed consumption calculated using stock and bond holdings are excessively volatile. These results are available upon request.

an increase in $\Delta M_t$ by DKK 0.5mn and thus consumption would appear to be DKK 0.5mn higher than otherwise. To avoid this issue, we disregard consumption in years where a housing transaction takes place. To control for differences in data registration of housing transactions, we disregard consumption in years where the total inflation-adjusted debt of the household increased or decreased by more than DKK 0.5mn in 2015-prices.[14] Following Browning and Leth-Petersen (2003), we exclude households with self-employed individuals due to their unstable income-tax conditions and the difficulties in measuring the value of their business.[15]

### 2.5 Summary statistics

Our data from the major mortgage bank provides a total of 2,664,423 household-year observations in the period 2001–2015. Table 1 presents the summary statistics with observations divided into subperiods or according to the mortgage type.[16] The observations are not equally distributed over the years as a result of an increase in the number of customers of the mortgage bank, so for the summary statistics for each mortgage type we represent each mortgage by a randomly chosen year to ensure that all mortgages are weighted equally. The summary statistics are similar for all Danish homeowners as for our sample, and we see no reason to believe that our sample is not representative of all Danish mortgage holders.[17]

[Table 1 about here.]

First, we describe the summary statistics for the different subperiods, cf. the shaded columns of Table 1. We focus on mortgage characteristics. The mortgage loan amount and outstanding debt as well as the household debt have increased substantially over the years, also when mortgage or total debt are measured relative to income or assets. For instance, the average loan-to-income ratio has increased from 2.24 in 2001-02 to 3.36 in 2011-15. Both household income and consumption have increased over time.[18] The

[14] Years of housing transactions count 5.1% of the observations, and large changes in total debt above DKK 0.5mn count 6.1%. In total, they represent 8.5% of the observations. Increasing the threshold defining a large change in total debt does not significantly change our results.

[15] We see no significant difference in the fraction of IO mortgages among households with at least one self-employed individual and the fraction of IO mortgages among households with no self-employed individuals in all the years from 2003 to 2015, cf. Table IA.3 in the Internet Appendix.

[16] Table IA.1 in the Internet Appendix presents summary statistics separately for households with an IO mortgage and households with a repayment mortgage both over 2006–08 and 2009-11. The changes from the pre- to the post-crisis period are quite similar for the IO households and the repayment households.

[17] Table IA.2 in the Internet Appendix summarizes household characteristics for all Danish homeowners for the same four sub-periods as stated in Table 1.

[18] Income, consumption, debt, asset values, and pension contributions are in nominal terms. The annual inflation rate over the 2001-15 period has averaged 1.8%, peaking at 3.4% in 2008, and being as low as 0.5% in 2015. The average value of the consumer price index, CPI, is stated in the top of Table 1 with CPI=100 in 2015.

consumption-to-income ratio is relatively stable around 1 over time.

The fraction of households in our sample for which the dominant loan is an IO mortgage has increased from 14% on average in 2003–06, to 35% in 2007–10, and 48% in 2011–15. In line with our observations for the overall Danish mortgage market, cf. Figure 1 discussed earlier, we see that 51% of the households in our sample in 2011–2015 have at least one IO mortgage. As previously mentioned, some of the IO mortgages do not require borrowers not to make repayments, but grants them the option not to do so. The summary statistics show that 93% of the IO mortgages only pay interest in the randomly chosen year for each mortgage. In other words, more than nine out of ten households with an IO mortgage use their right to pay only interest. As in the overall Danish mortgage market (see Figures 2 and IA.2), the popularity of FRMs in our sample has declined over the years with a corresponding growth in ARMs. The interest rates on the mortgages in our sample have decreased over the period considered both due to the general decrease in interest rates for all types of mortgages and to the increasing use of ARMs as these typically have lower interest rates than FRMs. Also note that for IO mortgages 33% are FRMs and 67% ARMs, whereas 68% of repayment mortgages are FRMs and only 32% ARMs. This difference explains why the average interest rate is higher for repayment mortgages than for IO mortgages. The average loan-to-income ratio (LTI) increases over the sample period. Looking at the average LTI by mortgage type, it follows that LTI equals 4.15 for the IO mortgages, whereas it is only 2.87 for the households with a repayment mortgage. This indicates that IO-borrowers borrow more and buy more expensive houses than borrowers with conventional repayment mortgages.

## 3 Which households use interest-only mortgages?

### 3.1 Mortgage choice across age groups

The summary statistics show a clear difference in mortgage choice across age groups. For example, households of age 34 or younger hold 21% of all IO mortgages but only 14% of all repayment mortgages. Households of age 65 or older also have a significantly larger share of all IO mortgages than of all repayment mortgages. In contrast, households of age 40-59 hold a larger share of repayment mortgages than IO mortgages. A similar picture emerges when looking at households entering the mortgage market in the 2004-2015 period. For these entrants, the fraction taking an IO mortgage is over 70% for households above 60, around 60% for households below 40, and only around 50% for the middle-aged households, cf. Figure IA.3 in the Internet Appendix.[19] The fraction of households changing their

[19] A household is defined as entering the mortgage market if the household does not have any mortgage debt in the two years prior to the entry.

dominant mortgage type (from IO to repayment or vice versa) varies considerably over time but stays below 6% each year in every age group, cf. Figure IA.4 in the Internet Appendix. Relatively few households changed their mortgage type in the first years after the introduction of IO mortgages, whereas we see more activity from 2010 and forward. In the early years, more households replaced their repayment with an IO mortgage, whereas towards the end of the sample more households have changed their dominant mortgage from an IO to a repayment mortgage. This pattern can be explained by two observations. First, 2014 and 2015 are the first years where the IO-period for the very first IO mortgages run out. Second, interest rates are very low in Denmark during the latest years of our sample, cf. Figure 2, which makes it more affordable to pay down mortgages.

Our finding that the popularity of the IO mortgages has increased since the introduction in 2003 across all age groups is clearly illustrated by Figure 3 which shows the fraction of households holding an IO mortgage in each age group in the years 2004, 2009, and 2014. Young and old households have a higher fraction of IO mortgages compared to middle-aged households, and the relation between age and IO mortgages has become more U-shaped over time, which indicates an increasing use of IO mortgages to smooth consumption over the life cycle.

[Figure 3 about here.]

In order to investigate whether the age-dependence in mortgage choice is correlated with differences in background characteristics of the households, we run the probit estimation

$$P(D_i^{\mathrm{IO}} = 1|X_i, C_i) = \Phi\left(\beta' X_i + \delta' C_i + u_i\right). \tag{2}$$

Here $D_i^{\mathrm{IO}}$ is a dummy variable equal to one if household $i$'s dominant loan is an IO mortgage; $X_i$ is a vector of dummies for nine different age groups (less than 34, 35-39, ..., 70+); and $\Phi$ is the standard normal cumulative distribution function. The $C_i$ in Eq. (2) is a vector of control variables and includes the mortgage interest type (ARM/FRM), the logarithm of current disposable income measured in Danish Kroner, log of current bank holdings measured in Danish Kroner, the debt-to-asset ratio, the number of borrowers, the number of residents (adults and kids), the household type, the gender, the educational level, as well as regional dummies and time dummies. The probit estimation requires that each household is only present once, hence we represent each household by the origination year. To avoid selection problems with respect to which households borrow after 2003, we only use mortgages originated after 2003.

[Table 2 about here.]

The left panel in Table 2 presents the average partial effects (APE) together with robust standard errors in parentheses. The age group of 45-49 years is used as the base group. The table shows that both the two youngest groups (age 39 and below) and the four oldest groups (age 50 and above) have a significantly higher probability of holding an IO mortgage compared to households of age 45-49 with similar characteristics. At age 70 and above, the likelihood of taking an IO mortgage is as much as 34.2% higher than for the base group. These results confirm that IO mortgages are more popular among young and old homeowners than among middle-aged homeowners also after controlling for background characteristics.

The left panel of Table 2 further shows how mortgage choice is affected by the control variables after separating out the age dependence. We see that homeowners are less likely to hold an IO mortgage when the mortgage has a fixed rate instead of an adjustable rate, when current income level is higher, a male borrower is present, and when the household consists of more adults. On the other hand, the likelihood of holding an IO mortgage increases with the number of children, the education level, and the debt-to-asset ratio.

The results in the right panel of Table 2 are based on a probit estimation similar to Eq. (2), but where the dependent variable is a dummy variable indicating an FRM and the estimation only includes homeowners with an IO mortgage. We see that the youngest group has a 7% higher probability of combining their IO mortgage with a fixed rate, whereas the older homeowners tend to combine their IO mortgage with an adjustable rate. As illustrated in Figure IA.6 in the Internet Appendix most young households have an LTV near 80%, and hence the mortgage bank might require young households to have a fixed rate on an IO mortgage to eliminate the risk of future increases in interest payments.

The Internet Appendix provides additional robustness checks. First, we run the probit estimation of Eq. (2) year by year. For the households above 45, we see that our results are robust over time, whereas the young have increased their tendency to take out an IO mortgage, cf. Figure IA.10. Second, as an alternative to the probit, we run an OLS with fixed effects and find comparable results, cf. Table IA.4 and Figure IA.11. Third, we compare homeowners with ARM to homeowners with FRM, cf. Figures IA.12 and IA.13.

### 3.2 Consumption smoothing

A standing assumption in financial economics is that households would like to smooth consumption over the life cycle so that consumption is less volatile than income. Labor income typically starts out at a low level, increases significantly until age 45-55, and subsequently flattens out or even drops somewhat until retirement (Cocco, Gomes, and Maenhout, 2005; Guvenen, Karahan, Ozkan, and Song, 2021). Consumption smoothing

is thus the key motivation for retirement saving and for why young households often borrow funds and pay back when their income has increased. The access to an IO mortgage grants households more flexibility in life-cycle consumption planning and, in particular, facilitates consumption smoothing. More specifically, young households may find IO mortgages attractive as they typically expect significant labor income growth in the coming years. Older homeowners with no or little labor income or pension payouts would like to finance consumption by reducing net wealth. Whereas a repayment mortgage increases net wealth by reducing the outstanding loan balance, an IO mortgage may be attractive, in particular if the homeowner is liquidity constrained in the sense that the home equity constitutes a large share of total household net wealth. That is, an IO mortgage may allow financially constrained older homeowners to stay in their home and avoid a stressful and costly process of selling and moving.

Section 3.1 already documented that young and old homeowners are more inclined to take an IO mortgage than middle-aged homeowners, which is consistent with the above consumption smoothing mechanisms. Figure 4 gives further support to this motivation. It depicts estimated life-cycle consumption and income profiles for households with an IO mortgage and households with a repayment mortgage. Panel A shows that homeowners with an IO mortgage tend to consume more than current income when they are below 35 and above 65 years, whereas middle-aged IO borrowers tend to be net savers. Panel B illustrates that homeowners with repayment mortgages tend to consume less than their current income and thus be net savers throughout their life cycle. These graphs indicate that IO borrowers engage more in consumption smoothing than borrowers with a conventional repayment mortgage.[20] The following two subsections dig deeper by investigating the motives behind the IO mortgage choice separately for young and for old households.

[Figure 4 about here.]

### 3.3 Young households and expected income growth

According to the consumption smoothing motive, borrowers should be more inclined to take an IO mortgage the higher is their expected future income growth, as also argued in Cocco (2013). To test this hypothesis with our data, we rerun the probit estimation stated in Eq. (2) with income growth added to the list of explanatory variables. As households' expected income growth is unobservable, we follow Cocco (2013) and measure

[20] Ideally, we would have liked to compare the *actual* life-cycle profiles of households with an IO mortgage to households with repayment mortgages but, due to the time-span of our data, this is impossible. Instead, inspired by Betermier, Calvet, and Sodini (2017), we sort households by birth year into different cohorts using balanced data, and estimate the life-cycle profile of the two different types of households as seen in Figure 4. The precise estimation method is described in Section IA.3 of the Internet Appendix.

the expected annual income growth rate by the average annual realized change in the logarithm of disposable income over $h$ years, i.e.,

$$\text{income growth} = \frac{\ln(\text{income}_{t+h}) - \ln(\text{income}_t)}{h}.$$

Larger values of $h$ reduce the noise in the income growth measure, but also lead to fewer observations in our sample. Figure 5 shows the average partial effect of income growth measured over $h = 7$ years on the likelihood of having an IO mortgage across the different age groups; similar patterns are seen for $h = 4, 5, 6$.[21] We see that the impact of future income growth on the likelihood of choosing an IO mortgage is large and positive for the young, is decreasing with age, and ends up small and even negative for households above 55.[22] Specifically for the youngest group of households, the likelihood that the household has an IO mortgage increases by approximately 100% when annual income growth over seven years increases by 1%. This clearly indicates that some households use IO mortgages to release money today when income is relatively low and wait repaying their mortgage until their income is higher. This supports the hypothesis that consumption smoothing over the life cycle by postponing repayments to periods with higher income is concentrated among younger households.[23] The findings are consisting with the conclusion of Cocco (2013) on a smaller sample of UK households of age 20-60. We refine his conclusion by showing that the income growth is driving IO take-up only among the younger households and, in fact, income growth has the opposite effect on IO choice among older households.[24] Other factors must explain the strong tendency for old households to use IO mortgages.

[Figure 5 about here.]

Using an alternative measure of permanent income in different education and occupation groups, Cocco (2013) finds that groups with higher income variance are less likely to choose an IO mortgage. However, for the variance-effect to be significant, income growth has to be excluded from the regression and, as noted by Cocco (2013), income risk and income growth are highly collinear. Cocco's finding could potentially explain the inclination of older households towards IO mortgages as they face relatively low income risk. It is not clear, though, why households with lower income risk should have a higher demand for

[21] We add the same control variables as for the probit estimation in Eq. (2) and find similar effects. For example, the effects of education on the probability of holding an IO is at the same level as in Table 2.

[22] As for the other probit estimation, we ran an OLS estimation with fixed effects as a robustness check, and found comparable results, cf. Figure IA.14 in the Internet Appendix.

[23] In our data, the annual mean income growth over 7 years is convex over the age-groups: 5.25% for the households of age 34 and below, dropping to around zero for the 55-64 year olds (of which most enter retirement over the subsequent 7 years), and then increasing to 2-3% in retirement (partly due to inflation-indexation of public pensions). The standard deviation is 3-4% across all age groups.

[24] The average mortgage holder is 34 years in Cocco's sample but 48 years in our sample.

IOs. In fact, households with uncertain income benefit from having an IO mortgage since the lower mortgage payments help them staying in their home should income temporarily fall. In the Internet Appendix, Table IA.3 shows that in our sample the IO take-up is similar among households with at least one self-employed adult as among households with no self-employed adults, even though self-employed typically have a more uncertain income. Moreover, Figure IA.15 shows that income volatility is positively correlated with the probability of having an IO mortgage for all age groups, but the correlation decreases with age and becomes insignificant for the oldest age group.

### 3.4 Old households and liquidity constraints

For older homeowners, we hypothesize that liquidity needs are the main driver of the demand for IO mortgages. Liquidity-constrained households have an incentive to free up needed liquidity by taking an IO mortgage and spend the saved repayments in order to maintain a given consumption level. Using a term coined by Kaplan and Violante (2014), some old households are "wealthy hand-to-mouth": they hold little or no liquid wealth but at the same time highly valuable illiquid assets in the form of home equity after having paid down their mortgage. Kaplan and Violante (2014) argue that wealthy-hand-to-mouth households should be more responsive to fiscal stimulus. In the same vein, our hypothesis is that the introduction of IO mortgages should impact constrained households more than unconstrained households.

To measure how liquidity constrained a given household is we calculate the illiquid-asset-ratio

$$\text{IAR} = \frac{\text{Public property value} - \text{Outstanding mortgage debt}}{\text{Total assets}},$$

where the numerator is a measure of the home equity, and the denominator includes cash, bank deposits, stock and bond holdings, as well as the public property value of all properties owned by the household (the public property value is explained in footnote 10).[25] A high IAR indicates that a large share of the household's assets are held as relatively illiquid home equity. Figure 6 shows that, except for very young households, the fraction of households with an IAR above 50% increases with age, and old households are the most liquidity constrained.[26]

[25] Note the IAR measure is not directly comparable to the "wealthy hand-to-mouth" measure used in e.g. Kaplan and Violante (2014). Most importantly the IAR measure does not include pension savings as part of the household's illiquid assets.

[26] The denominator in the IAR ratio is typical lower for young households. On top of this, banks might also require a higher down-payment for very young households buying their first home. This can explain why the fraction of households with an IAR above 50% decreases in age for households below 30.

[Figure 6 about here.]

To get a better understanding of the relation between a household's illiquid-asset-ratio and the probability of taking up an IO mortgage, we run the probit estimation

$$P(D_i^{\text{shift}} = 1|C_i) = \Phi\left(\beta_1 \,\text{IAR}_i + \beta_2 \,\text{DTA}_i + \beta_3 \,\text{IAR}_i \times \text{DTA}_i + \delta' C_i + u_i\right) \tag{3}$$

for each age group. $D_i^{\text{shift}}$ is a dummy variable equal to one if household $i$ refinances a repayment mortgage to an IO mortgage, and $\text{DTA}_i$ is the debt-to-asset ratio. We include only households with a repayment mortgage in the regression, and exclude first-time homeowners and households already holding an IO. To ensure all households are represented only once, we use data for the year where the given household refinances, if it does, and a random year if it does not refinance its mortgage in the period 2003–2011. To account for the economic situation of the household the year it refinances, various control variables are lagged one period, e.g. the debt-to-asset ratio, the illiquid-asset-ratio, the mortgage interest type (ARM/FRM), bank holdings, and income. We also include a dummy for a negative income shock of more than 10%, e.g. due to sudden unemployment, as this could raise an immediate need for liquidity and hence affect the probability of converting a repayment mortgage to an IO. We include both the current and a one-period lagged dummy for the negative income shock. We control for the number of borrowers, the number of residents (adults and kids), the household type, the gender, the educational level, as well as regional dummies and time dummies. From Section 3.3 we know that future income growth is a good predictor of young households' demand for IOs. Hence, we also control for future income growth.[27] The results from the probit regression can be seen in Table 3.

[Table 3 about here.]

Table 3 shows that a high illiquid-asset-ratio has a positive effect on the probability of refinancing a repayment mortgage with an IO mortgage. The effect is significant for all age groups, but larger for the older households where IAR has the largest explanatory power. A negative income shock also has a positive effect on the probability of refinancing to an IO mortgage, again with the effect increasing in age. For the middle-aged group, a negative income shock could come from a job loss, but as also seen in Andersen et al. (2020a) unemployment has a modest effect on refinancing to an IO mortgage as the borrower is typically prevented from refinancing by the mortgage bank due to the unemployment

[27] Here we calculate income growth over only four years to reduce the loss of observations. Our results are similar when using longer periods for estimating income growth, but less significant due to fewer observations.

status. For an older household, a negative income shock might follow from the death of a spouse. If the household at the same time has a high IAR, a conversion from a repayment mortgage to an IO mortgage can allow the widow(er) to stay in their home, and avoid a potentially stressful and costly process of selling and moving. In line with our earlier results, income growth has the highest explanatory power for the young households, whereas the IAR has the highest explanatory power for the oldest households.[28]

[Table 4 about here.]

To test our hypothesis that the introduction of IO mortgages should impact constrained households more than unconstrained households we use a difference-in-differences (diff-in-diff) estimation in which the IO introduction in late 2003 is considered an exogenous shock, cf. the discussion in Section 2.2. Before going into details with the diff-in-diff estimation, consider the sample used in this analysis. The left part of Table 4 shows summary statistics for households with an average age above 60 for the two sub-periods before and after the introduction of IO mortgages. When comparing these with the summary statistics for our full sample in Table 1, we see, as expected, that households above 60 have lower debt, lower debt-to-asset ratios, lower income, higher loan-to-income, lower consumption, higher use of IOs, and more live as singles. Comparing the two subperiods in Table 4, we note that total debt, income, and consumption increases over the two subperiods, and the same pattern is seen for the full sample in Table 1. Finally, we note that the average IAR equals 53%, i.e. more than half of the wealth of old households is tied up in their home, compared to approximately 38% for the full sample. This is consistent with the pattern seen in Figure 6.

As our sample starts in 2001, we calculate pre-shock consumption over 2001–2003 and, to balance the before- and after-period, we measure post-shock consumption over 2004–2006. In each of these years and for each household we calculate the IAR defined above. The treatment group includes households having a high IAR, defined as 50% or more, throughout the 2001–2003 period. The control group consists of households having an IAR below 50% in 2001–2003.[29] To align our treatment and control groups, we use matching in the form of a one-to-one matching minimizing the difference in the propensity score. The matching is based on year 2002 values, and the same low IAR-household is used as the match for each high-IAR homeowner through time. Replacement is allowed, meaning

[28] Liquidity needs may also be an important determinant of the demand for IO mortgages for young households, but the IAR measure does not capture this need. An alternative measure for young households could be their LTV but, when including LTV instead of DTA in our regressions, the LTV has only little explanatory power for the IO decision of young households. Figure IA.6 in the Internet Appendix shows that the distribution of the LTV is centered around 80% for young homeowners (so that most of them appear liquidity constrained), whereas this is not the case for the older households.

[29] Similar results are obtained using a threshold different from 50%.

that each low IAR-household can appear as match for several high-IAR homeowners.[30] Replacement improves the overall match and thereby minimizes the risk of a bias in the diff-in-diff estimation.[31] For completeness, the right panel of Table 4 shows the summary statistics in 2002 for our treatment and control groups, respectively.

To estimate the causal effect of IO mortgages on consumption we run the following diff-in-diff estimation

$$\log(\text{cons}_{it}) = \beta_0 + \beta_1 D_t^{\text{after IO}} + \beta_2 D_i^{\text{high IAR}} + \beta_3 D_i^{\text{high IAR}} D_t^{\text{after IO}} + \delta' C_i^{2002} + u_{it}, \quad (4)$$

where the dummy $D_i^{\text{high IAR}}$ is an indicator for the treatment group, and the time dummy $D_t^{\text{after IO}}$ differentiates the time before (2001–2003) and after (2004–2006) the shock. The vector of control variables, $C_i^{2002}$, includes type of mortgage, logarithm of disposable income, future income growth, debt-to-asset ratio, number of adults, borrowers, and kids, household type, gender, educational level, as well as regional trends in house prices. All control variables are represented by their 2002-level, i.e., before the introduction of IO mortgages, to make sure that changes in consumption are not driven by changes in the control variables.

[Table 5 about here.]

The results of the estimation are shown in Table 5. As expected, we see a significant effect only for households close to or above the retirement age. For households in the age group 60-64 the introduction of IO mortgages implied an increase in the annual consumption of 6% for households with a high IAR compared to households with a low IAR, whereas households in the age group 65-69 have an increase of 7%, and households above 70 have an increase of 9%. These results point to an important role of IO mortgages for liquidity-constrained older households. By using IO mortgages, these households can free up liquidity, allowing them to consume more. Without access to IO mortgages, these old households would have consumed less and build up an even larger home equity.[32]

One may question whether the consumption increase documented above is due to the general credit expansion in the period leading up to the financial crisis instead of the IO introduction itself. As a first check, we look at the credit developments around the

[30] Almost 60% of the households with low IAR are used as replacement only once, 22% twice, 8.5% three times, and only 3.3% are used more than 5 times.

[31] Figure IA.17 in the Internet Appendix verifies that the trends of consumption before the IO introduction are almost parallel.

[32] The IO choice may interact with the ARM/FRM choice as the lower interest rate of an ARM also reduces monthly payments and thus facilitates consumption smoothing. As a robustness check, we rerun the difference-in-difference regression in Eq. (4) controlling for the choice of mortgage in 2006. The results shown in Table IA.5 in the Internet Appendix are similar to those stated in Table 5 in the paper and, hence, the change in the interest rate type does not appear to drive the consumption effects.

IO introduction. Figure IA.16 in the Internet Appendix shows that while the younger households borrowed more right after the IO introduction in 2003, the older households did not. Also, Figure IA.5 shows that, across all age groups, the fraction of homeowners without a mortgage that take up a new mortgage is constant around the IO introduction. These findings indicate that there was no credit expansion for the older households around the IO introduction. Furthermore, running the probit regression of Table 3 over only the 2004-2006 period, we find that also in this period the liquidity-constrained older households were more likely to refinance from a repayment to an IO mortgage compared to those with high liquidity, see Table IA.7 in the Internet Appendix, so the consumption increase is most likely facilitated by this refinancing.

To separate the credit-supply effect from the effect of IO access, we conduct a placebo test by running a diff-in-diff estimation similar to Eq. (4), but comparing the 2006-2008 pre-crisis period to the 2009-2011 period where credit supply was tightened but the IO legislation was unchanged. The test results support our view that the consumption effects found in Table 5 are not due to a general credit expansion. See the Internet Appendix for details, in particular Table IA.6.

## 4 How do households use the extra liquidity from IO mortgages?

Interest-only mortgages have been blamed for leading households into excessive borrowing and consumption. By relaxing a commitment constraint to pay down a mortgage, IO mortgages allow households with preferences for constraining their own future choices (Laibson, 1997) to overconsume, in particular when young. In this sense, financial liberalization, in the form of interest-only loans, may provide consumers with "too much" liquidity. At a first glance, our data might appear to confirm this hypothesis.

The summary statistics in the right part of Table 1 show that IO mortgages are typically larger than repayment mortgages, also relative to household income. Households with an IO mortgage have, on average, lower income but a larger total debt, a larger debt-to-asset ratio, and a significantly larger loan-to-income ratio. Furthermore, IO borrowers have a higher consumption-to-income ratio and make lower pension contributions than borrowers with a repayment mortgage. Overall, these observations seem to justify the concerns often mentioned in the public debate on alternative mortgages. On the other hand, we find that default rates in our data set are low even for households with IO mortgages during the financial crisis: the average fraction of loans between 2009 and 2016 in arrears for 105 days is 0.28% for IO and 0.22% for repayment mortgages. At least these numbers show that IO mortgages do not necessarily lead to high default rates, even if households do not fully comprehend the IO features—as explored by Johnson and Sarama

(2015) and Jørring (2020) using US data. However, that default rates are so low and similar across mortgage types might be specific to the Danish setting. First, for most IO mortgages in Denmark, amortization starts 10 years after issuance, which means in 2013 or later and thus not in the midst of the crisis.[33] Second, IO mortgages may only be issued to households that could afford a repayment mortgage. Third, should an IO borrower be financially challenged when the amortization period begins, the mortgage institutions and banks can often offer a refinancing package allowing the borrower to stay in the home.[34]

In the next sections, we use the fact that we have detailed data on different types of debt and the asset composition of the households to see whether households with IO mortgages reshuffle their debt composition in meaningful ways and whether IO mortgages influence the asset composition and pension contributions of households.

### 4.1 Reduction in life-time borrowing costs

By taking an IO mortgage, households can pay down more expensive bank and credit card debt instead of their mortgage, and hence reduce life-time borrowing costs. Figure 7 gives a detailed picture of the financial situation of households with an IO mortgage and households with a repayment mortgage, respectively. The figure is designed like Figure 4 but illustrates patterns of total debt, other debt (i.e. bank debt and other types of non-mortgage debt), cash (balance of bank account), market value of stocks and bonds, public valuation of the home, and the contribution to pension saving schemes over the life cycle. In this section, we focus on mortgage debt and other debt, i.e. Panels (a) and (b). The four other panels are discussed in subsequent sections.

[Figure 7 about here.]

Panel (a) of Figure 7 shows that, at all ages, homeowners with IO mortgages have higher mortgage debt relative to income than homeowners with repayment mortgages. The distance between the two curves increases with age due to the drop in income, not an increase in mortgage debt.[35] Panel (b) illustrates that other debt relative to income is decreasing over the life cycle. Until the age of 72, other debt is higher for homeowners with an IO mortgage than for homeowners with repayment mortgages, whereas the reverse is

[33] It follows from Figure IA.2 that house prices in 2013 and forward are at the same level or above the prices in 2003, and hence the affected households can refinance to a new IO mortgage if needed. Some regions in Denmark did not see an increase in house prices after the financial crisis and hence faced the problem with the end of the IO period. This is investigated in detail in Andersen, Beck, and Stefani (2022).

[34] See Berg, Nielsen, and Vickery (2018) for a detailed description of the differences between the Danish and US mortgage market and further explanations for the generally low default rates in Denmark.

[35] In absolute terms the value of mortgage debt is higher for households with IO mortgages over the entire life cycle. Also, for both types of households we see a drop in the absolute value of their total mortgage debt. These results are available upon request.

true for households older than 72 years. This indicates that homeowners with IO mortgages tend to take up more non-mortgage debt when young, but repay that non-mortgage debt more rapidly than homeowners holding a repayment mortgage.

Motivated by these patterns, we run the simple OLS regression

$$y_i = \beta_0 + \beta_1 D_i^{IO} + \delta' C_i + u_i, \tag{5}$$

where $y_i$ is the ratio of other debt to total debt for household $i$, and $C_i$ is the vector of the standard control variables. Table 6 presents the results. We find that, for age 40 and above, IO borrowers have a lower fraction of other debt relative to total debt than borrowers with repayment mortgages. For example, a household in the age group 55–59 with an adjustable-rate IO mortgage has a 3.0 percentage points lower debt-ratio than a similar household with an adjustable-rate repayment mortgage. If the household instead had a fixed-rate IO mortgage, the debt-ratio would be 2.1 percentage points lower compared to a household with a fixed-rate repayment mortgage (the sum of the three coefficients in the column 55–59 is $-0.021$). Interestingly, we see this pattern only for the middle-aged and old households, whereas the young households with an IO mortgage have a higher fraction of other debt relative to total debt. Hence, it seems that, except for young households, IO mortgages are used for reducing financial costs related to other, more expensive loans.

[Table 6 about here.]

### 4.2 Improved diversification

Homeowners may benefit from reducing their mortgage repayments and instead investing in financial assets to obtain a more diversified portfolio. Panel (c) of Figure 7 shows that homeowners with repayment mortgages hold more money in bank accounts relative to income than homeowners with IO mortgages. This indicates that IO mortgages are not chosen with the purpose of increasing cash balances.

On the other hand, Panel (d) reveals that savings in stocks and bonds relative to income are slightly higher for homeowners with IO mortgages. The market value of stock and bond holdings relative to income increases with age both for IO borrowers and borrowers with repayment mortgages but, in particular for middle-aged and older households, financial asset holdings are larger for IO borrowers. This suggests that some age groups might choose IO mortgages to increase investments in stock and bonds. To explore the effect in

more detail, we run the probit estimation

$$P(D_i = 1|X_i, C_i) = \Phi\left(\beta' X_i + \delta' C_i + u_i\right), \tag{6}$$

where $D_i$ is a dummy variable equal to one if household $i$ holds stocks, $X_i$ is the vector of interest and includes dummies for the nine different age groups, and $C_i$ is a vector of standard control variables. The probit estimation requires that each household is only present once, hence we represent each household by a random year after 2003. The results listed in Panel A of Table 7 show that the probability of investing in stocks increases with approximately 5% for middle-aged and old households with an IO mortgages, whereas among young households IO borrowers are slightly less inclined to participate in the stock market than borrowers holding a repayment mortgage.[36] These findings question the view that risk tolerance is a key driver of mortgage choice as was suggested by Cox et al. (2015). If IO mortgages are predominantly taken by more risk-tolerant households, we should see more stock market participation among IO borrowers across all age groups, but the younger households contradict this pattern. However, it could also be that younger IO borrowers (even risk-tolerant ones) are constrained—as indicated by Figure IA.6 in the Internet Appendix showing that most young households have an LTV around 80%—and hence have little money left to invest in the stock market.

Based on a simple probit regression, we cannot reject that there are unobservable determinants driving both the choice of IO mortgages and higher participation rates in stocks. We have estimated several diff-in-diff specifications using the introduction of IO mortgages to say something more precise about causality. First, Panel A of Table IA.8 in the Internet Appendix shows the results of a diff-in-diff regression similar to Eq. (4), but with stock market participation as the dependent variable, so that we test whether the IO introduction affected stock market participation differently for the liquidity-constrained, high-IAR homeowners than the low-IAR homeowners. We see no significant effect of the IO introduction in any of the age groups. This is not surprising given the empirical literature showing that indirect entry costs (representing, e.g., lack of knowledge) are central for the stock market participation decision, and the IO introduction has no obvious effect on these costs. However, households already investing in the stock market have paid the entry costs so they might increase their stock investments when getting access to IO mortgages. Hence, in a second diff-in-diff regression where we restrict our sample to households that at some point in time have participated in the stock market in the 2001–2006 period, we hypothesize that households with a high IAR increase their allocation to stocks after

[36] When running the probit estimation with $D_i$ indicating participation in the stock or the bond market (or both), the age group coefficients are slightly higher, e.g., 0.063 for the 60-64 year old instead of 0.058 with stock market participation only. Details are available upon request.

the introduction of IOs compared to households with a low IAR. That is, we rerun the diff-in-diff estimation stated in Eq. (4) with

$$\text{RAS} = \frac{\text{Market value of stock holdings}}{\text{Market value of bank deposits, stock-, and bond-holdings}}$$

as the dependent variable. The results in Panel B of Table IA.8 show that, in the age group 55–59, households with a high IAR increase their risky asset share by 2.9% more compared to households with a low IAR due to the introduction of IO, and the effect is significant at the 5% level. For all other age groups, the effect is smaller and insignificant. So while the proofs of causality are limited, our results indicate that some middle-aged households choose IO mortgages to increase stock investments.[37] The old and the young seem to use IO mortgages for other purposes. For example, Table 7 shows that an old household with an IO mortgage has a higher probability of holding stocks, but the results from the diff-in-diff regressions indicate that old households do not take an IO mortgage to buy stocks, but to smooth consumption as illustrated in Table 5.

### 4.3 Pension contributions

As explained by Amromin et al. (2007), homeowners may, under some conditions, benefit from reducing their mortgage repayments and instead increase their contributions to retirement saving accounts. Panel (f) of Figure 7 shows that pension contributions in our data are hump shaped, peaking around the age of 45, and turning negative in the late 60s when the pension payout period typically starts. Pension contributions seem almost unrelated to the mortgage type. To investigate this in more detail, we first run a probit estimation similar to Eq. (6), but with the dummy variable $D_i$ being equal to one if household $i$ contributes to a private pension saving account. All working households in Denmark pay into a labor-market pension program. On top of that, households may voluntarily pay contributions to a private pension scheme. Hence, our probit regression tells us if households with an IO mortgage are more likely to make voluntary pension contributions, in this case indicating that they use some of the saved repayments to pension contributions. Panel B of Table 7 shows that very young households are less likely to make private pension contributions if they have an IO mortgage. On the other hand, households above 55 seem to use the saved repayments to pay into a private pension.

To get an idea of the magnitude, we run an OLS regression similar to Eq. (5), but with the dependent variable $y_i$ being the average total pension contribution per adult per year. Panel C of Table 7 shows that households above 45 with an IO mortgage make larger

[37] As in other European countries, the stock market participation rate in Denmark is low which implies a low number of observations and thus makes it difficult to show significance.

voluntary pension contributions. For example, in the age group 50-54 a household with an adjustable-rate IO mortgage pays on average 4,761 DKK more into their pension account per adult compared to a household with an adjustable-rate repayment mortgage. A household with a fixed-rate IO mortgage pays 7,198 DKK more into their pension account than a household with a fixed-rate repayment mortgage. Interestingly, the coefficients are only significant for households in the age groups 45-49, 50-54, and 55-59, and the biggest difference is seen for households of age 50-54. Hence, it seems that households in their late 40s and 50s use some of the saved repayments from their IO mortgages to increase their pension savings, and in this way smooth consumption over the life cycle.

[Table 7 about here.]

Amromin et al. (2007) suggest that non-conventional mortgages can be used by US households to set up a tax-arbitrage strategy. US households can save taxes by reducing repayment of mortgage debt and investing a similar amount in tax-favored retirement saving schemes (in mortgage bonds or similar assets to keep the overall risk unchanged). In Denmark, a similar arbitrage-like strategy can be implemented by homeowners who (i) have less than ten years to retirement and can thus take an IO mortgage at least until retirement and (ii) pay the highest marginal tax rate while working but a lower tax rate during retirement. Consider, for example, a mortgage with a 2% interest rate and a 0.5% contribution rate to the issuer. Since tax deductability of interest rate (and contribution) expenses is about 25%, the after-tax borrowing cost is $(2\% + 0.5\%) \times (1 - 0.25) = 1.875\%$. This represents the costs of postponing the repayment of the loan. By investing the saved repayment in a similar 2% mortgage bond through a pension fund, the return is taxed at a rate of 15.3%, leaving an after-tax return of $2\% \times (1 - 0.153) = 1.694\%$, which is lower than the saved mortgage costs and thus apparently not an arbitrage. However, pension contributions are deductable from labor income so the household can increase their investment by more than the saved repayment. On the other hand, pension payouts are also taxed as labor income but, due to the progressive tax system, the income tax rate for some households is considerably higher before retirement when the extra pension contributions are made than after retirement where income is typically lower and where the extra pension payouts are received. For such households an arbitrage-like strategy involving IO mortgages is possible also in a Danish context.[38] Unlike the case for some retirement saving schemes in the US, pension savings can only at a high cost be paid out prematurely in Denmark (premature pension payouts are taxed heavily to discourage such withdrawals), so the above strategy is not feasible for younger households. As mentioned, Panel B of Table 7 reveals that in particular households above 50 seem to have used saved

[38] This strategy is sometimes discussed in the Danish media and on webpages of Danish pension funds.

repayments to increase pension contributions. Given that the average retirement age in Denmark is around 65, this could reflect the tax arbitrage described above.

## 5 Summary and conclusion

We make two main contributions to the literature on households' use of IO mortgages. First, we show that there is not a uniformly positive relation between households' future income growth and their use of IO mortgages. The relation is positive for young households, as has been reported in the literature, but negative for old households. To explain the large use of IO mortgages among old households, we propose and verify empirically that IO mortgages relax an otherwise binding liquidity constraint, by allowing old households to reduce repayment of existing mortgages, thereby increasing liquidity and improving consumption smoothing.

Second, based on our detailed data on the debt and asset composition of households, we show that households with IO mortgages are more indebted, but pay down non-mortgage debt to a larger extent, save more in stocks, and contribute more to pension savings, compared to households with repayment mortgages.

Several of our findings thus indicate that, by relaxing a borrowing constraint, IO mortgages facilitate household consumption smoothing over the life cycle and, in particular, they can improve the welfare of young households expecting increasing income and old, liquidity-constrained households. Furthermore, IO mortgages allow households to reduce life-time borrowing costs and to obtain a better diversified asset portfolio. When assessing the overall welfare implications of IO mortgages, these benefits can be contrasted with the higher leverage of households with IO mortgages.

We look at the microeconomic evidence. We cannot rule out that IO mortgages have additional macroeconomic effects that cannot be covered in full when studying microdata. For instance, as mentioned earlier, Dam et al. (2011) find that the introduction of IO mortgages contributed to the surge in home prices during the housing boom in Denmark. This not only harms prospective homeowners but also the broader economy by potentially contributing to boom-bust cycles. Furthermore, increasing the ability for households to lever up may lead to a misallocation of credit to the household sector relative to more productive sectors and can thereby reduce innovation and growth, cf. Jappelli and Pagano (1994). It is outside the scope of this paper to evaluate these macroeconomic effects.

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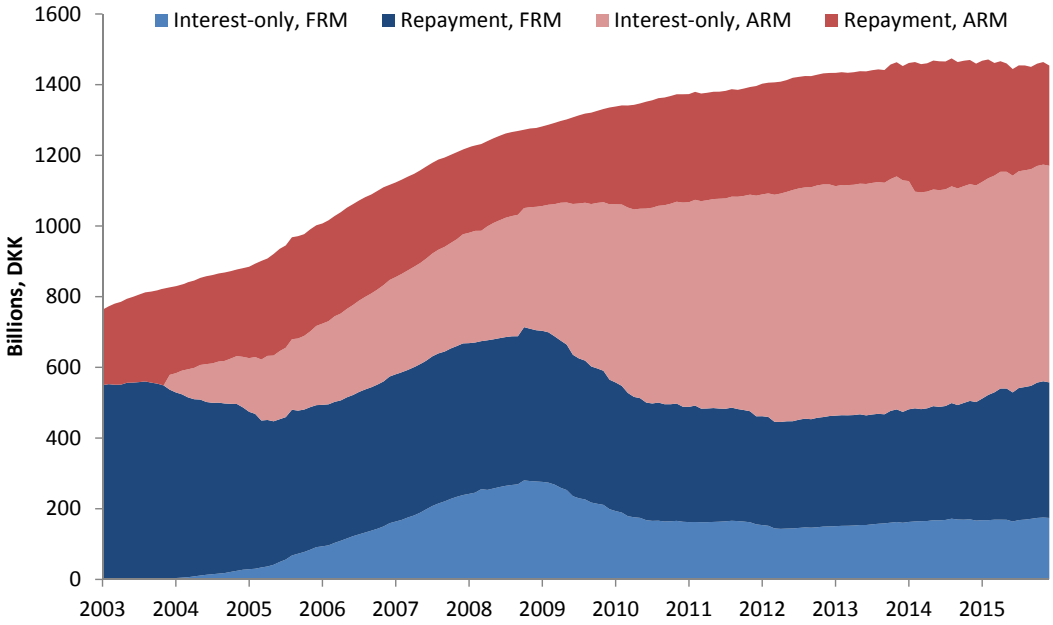


**Figure 1: Outstanding mortgages by type.** The graph shows the face value of outstanding residential mortgages in Denmark each month in the period 2003–2015. As of 6 October 2021, the exchange rates are DKK 1 ≈ USD 0.155 ≈ EUR 0.134. The total issuance is divided into four subgroups: interest-only FRMs (light blue area), repayment FRMs (dark blue), interest-only ARMs (light red), and repayment ARMs (darker red). Data source: Danmarks Nationalbank.

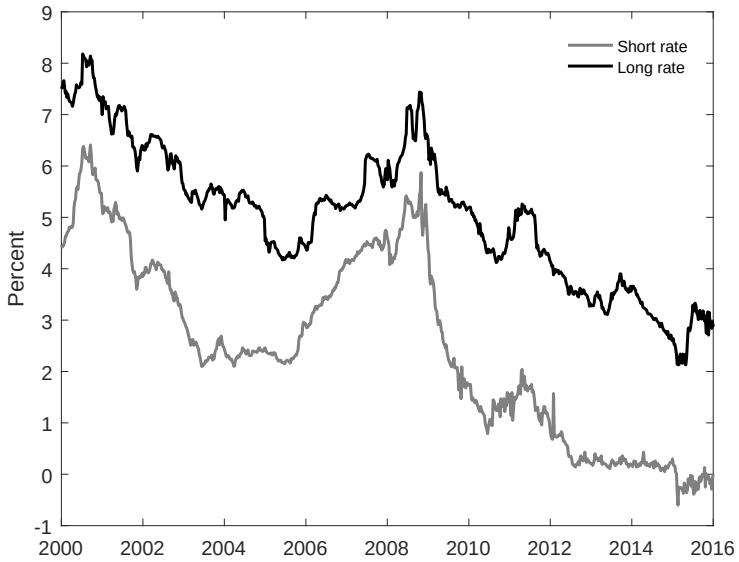


**Figure 2: Average Danish mortgage rates in percent.** The rates are calculated on a weekly basis and show the average yield-to-maturity on mortgage-backed bonds denominated in Danish Kroner. Data source: Finance Denmark.

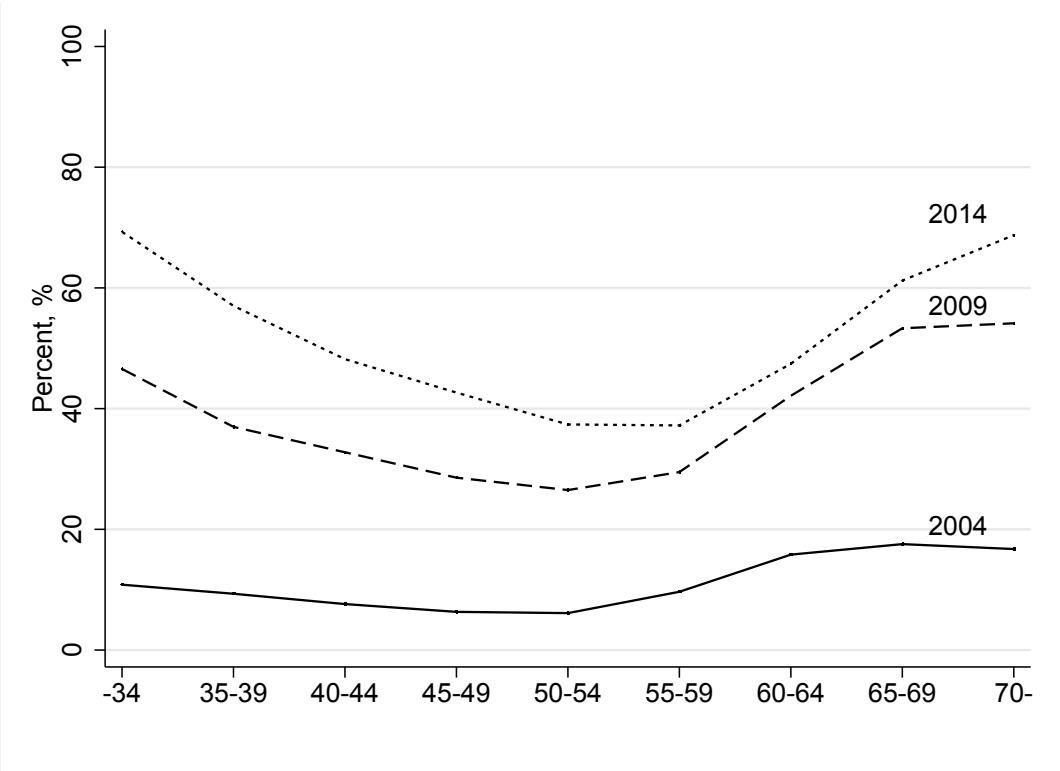


**Figure 3: Fraction of IO mortgages.** For each of the years 2004, 2009, and 2014, the graph shows the fraction of households in each age group that holds an IO mortgage.

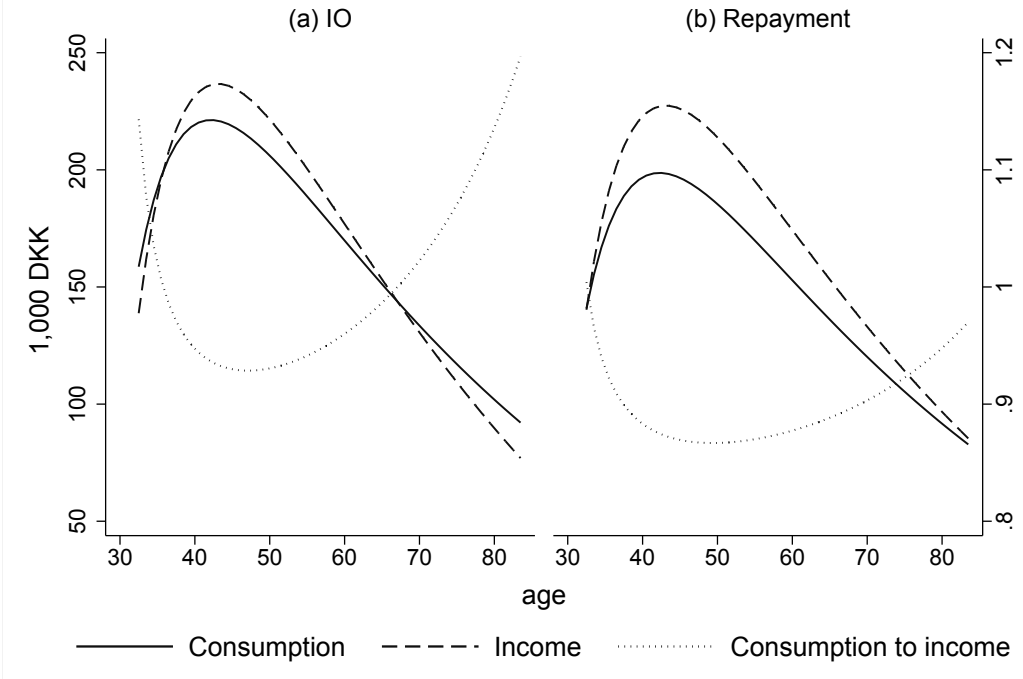


**Figure 4: Consumption and income patterns over the life cycle.** The graph presents median of annual consumption (solid line), annual income (dashed line), and the consumption-to-income ratio (dotted line; right-hand axis) over the life cycle. Consumption and income are measured as an average per adult in the household. Panel A is based on homeowners holding an IO mortgage at some point within the period from 2004 to 2015, whereas Panel B is based on homeowners holding only repayment mortgages within this time period. The graphs are generated by polynomial fits of nine age groups defined as: below 35, 35-39, 40-44, ..., 65-69, and 70+ in 2004. Each observation for an age group is illustrated at the average age in that group. The graph applies balanced data on homeowners from 2004 to 2015.

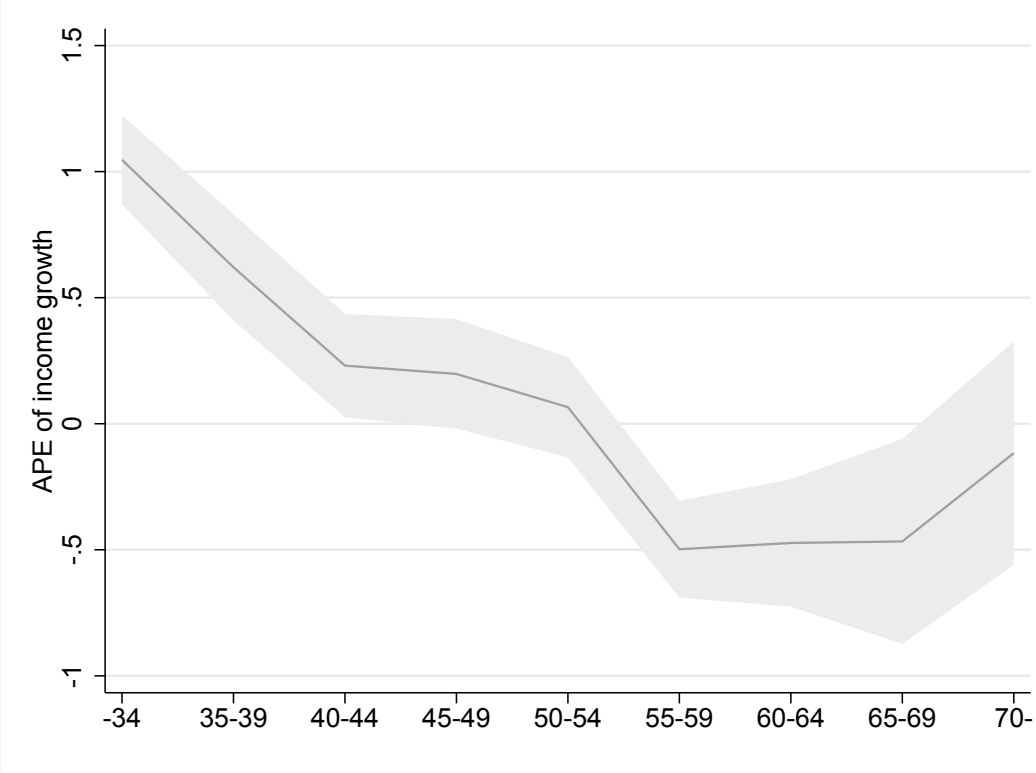


**Figure 5: Average partial effects of income growth across age groups.** The figure presents average partial effects (solid line) of income growth measured over $h = 7$ years for each age group from the probit estimation stated in Eq. (2) with the income growth rate added to the list of explanatory variables. The shaded area displays the 95% confidence interval.

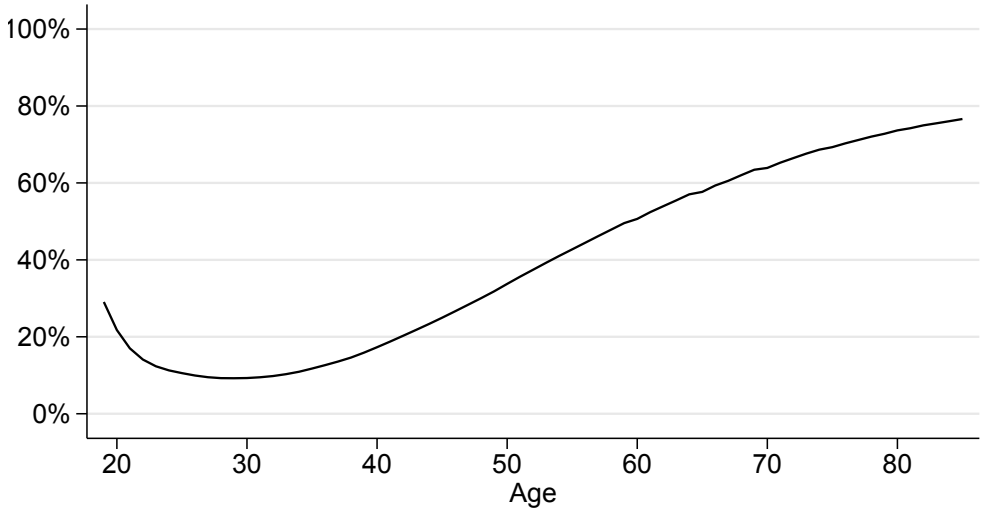


**Figure 6: Age profile of fraction of households with IAR $> 50\%$.** The figure presents the age profile of the fraction of households with an IAR above 50%. The figure is based on all Danish homeowners in the period from 1995 to 2015.

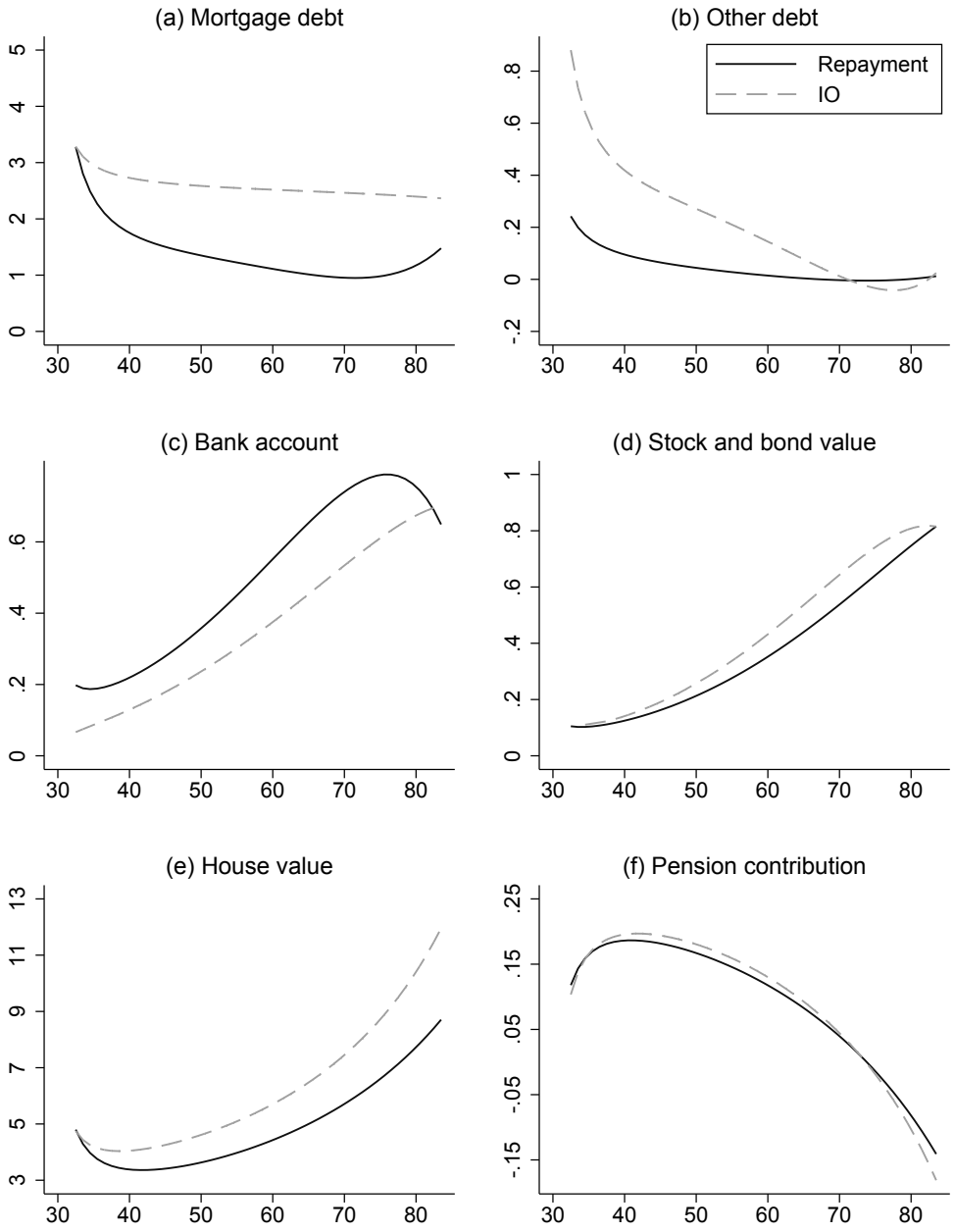


**Figure 7: Life-cycle patterns for different financial variables relative to income.** The graphs depict medians of mortgage debt, other debt, bank account, public house value, and pension contributions, as well as means of market value of stocks and bonds, from 2004 to 2015 for different age groups and across mortgage type. All variables are measured relative to annual income. The graphs show an overall polynomial fit of all the age groups. Nine age groups are used; below 35, 35-39, 40-44, ..., 65-69, 70 and above in 2004. Each observation for an age group is illustrated at the average age in that group. The dashed curves are based on homeowners holding an IO mortgage at some point within the period from 2004 to 2015, whereas the solid curves are based on homeowners holding only repayment mortgages within this time period. The graph applies balanced data on homeowners from 2004 to 2015.

| | By subperiod | | | | By mortgage type | |
|---|---|---|---|---|---|---|
| | 2001-02 | 2003-06 | 2007-10 | 2011-15 | IO | Repay |
| CPI (2015=100) | 77.48 | 82.38 | 88.90 | 97.64 | 95.25 | 93.62 |
| **Mortgage characteristics** | | | | | | |
| Loan amount | 316.27 | 404.13 | 612.23 | 721.31 | 817.79 | 615.32 |
| LTI | 2.24 | 2.50 | 3.37 | 3.36 | 4.15 | 2.87 |
| IO mortgage | . | 0.14 | 0.35 | 0.48 | | |
| At least one IO mortgage | . | 0.14 | 0.37 | 0.51 | | |
| Actual IO period | . | 0.13 | 0.34 | 0.44 | 0.93 | 0.00 |
| FRM | 0.93 | 0.70 | 0.50 | 0.42 | 0.33 | 0.68 |
| Nom. interest rate (%) | 6.93 | 5.03 | 4.24 | 2.29 | 2.46 | 3.45 |
| **Household characteristics** | | | | | | |
| Total debt | 405.73 | 490.65 | 710.15 | 818.79 | 1003.84 | 687.23 |
| Debt to Asset ratio | 0.63 | 0.60 | 0.72 | 0.87 | 0.99 | 0.75 |
| Illiquid Asset Ratio | 0.39 | 0.37 | 0.31 | 0.17 | 0.10 | 0.25 |
| Income | 147.17 | 168.00 | 190.56 | 222.77 | 206.56 | 218.90 |
| Consumption | 135.94 | 161.56 | 184.68 | 203.09 | 200.14 | 199.11 |
| Consumption to Income | 0.94 | 0.99 | 0.99 | 0.94 | 1.01 | 0.93 |
| Pension contribution | 21.13 | 27.74 | 36.14 | 36.70 | 34.51 | 40.24 |
| Number of borrowers | 1.43 | 1.51 | 1.54 | 1.67 | 1.66 | 1.66 |
| Avg. age (borrowers) | 48.20 | 50.43 | 48.54 | 50.10 | 48.68 | 47.80 |
| age: -34 | 0.13 | 0.09 | 0.16 | 0.13 | 0.21 | 0.14 |
| age: 35-39 | 0.13 | 0.11 | 0.13 | 0.12 | 0.13 | 0.13 |
| age: 40-44 | 0.15 | 0.14 | 0.14 | 0.13 | 0.12 | 0.15 |
| age: 45-49 | 0.16 | 0.15 | 0.13 | 0.14 | 0.10 | 0.15 |
| age: 50-54 | 0.16 | 0.16 | 0.13 | 0.12 | 0.08 | 0.14 |
| age: 55-59 | 0.11 | 0.13 | 0.11 | 0.11 | 0.08 | 0.12 |
| age: 60-64 | 0.06 | 0.08 | 0.09 | 0.09 | 0.09 | 0.08 |
| age: 65-69 | 0.04 | 0.05 | 0.05 | 0.07 | 0.08 | 0.04 |
| age: 70- | 0.06 | 0.08 | 0.06 | 0.08 | 0.10 | 0.04 |
| Single | 0.21 | 0.21 | 0.18 | 0.17 | 0.18 | 0.15 |
| Household with several families | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 |
| Couple | 0.73 | 0.73 | 0.77 | 0.78 | 0.76 | 0.81 |
| Male | 0.88 | 0.88 | 0.90 | 0.90 | 0.88 | 0.92 |
| Number of adult residents | 1.76 | 1.77 | 1.81 | 1.81 | 1.80 | 1.84 |
| Number of kids | 0.85 | 0.80 | 0.91 | 0.92 | 0.92 | 0.98 |
| Education level 1 | 0.17 | 0.15 | 0.11 | 0.10 | 0.09 | 0.09 |
| Education level 2 | 0.46 | 0.44 | 0.45 | 0.43 | 0.42 | 0.43 |
| Education level 3 | 0.38 | 0.41 | 0.43 | 0.47 | 0.48 | 0.48 |
| Region Copenhagen | 0.22 | 0.22 | 0.17 | 0.16 | 0.20 | 0.15 |
| Region Zealand | 0.14 | 0.15 | 0.14 | 0.14 | 0.14 | 0.12 |
| Region South Denmark | 0.29 | 0.29 | 0.28 | 0.27 | 0.25 | 0.28 |
| Region Middle Jutland | 0.22 | 0.22 | 0.26 | 0.27 | 0.26 | 0.27 |
| Region North Jutland | 0.13 | 0.12 | 0.15 | 0.16 | 0.15 | 0.17 |
| Observations | 69,492 | 248,915 | 904,666 | 1,441,350 | 257,541 | 329,409 |
| Total observations | 2,664,423 | | | | 586,950 | |

**Table 1: Summary statistics.** The table presents average values related to the dominant mortgages. Loan amounts, debt, income, consumption, and pension contributions are in DKK 1,000, and measured as an average per adult in the household. For each subperiod the average value over the years is displayed. In the right panel, a random year of each mortgage is used as representative of the mortgage to ensure that each mortgage is weighted equally. Using a t-test, we find that all means for the two mortgage types are statistically different on a significance level of 1%, except for the educational levels. See Section 2 for a more detailed description of variables.

| | IO-borrowers among all borrowers | | FRM-borrowers among IO-borrowers | |
|---|---|---|---|---|
| | APE | Robust SE | APE | Robust SE |
| Age: -34 | 0.068*** | (0.003) | 0.070*** | (0.005) |
| Age: 35-39 | 0.011*** | (0.003) | 0.030*** | (0.005) |
| Age: 40-44 | 0.006 | (0.003) | 0.011* | (0.005) |
| Age: 50-54 | 0.017*** | (0.003) | -0.000 | (0.005) |
| Age: 55-59 | 0.108*** | (0.004) | -0.006 | (0.006) |
| Age: 60-64 | 0.233*** | (0.005) | -0.008 | (0.006) |
| Age: 65-69 | 0.294*** | (0.006) | -0.051*** | (0.007) |
| Age: 70- | 0.342*** | (0.007) | -0.077*** | (0.007) |
| FRM | -0.306*** | (0.002) | | |
| Log bank account | -0.002*** | (0.001) | 0.001 | (0.001) |
| Log income | -0.151*** | (0.003) | -0.106*** | (0.004) |
| Debt to Asset ratio | 0.227*** | (0.002) | -0.051*** | (0.003) |
| Male | -0.050*** | (0.004) | -0.022*** | (0.005) |
| Education level 2 | 0.022*** | (0.003) | -0.032*** | (0.004) |
| Education level 3 | 0.036*** | (0.003) | -0.015*** | (0.004) |
| Number of borrowers | 0.012*** | (0.002) | 0.021*** | (0.004) |
| Number of adult residents | -0.049*** | (0.006) | -0.011 | (0.008) |
| Number of kids | 0.015*** | (0.001) | -0.018*** | (0.001) |
| Single | 0.023*** | (0.006) | -0.002*** | (0.008) |
| Region Zealand | -0.071*** | (0.003) | 0.035*** | (0.004) |
| Region South Denmark | -0.140*** | (0.002) | 0.011** | (0.003) |
| Region Middle Jutland | -0.103*** | (0.002) | 0.014*** | (0.003) |
| Region North Jutland | -0.137*** | (0.003) | 0.043*** | (0.004) |
| Observations | 290,494 | | 145,951 | |
| Pseudo-$R^2$ | 0.236 | | 0.106 | |

Standard errors in parentheses

$^{*}$ $(p < 0.05)$ ,$^{**}$ $(p < 0.01)$ ,$^{***}$ $(p < 0.001)$

**Table 2: Characteristics of homeowners using interest-only mortgages.** The table presents average partial effects and robust standard errors (in parentheses) from two probit estimations. The numbers in the left shaded panel are based on the probit estimation in Eq. (2), where the dependent variable is a dummy variable indicating an IO mortgage, and the estimation includes homeowners with a mortgage originated between 2004 and 2015. The numbers in the right panel are based on a similar probit estimation, but where the dependent variable is a dummy variable indicating an FRM, and the estimation only includes homeowners with an IO-mortgage originated between 2004 and 2015. For both estimations household characteristics and regional and time fixed effects are also included. The origination year is used to represent the mortgage choice for each household.

| | -34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70- |
|---|---|---|---|---|---|---|---|---|---|
| IAR, lag 1 | 0.124*** | 0.080*** | 0.040*** | 0.041*** | 0.038*** | 0.063*** | 0.113*** | 0.132*** | 0.293*** |
| | (0.011) | (0.009) | (0.008) | (0.008) | (0.008) | (0.010) | (0.016) | (0.024) | (0.042) |
| DTA, lag 1 | 0.146*** | 0.119*** | 0.081*** | 0.071*** | 0.061*** | 0.070*** | 0.102*** | 0.103*** | 0.135*** |
| | (0.008) | (0.007) | (0.006) | (0.005) | (0.006) | (0.007) | (0.013) | (0.020) | (0.040) |
| Log income, lag 1 | -0.001 | -0.001 | 0.007 | 0.021*** | 0.020*** | -0.006 | -0.053*** | -0.044** | -0.050* |
| | (0.009) | (0.007) | (0.006) | (0.005) | (0.006) | (0.006) | (0.009) | (0.013) | (0.020) |
| Neg. income shock | 0.035*** | 0.043*** | 0.048*** | 0.036*** | 0.046*** | 0.065*** | 0.067*** | 0.053*** | 0.111*** |
| | (0.008) | (0.007) | (0.006) | (0.006) | (0.006) | (0.007) | (0.007) | (0.012) | (0.032) |
| Neg. income shock, lag 1 | 0.004 | 0.026*** | 0.025*** | 0.031*** | 0.028*** | 0.030*** | 0.021** | 0.027** | -0.002 |
| | (0.007) | (0.007) | (0.006) | (0.006) | (0.006) | (0.006) | (0.007) | (0.010) | (0.023) |
| Inc. growth, 4 year | 0.185*** | 0.153*** | 0.093** | 0.108*** | 0.035 | -0.144*** | -0.208*** | -0.092 | 0.135 |
| | (0.044) | (0.036) | (0.032) | (0.031) | (0.031) | (0.028) | (0.042) | (0.084) | (0.119) |
| Observations | 27,491 | 33,338 | 37,853 | 37,433 | 35,335 | 30,157 | 19,437 | 9,114 | 5,252 |
| Pseudo $R^2$ | 0.139 | 0.116 | 0.083 | 0.073 | 0.067 | 0.070 | 0.085 | 0.093 | 0.099 |

Standard errors in parentheses

$^{*}\,(p < 0.05)\,,^{**}\,(p < 0.01)\,,^{***}\,(p < 0.001)$

**Table 3: Characteristics of homeowners refinancing a repayment mortgage to an IO mortgage.** The table presents average partial effects and robust standard errors (in parentheses) from the probit estimation stated in Eq. (3). The dependent variable is a dummy variable indicating if household $i$ refinances a repayment mortgage to an IO mortgage. The regression controls for one-year lagged DTA, IAR, mortgage interest type, bank holdings, income, as well as the current level of education, gender, number of borrowers, number of kids and adults, household type, and regional and time fixed effects. Finally, as a control variable we include a dummy for a negative income shock of more than 10% (a dummy is included both for the year of action and the year before). The table includes homeowners with a repayment mortgage between 2003 and 2011. For households with a conversion from repayment mortgage to an IO mortgage, the household is represented by the conversion year. For households with no conversion, we use a random year to represent the mortgage choice for each household.

| | By subperiod | | Diff-in-Diff | |
|---|---|---|---|---|
| | 2001-02 | 2003-06 | Treatment | Control |
| CPI (2015=100) | 77.48 | 82.38 | 78.38 | 78.38 |
| **Mortgage characteristics** | | | | |
| Loan amount | 229.02 | 290.11 | 150.00 | 289.04 |
| LTI | 2.39 | 2.82 | 1.60 | 3.05 |
| IO mortgage | - | 0.23 | - | - |
| FRM | 0.97 | 0.79 | 0.97 | 0.93 |
| Nom. interest rate (%) | 7.33 | 5.69 | 7.19 | 6.64 |
| **Household characteristics** | | | | |
| Total debt | 253.03 | 310.36 | 159.11 | 312.22 |
| Debt to Asset ratio | 0.34 | 0.33 | 0.21 | 0.43 |
| Illiquid Asset Ratio | 0.53 | 0.53 | 0.69 | 0.33 |
| Income | 102.42 | 108.64 | 100.07 | 99.14 |
| Consumption | 98.84 | 112.68 | 104.13 | 105.16 |
| Consumption to Income | 0.99 | 1.07 | 1.06 | 1.09 |
| Number of borrowers | 1.14 | 1.16 | 1.09 | 1.20 |
| Avg. age (borrowers) | 68.42 | 71.37 | 69.16 | 69.03 |
| age: 60-64 | 0.36 | 0.12 | 0.29 | 0.29 |
| age: 65-69 | 0.27 | 0.36 | 0.28 | 0.28 |
| age: 70- | 0.37 | 0.52 | 0.43 | 0.42 |
| Single | 0.42 | 0.45 | 0.44 | 0.44 |
| Male | 0.69 | 0.67 | 0.69 | 0.69 |
| Number of adult residents | 1.54 | 1.51 | 1.54 | 1.54 |
| Number of kids | 0.01 | 0.00 | 0.00 | 0.00 |
| Education level 1 | 0.40 | 0.40 | 0.45 | 0.45 |
| Education level 2 | 0.36 | 0.36 | 0.35 | 0.35 |
| Education level 3 | 0.24 | 0.24 | 0.20 | 0.20 |
| Region Copenhagen | 0.19 | 0.21 | 0.20 | 0.20 |
| Region Zealand | 0.15 | 0.15 | 0.14 | 0.14 |
| Region South Denmark | 0.33 | 0.32 | 0.35 | 0.35 |
| Region Middle Jutland | 0.21 | 0.20 | 0.20 | 0.20 |
| Region North Jutland | 0.12 | 0.12 | 0.11 | 0.11 |
| Observations | 10,511 | 33,477 | 1,989 | 1,989 |

**Table 4: Summary statistics for households above 60.** The left panel displays the average values over the years related to the dominant mortgages for the two subperiods before and after the introduction of the IO mortgages in 2003. The right panel displays the values in 2002 for our control and treatment group used in the diff-in-diff estimation stated in Eq. (4). Loan amounts, debt, income, and consumption are in DKK 1,000, and measured as an average per adult in the household. See Section 2 for a more detailed description of variables.

| | -34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70- |
|---|---|---|---|---|---|---|---|---|---|
| After intro of IO | 0.053* | 0.069*** | 0.096*** | 0.092*** | 0.032** | -0.013 | -0.079*** | -0.055** | -0.073*** |
| | (0.024) | (0.018) | (0.012) | (0.012) | (0.010) | (0.013) | (0.016) | (0.017) | (0.016) |
| High IAR before IO intro | -0.008 | 0.007 | -0.000 | 0.031* | -0.000 | -0.019 | -0.034 | -0.027 | 0.023 |
| | (0.026) | (0.021) | (0.014) | (0.013) | (0.011) | (0.015) | (0.018) | (0.018) | (0.015) |
| After intro of IO X High IAR before IO intro | 0.063 | 0.039 | 0.008 | -0.011 | 0.003 | 0.031 | 0.062** | 0.073*** | 0.089*** |
| | (0.032) | (0.022) | (0.016) | (0.015) | (0.013) | (0.018) | (0.022) | (0.021) | (0.018) |
| Observations | 1,911 | 3,850 | 7,454 | 11,892 | 15,744 | 10,562 | 7,435 | 5,884 | 8,573 |
| $R^2$ | 0.310 | 0.315 | 0.325 | 0.252 | 0.223 | 0.280 | 0.199 | 0.286 | 0.327 |

Standard errors in parentheses

* $(p < 0.05)$, ** $(p < 0.01)$, *** $(p < 0.001)$

**Table 5: Difference-in-difference estimation across age groups.** The table presents the coefficients of interest from the difference-in-difference estimation of Eq. (4) that examines how the introduction of IO mortgages in late 2003 affects consumption for homeowners with a high illiquid asset ratio (IAR) relative to those with a low IAR. Each column includes only the subsample of households in that age group. Propensity matching is used to improve comparison between treatment and control groups. The matching is based on 2002-levels of age, income, gender, household type, education, number of kids and adults in household, and geographical region. Robust standard errors are used. Data used include homeowners from 2001 to 2006.

| | -34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70- |
|---|---|---|---|---|---|---|---|---|---|
| IO mortgage | 0.024*** | 0.007*** | -0.006*** | -0.010*** | -0.019*** | -0.030*** | -0.037*** | -0.040*** | -0.034*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) | (0.004) |
| FRM | 0.014*** | 0.009*** | 0.006*** | 0.014*** | 0.018*** | 0.023*** | 0.011*** | -0.003 | 0.007 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.003) | (0.005) |
| FRM × IO mortgage | 0.004 | 0.005 | 0.008** | -0.005 | -0.012*** | -0.014*** | -0.009** | 0.008 | -0.010* |
| | (0.002) | (0.002) | (0.003) | (0.003) | (0.003) | (0.003) | (0.003) | (0.004) | (0.004) |
| Observations | 58,913 | 44,319 | 45,797 | 44,227 | 39,854 | 36,207 | 29,585 | 20,606 | 24,011 |
| $R^2$ | 0.308 | 0.305 | 0.277 | 0.231 | 0.209 | 0.167 | 0.144 | 0.122 | 0.081 |
| Adjusted $R^2$ | 0.307 | 0.304 | 0.276 | 0.231 | 0.208 | 0.167 | 0.143 | 0.121 | 0.080 |

Standard errors in parentheses

$^{*}(p < 0.05)$ ,$^{**}(p < 0.01)$ ,$^{***}(p < 0.001)$

**Table 6: Other debt over total debt.** The table presents coefficients and robust standard errors (in parentheses) from the OLS estimation stated in Eq. (5) across age groups. The dependent variable is the fraction of other debt relative to total debt. The regression controls for income, debt-to-asset ratio, gender, education level, household type, number of borrowers, numbers of kids and adults and families represented in the household, and regional and time fixed effects are also included. The table includes homeowners with a mortgage between 2003 and 2015. A random year is used to represent the mortgage choice for each household.

| | -34 | 35-39 | 40-44 | 45-49 | 50-54 | 55-59 | 60-64 | 65-69 | 70- |
|---|---|---|---|---|---|---|---|---|---|
| **Panel A: Probit, Stock Market Participation** | | | | | | | | | |
| IO mortgage | -0.015*** | -0.013* | 0.003 | 0.030*** | 0.039*** | 0.056*** | 0.058*** | 0.059*** | 0.045*** |
| | (0.004) | (0.005) | (0.005) | (0.006) | (0.006) | (0.006) | (0.006) | (0.008) | (0.008) |
| Observations | 58,913 | 44,319 | 45,797 | 44,227 | 39,854 | 36,207 | 29,585 | 20,606 | 24,011 |
| Pseudo-$R^2$ | 0.047 | 0.060 | 0.065 | 0.067 | 0.063 | 0.058 | 0.049 | 0.055 | 0.055 |
| **Panel B: Probit, Private Pension Participation** | | | | | | | | | |
| IO mortgage | -0.028*** | -0.013* | -0.012* | 0.001 | 0.013* | 0.024*** | 0.016** | 0.003 | |
| | (0.004) | (0.005) | (0.006) | (0.006) | (0.006) | (0.006) | (0.006) | (0.005) | |
| Observations | 58,913 | 44,319 | 45,797 | 44,227 | 39,854 | 36,207 | 29,585 | 20,606 | |
| Pseudo-$R^2$ | 0.065 | 0.054 | 0.055 | 0.058 | 0.068 | 0.088 | 0.090 | 0.111 | |
| **Panel C: OLS, Pension contribution** | | | | | | | | | |
| IO mortgage | -345.380 | 182.895 | 738.983 | 1893.912*** | 4761.639*** | 4089.196*** | 698.087 | 268.007 | |
| | (245.916) | (374.718) | (418.785) | (495.030) | (630.413) | (717.831) | (711.320) | (528.053) | |
| FRM | 1311.937*** | 1540.813*** | 513.802 | 413.091 | -5.750 | -746.665 | 531.835 | -243.395 | |
| | (236.522) | (343.953) | (382.043) | (468.561) | (439.127) | (597.423) | (677.082) | (459.421) | |
| FRM × IO mortgage | 448.223 | 1235.544* | 3081.585*** | 3909.618*** | 2441.985* | 4548.786*** | 1572.829 | 1347.277* | |
| | (323.122) | (564.387) | (803.386) | (895.694) | (1055.682) | (1129.685) | (1079.918) | (606.182) | |
| Observations | 58,913 | 44,319 | 45,797 | 44,227 | 39,854 | 36,207 | 29,585 | 20,606 | |
| $R^2$ | 0.364 | 0.303 | 0.311 | 0.279 | 0.267 | 0.233 | 0.245 | 0.131 | |
| Adjusted $R^2$ | 0.363 | 0.302 | 0.310 | 0.278 | 0.266 | 0.233 | 0.245 | 0.130 | |

Standard errors in parentheses

* $(p < 0.05)$ ,** $(p < 0.01)$ ,*** $(p < 0.001)$

**Table 7: Asset diversification.** The table presents coefficients (OLS), average partial effects (probit) and robust standard errors (in parentheses) from the probit and OLS estimations stated in Eqs. (6) and (5), respectively, across age groups. The dependent variable in Panel A is a dummy variable indicating whether or not the homeowner invests in bonds and stocks. In Panel B the dependent variable is a dummy variable indicating whether or not the homeowner contributes to a private pension saving account. In Panel C the dependent variable is the average pension contribution per adult in the household. The regression controls for income, debt-to-asset ratio, gender, education level, household type, number of borrowers, numbers of kids and adults and families represented in the household, and regional and time fixed effects are also included. The table includes homeowners with a mortgage between 2003 and 2015. A random year is used to represent the mortgage choice for each household. Households above 70 are ignored in the analysis of pension contributions.