



The impact of interest-only loans on affordability

Claes Bäckman^a, Chandler Lutz^{b,*,1}

^a Department of Economics, Lund University and Knut Wicksell Centre for Financial Studies. Tycho Brahes väg 1, 223 63 Lund, Sweden

^b U.S. Securities and Exchange Commission

ARTICLE INFO

JEL Classification:

D1
G21
R3
R21
R31
E30

Keywords:

Interest only mortgages
Housing affordability
Mortgage lending

ABSTRACT

We study the 2000s Danish legalization of interest-only (IO) loans, a mortgage market innovation aimed at increasing affordability and homeownership rates for cash-strapped buyers by substantially reducing first-year payments. Our results show that IO mortgages rapidly became popular in regions with higher house prices pre-treatment as well as with both the targeted cash-strapped borrowers and mortgage applicants spanning the wealth and income distributions. Just three years after policy implementation, IO mortgages constituted half of all outstanding Danish mortgages. The introduction of IO loans thus led to an increase in housing turnover and transactions. However, as these increases were dispersed across the distribution of homeowners, they did not lead to any changes in homeownership rates for the targeted group or allow any underserved buyer groups to enter the market. Broadly, our policy analysis documents how reforms targeting housing affordability and inequality can be exploited by the wider population, limiting intended effects.

Rising global house prices are prompting public concerns over decreased affordability, low homeownership rates, and inequality. Increasing affordability is thus a key policy goal as governments around the world are seeking solutions that give underserved households access to the housing market (Gruber et al., 2017). A potential path to affordability is to change mortgage market design and allow products with differing repayment schedules. In theory, by allowing the bulk of principal repayments to take place in a later period, such products can help credit constrained households reduce costs in the initial periods and have desirable effects on homeownership rates (Chambers et al., 2009; Garmaise, 2017).

In this paper we evaluate a 2003 Danish mortgage market reform intended to increase affordability through the introduction of interest-only (IO) mortgages. Prior to 2003, Danish mortgages largely consisted of fully amortizing, 30-year fixed rate mortgages, like in the United States. But between 1998 and 2002, house prices across Denmark marched upwards and policymakers became increasingly concerned

about housing affordability for lower income households or those at the beginning of their earnings lifecycles. Thus in 2003, the Danish government legalized IO mortgages. The new law stated that mortgage banks could issue mortgages devoid of amortization payments for the first ten years. After the interest-only period ended, the borrower was required to pay back all principal within the next twenty years. Importantly, the law did not restrict IO loans to any subgroup of the population, and lending standards, such as loan-to-value ratios or income requirements, did not change following the policy implementation.² Denmark therefore provides an opportunity to analyze the impact of interest-only mortgages on affordability, as IO loans were introduced into a highly regulated and conservative mortgage market through a rapidly implemented policy proposal where changing lending standards or loan-to-value ratios do not act as confounding factors.

The government expected that only young and lower income households would consider IO mortgages and that the law change would not have a meaningful impact on housing markets.³ Yet IO mort-

* Corresponding author.

E-mail addresses: claes.backman@nek.lu.se (C. Bäckman), lutzc@sec.gov (C. Lutz).

¹ The Securities and Exchange Commission disclaims responsibility for any private publication or statement of any SEC employee or Commissioner. This article expresses the author's views and does not necessarily reflect those of the Commission, the Commissioners, or other members of the staff.

² New mortgage products have to be approved by the Danish parliament and because Danish mortgage lending is subject to a strict regulatory framework Campbell (2013), this law change is the only significant instance of financial innovation during this time.

³ The law proposal includes a rationale the reform, along with the expected effects. The material is available in Danish at <https://www.retsinformation.dk/Forms/R0710.aspx?id=91430>.

gages quickly became popular, making up 50 percent of outstanding mortgage debt four years after the reform. The wide uptake of these new mortgages is perhaps not surprising, considering that the typical borrower could reduce first-year payments substantially by choosing a fixed-rate IO mortgage instead of a comparable traditional mortgage.

At the same time, aggregate housing market transactions rose rapidly following the implementation of the reform. The rise in transactions associated with IO mortgages, however, did not coincide with any increases in homeownership rates for the targeted group. This fact holds both in the immediate aftermath of the reform and in the long run: The characteristics of homebuyers were essentially unchanged before and after IO loans were introduced and homeownership rates were stable across all subgroups. To show this, we use detailed administrative data linked to the universe of housing transactions during our sample period and find that the age, income, and wealth distributions of buyers did not move following the reform and hence that homeownership rates among young and low income households were essentially unchanged. These results are robust to a variety of subsamples, including those for expensive cities, first time homebuyers, and low-income households. In the period after the policy change, the households most in need of affordability relief thus did not experience a change in their housing market prospects.

Why did homeownership rates not change following the introduction of a popular new product that could decrease the cost of homeownership? We argue that the answer lies in the fact that IO loans were valuable for a large fraction of the population. While concerns over affordability normally refer to a small fraction of the population, a substantial part of the population may in fact be constrained by amortization payments (Kaplan et al., 2014). For instance, Gorea and Midrigan (2017) estimate that 75 percent of US homeowners are liquidity constrained. In Denmark, approximately 43 percent of households held very low levels of liquid assets relative to income at the time of the reform, suggesting that a sizable fraction of Danish households were liquidity constrained (Gross and Souleles, 2002). In support of this view, we find that IO loans are popular in higher house price areas as well as throughout the income and age distribution. With regard to the latter, approximately 70 percent of low income households with mortgage debt borrow via an IO mortgage, compared to 60 percent of high income households. A similar fraction of both young and old households hold IO loans, consistent with a large share of households valuing IO loans. However, since IO mortgages were essentially introduced everywhere in Denmark we are left without a natural control group when we estimate the effects on homeownership. It is certainly possible that the homeownership rates for young and low income households would have declined without IO mortgages, and we would therefore like to clearly state that the results are suggestive rather than conclusive.

While the finding that IO mortgages were popular throughout the income distribution contradicts the view that these mortgage products are mainly used by marginal borrowers, our findings are congruent with Amromin et al. (Forthcoming), who find that IO loans are popular among financially sophisticated households in the United States. Indeed, many of our reported statistics on IO mortgage use in Denmark echoes what occurred in the United States, suggesting that IO mortgage use in Denmark and the US was not dissimilar prior to the financial crisis. However, while IO mortgages have largely disappeared in the US post-financial crisis, they remain popular in Denmark. We provide an overview of IO mortgages in Denmark and elsewhere, and suggest that IO mortgages in Denmark did not face the type of regulatory scrutiny that similar products faced in the United States and the United Kingdom. In particular, Danish IO mortgages were not blamed for the financial crisis in Denmark. The mortgage banking sector did not run into any large problems with mortgage defaults even with a 30 percent fall in house prices (Rangvid et al., 2013).

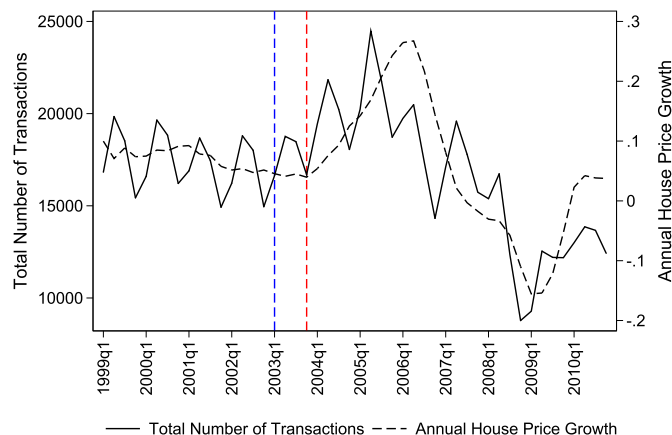


Fig. 1. House Prices and Transactions. *Notes:* The solid line plots the number of transactions per quarter on the left axis. The dashed line plots the annual house price growth in percent on the left axis using the official house price index from Statistics Denmark. The red vertical line indicates the introduction of interest-only mortgages in October, 2003. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

While the introduction of IO loans lowered initial total mortgage costs, there were no affordability gains for the targeted households as penetration of IO mortgages was proportional to ex ante homeownership rates across all households.⁴ Theoretically, with a fixed supply of housing (at least in the short run), the increase in affordability translates into rising house prices and not into increased access to housing for low income or credit constrained households. For lower income households to gain increased access to housing markets, they would have to experience a larger relative increase in their purchasing power. In other words, they would have to outbid other buyers. But if all households benefit, this distributional shift does not occur and the composition of buyers remains unchanged. Thus, policymakers targeting affordability for low income or young households using broad-based IO loan availability policies may miss their mark or even exacerbate affordability problems. While the lack of cross-sectional variation with respect to policy implementation unfortunately does not yield natural treatment and control groups, Fig. 1 does document an increase in transactions and prices following the announcement and implementations of the IO policy. Specifically, the figure plots transactions and house price growth from 1999 to 2010 where the blue-dashed and red-dashed vertical lines represent the announcement in March 2003 and implementation of the IO loan policy in October 2003. Housing market transactions quickly increase following the law change. Then shortly thereafter there is an increase in house prices, suggesting that the affordability gains associated the IO loan policy may have been limited.

If IO loans lead to an increase in house prices commensurate to the increase in affordability, the net effect of introducing IO loans for affordability is zero. This argument is reminiscent of the user-cost model of Poterba (1984), where lower interest rates are capitalized into higher house prices. Lower interest rates reduce the cost of borrowing, but this does not translate into higher homeownership rates. Amortization payments are normally not included in a user-cost model as they are considered savings and not a true cost. However, amortization payments represent a real cost for constrained households who

⁴ The initial total mortgage cost that we refer to here includes both amortization payments and interest rate payments. An IO mortgage will have higher interest payments over the course of a 30 year mortgage, compared to amortizing mortgage where the lower principal in the early parts of the loan reduces interest payments.

would optimally choose to defer principal payments (Cocco, 2013). In addition, a household can avoid buying an equity stake in their house with an IO mortgage. Indeed, for credit constrained households, lower savings can yield a desirable increase in consumption in the current period. Piskorski and Tchistyi (2010) derive an optimal mortgage contract for households with income uncertainty that would prefer to purchase a large property, and find that the optimal mortgage contract closely resembles an option adjustable rate mortgage with an attached credit line. The option to postpone principal repayments is a valuable feature for constrained households, who make up a substantial part of the housing market (Kaplan and Violante, 2014; Kaplan et al., 2014; Gorea and Midrigan, 2017). Households who are not credit constrained and are saving to fund future consumption may instead channel saved amortization payments into other assets, such as stocks or bonds, yielding valuable diversification possibilities or higher potential returns (Cocco, 2013). These effects are magnified for areas with higher house prices and larger mortgages (Amromin et al. Forthcoming). Regardless of why lower amortization payments are valuable, forced amortization payments represent actual costs to households. Due to their wide uptake in Denmark, the introduction and growing share of IO loans should be capitalized into house prices if they are valuable to households.

To further illustrate this point, the solid line in Fig. 2 plots the average first-year costs for borrowing a fixed amount. The line combines first year costs for fixed- and variable interest rates with and without amortization payments, using the share of lending in each product as weights. As the line shows, the cost for borrowing a fixed amount is declining over time, representing a decrease in the interest rate, an increasing share of variable rate mortgages and a rapidly growing share of interest-only mortgages. However, consistent with rising house prices canceling out any increase in affordability, the amount that households need to borrow does not remain fixed. The dashed line in Fig. 2 scales the first-year costs by the house price index. While the cost for borrowing a fixed amount is declining, the cost scaled by house prices is flat over the early part of the housing boom. On average, homes did not become more affordable following the introduction and increased prevalence of interest-only mortgages. Affordability is flat over the early parts of the housing boom, but scaled housing costs increase as prices and interest rates start to rise in late 2005 and early 2006.⁵

The supply side of the housing market could also be affected by the introduction of interest-only mortgages. New housing supply typically adjusts with a long lag time to changes in demand (Glaeser et al., 2008), implying that the long-run homeownership rate is the appropriate measure to examine. If homebuilders respond to IO mortgages by shifting new housing construction towards previously credit constrained households, the homeownership rate for this group may increase in the long run. However, even though considerable construction activity took place during this time period in Denmark, the long-run homeownership rates were largely unchanged. Indeed, we observe a decline in homeownership for young and low-income households starting in 2007 instead of an increase.

A concern related to the implementation of IO loans is that if households are myopic or financially illiterate (Lusardi and Mitchell, 2007), IO loans may appear more affordable as the first-year payments are lower even though the total interest payments will be higher. The households who entered the housing market may then be of worse credit quality, as in Garmaise (2013). Although this is a possibility, there are three reasons why this concern is less important in Denmark than in other countries. First, mortgage banks are legally required

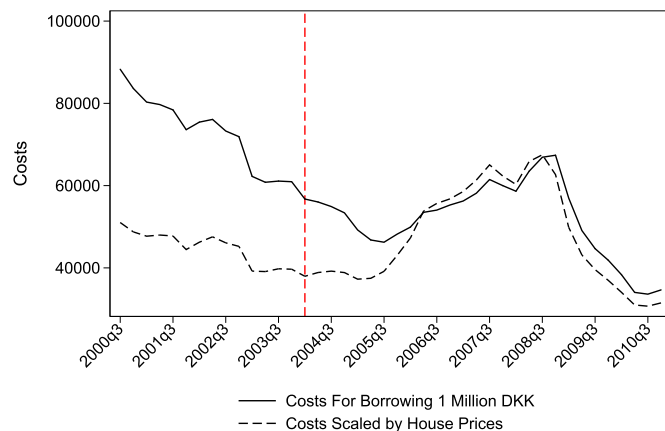


Fig. 2. First Year Costs. Notes: The first year cost is calculated as the total first year payments for a 30-year fixed interest-rate and a 30-year variable rate mortgage, with and without amortization payments. The solid line plots the cost for borrowing 1 million DKK, where we use the share of total lending in each product as the weight. The dashed line weights this first year cost by house prices.

to maintain all credit risk associated with each mortgage they issue, providing them with a clear incentive to not take advantage of unsophisticated borrowers. Second, all mortgage banks were specifically mandated in the law proposal to inform their customers of the consequences of choosing an interest-only mortgage. Third, in a 2011 survey of IO loan holders, 89 percent report being “well informed” or “very well informed” of the higher risk and the higher costs associated with an interest-only mortgage. Finally, the full recourse nature of Danish loans makes default prohibitively expensive, suggesting that households are not using IO loans to speculate, as in Barlevy and Fisher (2011). Recourse is rigorously enforced in Denmark, and mortgage banks did use their legal right to sell the collateral during the housing bust. However, the number of households who defaulted and the number of forced sales was low throughout the crisis period, even with a large decline in house prices.

Overall, our results show that the introduction of interest-only mortgages to Denmark did not increase affordability for cash-constrained households. Instead, the characteristics of buyers remained constant following the reform. At the same time, IO mortgages in Denmark were widely popular across income and age groups, and remained so after the financial crisis.

Changing payments associated with homeownership do not induce a change in the share of households who own a home and did not reallocate housing towards specific groups; instead, the costs appear to be capitalized into house prices. The high share of IO loans at both the bottom and upper ends of the income distribution suggests that these products are too blunt to address the affordability concerns of a small group of the population. Instead, the high penetration of IO loans throughout the income distribution suggests that amortization payments represent a real constraint for a large fraction of the population.

1. Data

We collect high-quality micro-data from Statistics Denmark on the full population of Danish individuals. Specifically, our dataset includes individual-level variables for demographics such as age, gender, education, municipality of residence; labor market statistics on labor income, employment and industry; financial statistics on the holdings of stocks, bonds, cash deposits, and bank debt. We further collect data on all property transactions and link these to both the buying and the selling household. The property transactions include the purchase price and

⁵ By scaling borrowing costs with house prices we are implicitly assuming that leverage remains constant throughout the housing market cycle. However, in practice leverage declines in 2006 and 2007, and the actual cost is lower than what the figure implies.

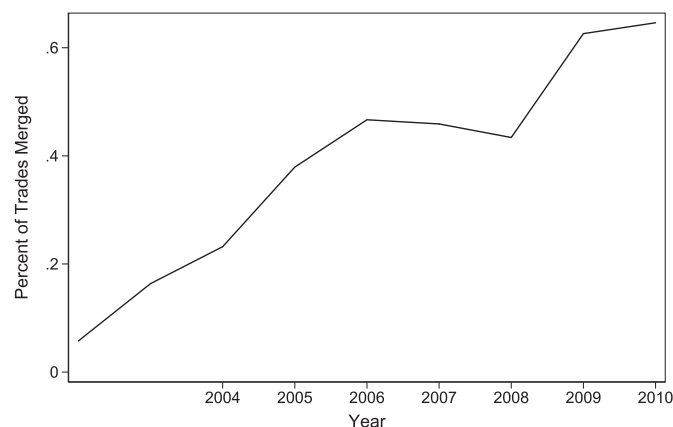


Fig. 3. Sample Selection in Mortgage Choice. *Notes:* The figure plots the fraction of housing transactions where we can merge the mortgage choice from that year to the purchase. We start with the full sample of transactions, and match the identification number for each buyer with a mortgage in 2009, that originated in the respective year.

date of transactions along with property characteristics such as size, property type, and location. The ownership registers also contain information on all owners of a given property, including the start date of ownership and the share of the property that each individual owns. We identify the owners of a property in the year before a property transaction as the seller of the property, and the owners in the year after as the buyers of the property.

Our dataset starts with all housing transactions in Denmark. We limit this sample in the following ways. First, we select only transactions involving individuals and remove any transaction by a firm. Second, we remove all properties marked as “summer houses” or properties without a registered occupant at the property. Third, we select transactions with one or two buyers. We then link individual characteristics for each buyer for the year of the transaction. We mark the age of the buyer as the age of the oldest buyer, and similarly define the education level as the education level of the most educated buyer. We take the sum of income, mortgage debt and wealth of all buyers.

We also have access to an individual-level dataset on all mortgage loans given to Danish households starting from 2009. This sample ends in 2016. We obtain data from the five largest mortgage banks from FinansDanmark, covering 94.2 percent of the mortgage market in Denmark. For each loan, we observe the following characteristics: whether it is an interest-only mortgage, whether it has a fixed or variable interest rate, the interest rate on the loan, the amount borrowed at origination, the market value of the mortgage bond at origination, the current balance of the loan, the current market value of the bond and the origination date. We use the origination date to assign each loan to each individual back in time, and match it to a housing transaction. We consider a housing transaction as using an IO mortgage if at least one of the buyer has an IO mortgage at the time of the purchase. Because our dataset starts in 2009, this implies that anyone who took out an interest-only mortgage in 2004 and refinanced in 2008 would be missing from our dataset. We examine this survivorship bias in Fig. 3, showing that we match approximately 60 percent of housing purchases in 2009 and 2010, but only 40 percent in the preceding years. As expected, the match worsens further back in time.

2. Housing and mortgage markets

The Danish mortgage finance system is highly rated internationally (Campbell, 2013). Similar to the United States, Danish mortgages have historically consisted of a long-term, 30-year fixed rate loan without pre-payment penalties. The mortgage system is based on a system of

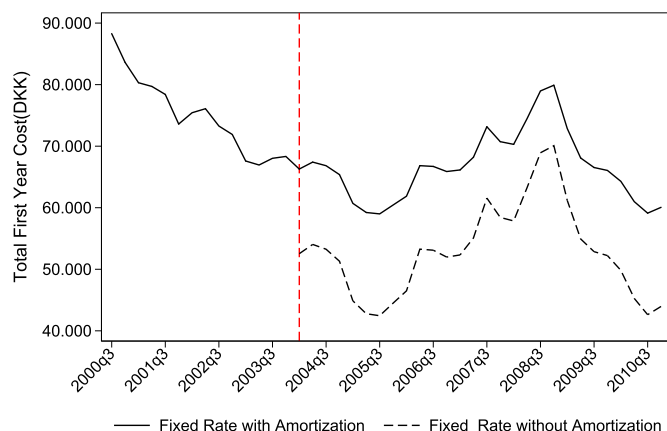


Fig. 4. First Year Payments. *Notes:* The red vertical line indicates the introduction of interest-only mortgages. The figure plots the total annual cost for a 1 million DKK, fixed rate mortgage contract, with amortization payments (solid line) and without amortization payments (dashed line). Amortization payments are calculated according to an annuity formula. The interest-rate used is the long-bond rate from the Association of Danish Mortgage Banks. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

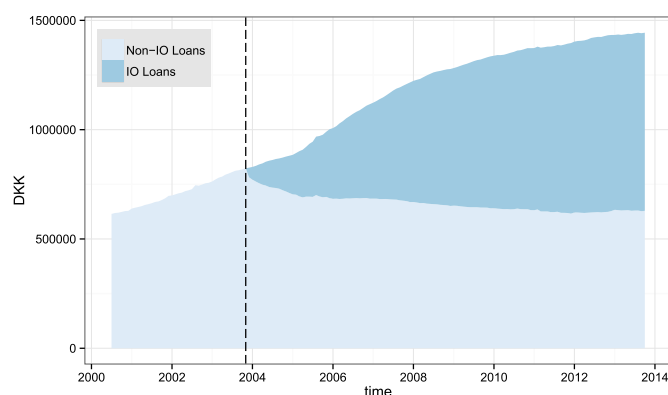
callable bonds, where all mortgage loans are traded on a highly liquid mortgage bond market.

Households can finance up to 80 percent of home purchases using mortgage loans with a legally mandated maximum maturity of 30 years, and can fund an additional 15 percent using higher interest bank debt. There are no pre-payment penalties, and households are always legally allowed to refinance their mortgage loans to take advantage of lower interest-rates, provided the principal balance does not increase. All homeowners are allowed to extract equity, provided that the new mortgage balance does not exceed the 80 percent leverage ratio.

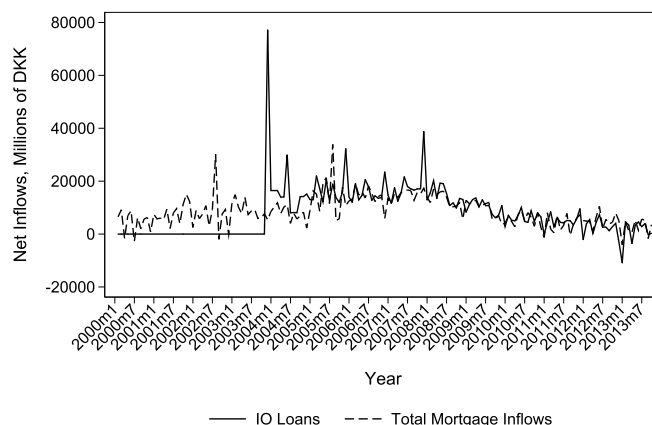
Danish borrowers obtain mortgage credit through specialized lenders called mortgage credit banks (henceforth, mortgage banks), who act as intermediaries between borrowers and investors. These institutions face strict underwriting criteria that require them to assess the creditworthiness of all borrowers upon granting a mortgage. Moreover, mortgage banks are prohibited from offering new products without regulatory and legal approval, which has limited financial innovation. This ensures that the introduction of interest-only mortgages are the only instance of mortgage market financial innovation that occurs during our sample period.

Mortgage banks are required to assess both the value of the underlying property and the borrower's ability to afford mortgage payments (International Monetary Fund, 2011). After extending credit to borrowers, the proceeds from the loans are sold to investors in the form of mortgage bonds. The interest rate for borrowers is set by the mortgage bond market and not by the issuing bank and is derived from the cost for the mortgage on the open market.⁶ The mortgage bank is legally mandated to hold the mortgage bond on their balance sheet throughout the loan period, thereby retaining any credit risk. If a borrower defaults, the mortgage bank is required to compensate the investor by replacing the defaulting mortgage by one with similar characteristics. Investors in mortgage bonds therefore face no credit risk, provided the issuing lender remains solvent, and the investors instead assume interest rate and prepayment risk. In over 200 years of operation, no investor in mortgage bonds has faced losses due to default (Andersen et al., 2014). Market interest rates on mortgage bonds thus do not reflect the credit risk associated with individual borrowers.

⁶ The mechanics of Danish mortgage bonds is described in Andersen et al. (2014).



Mortgage Loan Types



Net Inflows

Fig. 5. Stock and Flow of Outstanding Mortgage Debt. *Notes:* The figure on the left plots outstanding mortgage debt by loan type, including loans for residential properties and vacation homes. The figure on the right plots inflows into each mortgage type. Source: Nationalbanken.

Instead, mortgage banks, who retain all credit risk, charge borrowers additional administrative and servicing fees associated with the loan.⁷

If a borrower defaults, the issuing mortgage bank can trigger a forced sale of the underlying asset. In legal parlance, mortgage loans in Denmark are full recourse – any residual claim is converted into an unsecured personal claim. Further, personal bankruptcy in Denmark is difficult and does not necessarily reduce the debt burden. Since the residual claim is unsecured, the interest rate is higher than the mortgage rate. Households therefore have an incentive to keep making interest-payments as long as possible and to not default on the mortgage. This feature of the Danish mortgage system makes default unattractive for borrowers and default rates are low (see Ghent and Kudlyak, 2011, for evidence on recourse laws and default from the United States). For example, even though house prices declined by 30 percent nationally in Denmark from 2007 to 2009, quarterly mortgage arrears peaked at just 0.6 percent of outstanding loans and forced home sales remained low throughout the housing bust. Compare this to the United States, where monthly mortgage defaults relative the number of loans outstanding peaked above 10 percent.⁸ In addition, no investor in Danish mortgage bonds faced losses due to a borrower default, and no government bailout of the mortgage banking sector was required.

In total, the Danish mortgage system provides strong incentives for originators to screen borrowers during the underwriting process and for borrowers to carefully assess the state of both their future income and the state of the housing market as well as ensuring that their loan is within their financial means. Together, these factors yield a low risk environment for investors in mortgage bonds (Campbell, 2013) due to limited concerns regarding moral hazard in lending, excessive points and fees, low documentation loans, and limited monitoring of new borrowers during a boom.

3. Interest-only mortgages in Denmark

Following a rapidly implemented law change, the Danish government legalized a new mortgage product, interest-only loans, on Octo-

ber 1st, 2003. The motivation behind the law proposal was to increase flexibility in mortgage financing, thereby increasing affordability for cash-constrained households such as students, young adults and households on temporary leave from the labor market. The expectation from the government was that the penetration of IO loans would be low and that the reform therefore would have no long-term impact on house prices.⁹

The law was introduced to the Danish parliament on March 12, 2003, and passed on June 4, 2003 with a large majority voting in favor of the proposal. The law change allowed mortgage banks to offer a new product (*afdragsfrie lån*), where principal repayments could be postponed for up to 10 years, even though the full amount still had to be repaid over the 30-year contract. Technically, the new law allowed the mortgage to have a ten-year interest-only period.

Importantly, there was no change in the criteria that mortgage banks used to evaluate borrowers. The mortgage banks state that IO mortgages were only granted to households who could afford a standard 30-year fixed interest mortgage (Ministry of Economic and Business Affairs, 2007). This implies that there was no reduction in credit standards similar to what happened in the United States.

Prior to the financial crisis, administrative fees for IO mortgages did not differ from traditional, amortizing mortgages. Hence, before 2007 mortgage banks' perceived risk of IO loans did not differ substantially from traditional, amortizing mortgages. After the financial crisis, the mortgage banks state that they have increasingly differentiated their fees because of stricter regulatory requirements and demands from rating agencies (Rangvid et al., 2013). Indeed, post-financial crisis there is a small fee increase for associated with the origination of an IO mortgage where the typical amount is 1000 DKK (135 Euros).¹⁰

Although investors in Danish mortgage bonds face no credit risk from the individual borrowers, they are subject to credit risk related to mortgage bank default. Using weekly panel of Danish mortgage bonds downloaded from Datastream, in unreported results we find no change

⁷ See e.g. “Danish mortgage bonds provide attractive yields and low risk”. Danske Capital. 2015. Link Retrieved June 15 https://www.danskeinvest.com/web/show_download.hent_fra_arkiv?p_vld=whitepaper-dkmortgagebonds.pdf.

⁸ Data on US defaults is from the Mortgage Bankers' Association.

⁹ The law proposal includes a rationale the reform, along with the expected effects. The material is available in Danish at <https://www.retsinformation.dk/Forms/R0710.aspx?id=91430> and at http://webarkiv.ft.dk/?samling/20021/lovforslag_oversigtsformat/L177.htm.

¹⁰ See for example “List of Charges, Realkredit Danmark”, 2017. Link Retrieved June 15, 2018. <https://www.rd.dk/PDF/Erhverv/List-of-charges-business.pdf>.

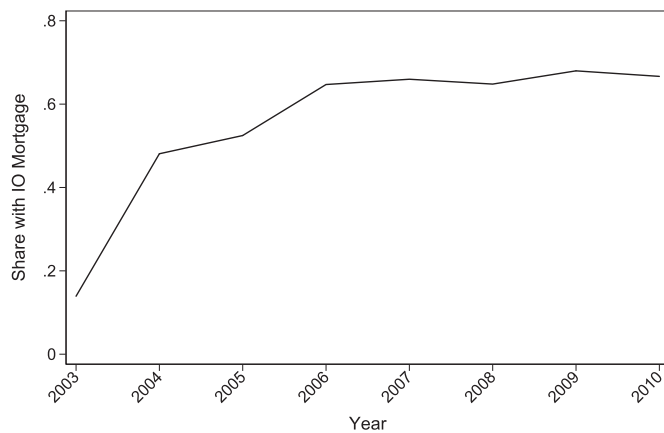


Fig. 6. Share of IO Mortgages For Homebuyers. *Notes:* The figure plots the share of IO mortgages among homebuyers. We only include the sample where we can match the homebuyer to a mortgage.

in the prices of Danish mortgage bonds following the announcement or introduction of IO loans in Denmark. Hence, mortgage bond investors did not view the introduction of IO loans as a potential increase in default risk for Danish mortgage banks.¹¹

Even though an IO loan is considerably more expensive due to higher interest payments over the lifespan of the loan, the affordability of these loans within the first year of issuance is notable.¹² Fig. 4 plots the first-year cost for borrowing 1 million DKK (\$155,000) with a fixed-rate mortgage with (solid line) and without (dashed line) amortization payments. Beginning in October 2003 with the legalization of IO loans, total payments could be reduced by approximately 18 percent, or 13,000 DKK (\$2000 USD) per year. For the average home buyer in Copenhagen during 2003, the first year payment reductions associated with a fixed rate IO mortgage amount to over 7 percent of annual disposable income. Comparing adjustable rate mortgages with and without amortization payments, this number is 11 percent.¹³ If we compare a variable rate IO mortgage to a fixed rate amortizing mortgage, the reduction in payments is 67 percent.

Note that in Denmark that amortization payments can potentially be deferred indefinitely by rolling over into a new mortgage contract after ten years, provided that the house value does not decrease and that the household qualifies for a new mortgage, an aspect of the new loan that Danish media reported (see e.g. *Politiken*, 2003). Thus, households can enjoy long periods of lower payments that may be quite valuable during prime working and child-rearing years. However, Danish households must qualify for a new mortgage at each re-financing and cannot die

¹¹ Additionally, if the demand for mortgage credit increased with IO loans, interest rates may have increased. However, Denmark is well characterized as a small open economy facing an international interest-rate. Using the same IO dataset from Datastream, we find no changes in prices of bonds post-reform.

¹² Since investors do not bear any default risk and the mortgage bank has recourse on the property, there is no different in the interest-rate for IO and non-IO loans.

¹³ Calculations are based on an annuity schedule, where the total monthly cost is constant across the loan period. The average sales price in Copenhagen was 1.3 million DKK, the average disposable income for buyers was 204,575 DKK per year, and the average difference in payments from the introduction of IO loans to the end of 2003 for a 1 million DKK mortgage was 13,000 DKK for a fixed rate mortgage and 22,000 DKK for a variable interest mortgage. Assuming a down-payment of 20 percent, the savings as a percentage of disposable income is $13,000 \cdot 1.3 \cdot 0.8 / 204,575 = 6.7\%$ for a fixed rate mortgage and $22,000 \cdot 1.3 \cdot 0.8 / 204,575 = 11.1\%$ for a variable rate mortgage. For a calculation that compares initial payment reductions across US mortgage types, see Dokko et al. (2011) (p. 40 of their Fed 2009-49 working paper).

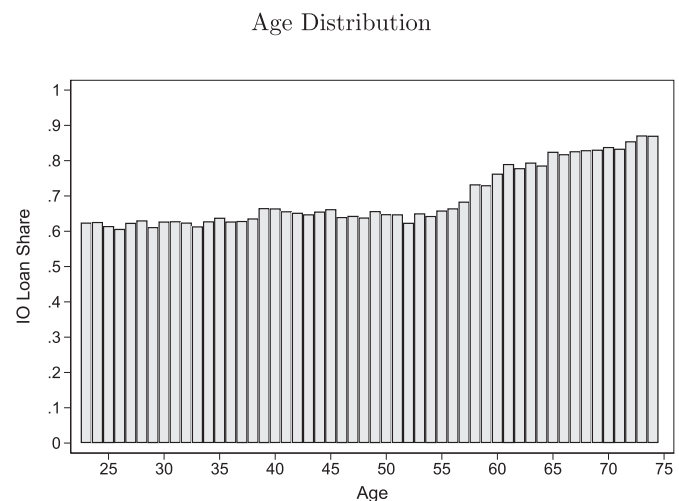
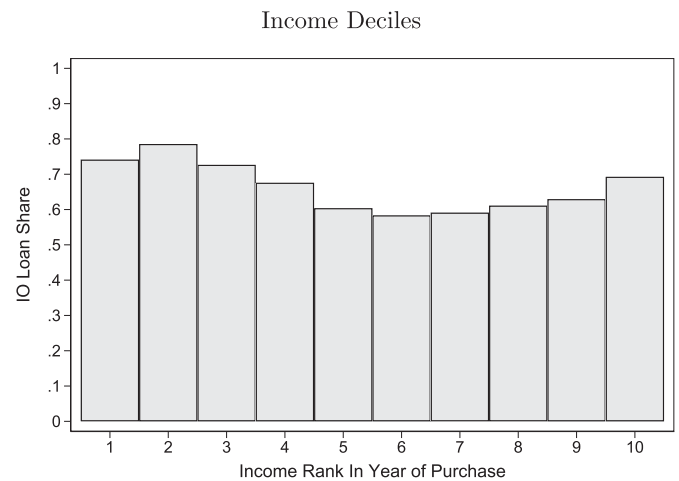
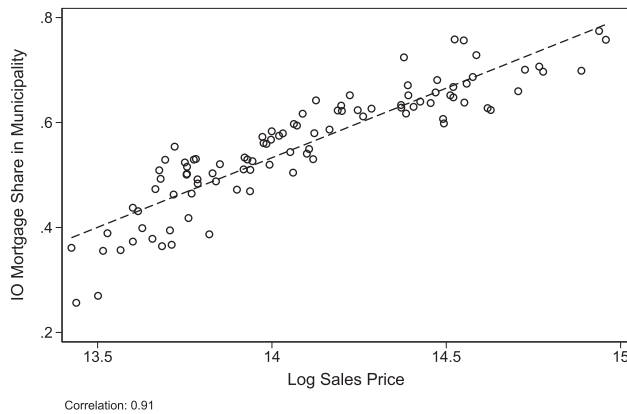


Fig. 7. Fraction of IO Loans Among Homebuyers. *Notes:* All figures plots the IO loan share among homebuyers. The top figure divides the sample into deciles based on disposable income. The middle figure divides the sample into quintiles based on initial total wealth. The bottom figure divides the sample into age groups.

with mortgage debt.¹⁴ Hence, as principal payments are delayed with an IO mortgage, households pay more interest (and still must pay the

¹⁴ All assets will be used to pay off any debts upon death.

IO Loan Penetration and Price Level



IO Loan Penetration and Pre-Boom House Price Growth



IO Loan Penetration and Boom House Price Growth

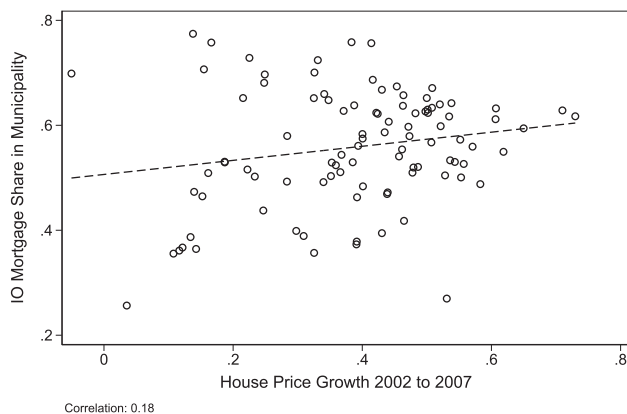


Fig. 8. IO Loan Penetration. *Notes:* The top panel plots the IO loan share on the municipality level against the average house price level for each municipality in 2002. The correlation between the two variables are listed below the graph. The middle panel plots the IO loan share on the municipality level against house price growth between 1998 and 2002. The bottom panel plots the IO loan share against house price growth during the housing boom. The IO loan share is calculated using data from mortgage data from 2009 for matched to buyers from 2003 to 2009.

principal balance). Thus borrowing via an IO mortgage leads to larger total mortgage payments, even if these payments are smaller during the interest-only period.

Interest-only mortgages may be valuable for several reasons. First, myopic or financially illiterate households may only consider the lower first-year costs deriving from lower amortization payments and may not understand that total payments will be higher over the total life-span of the loan. The law proposal mandated that the issuing bank should inform the borrower of the risk that lower amortization payments entails, an issue that households seemingly understood. In a 2011 survey of households with IO mortgages, 89 percent reported that they were “very well informed” or “well informed” on the implications of choosing IO mortgages, including both the higher interest payments over the lifespan of the loan and the higher risk associated with lower amortization payments (Association of Danish Mortgage Credit Banks, 2011). Second, households may value the increased opportunity for consumption smoothing that IO loans provide (Cocco, 2013). This feature is particularly important for households with growing incomes, for whom consumption smoothing is more valuable. Third, interest-only mortgages allow for potential amortization payments to be re-purposed for savings in alternative assets, yielding diversification benefits and potentially higher expected returns. Note that this implies that different households may have different reasons for choosing an IO loan and thus the product is not just beneficial for low-income households. Indeed, households that are financially constrained may appreciate the consumption smoothing aspect of IO loans, while higher income households instead value the option to increase diversification and achieve higher returns by investing in alternative assets.

3.1. Danish IO loan summary statistics

Given that IO loans were potentially valuable for different groups of the population, it is perhaps not surprising that the penetration of IO loans in the Danish mortgage market increased rapidly following their introduction. The left hand side of Fig. 5 plots outstanding mortgage amounts by loan type, showing how the mortgage market was rapidly transformed following the introduction of IO loans. One year after the reform, 15 percent of all *outstanding mortgages* were IO loans. This number increased to 30 percent in 2005 and to 50 percent in 2010. The right hand side of the figure plots net flows for IO mortgages (solid black line) and net flows of total mortgage debt (dashed line), showing that IO mortgages almost immediately made up nearly all of new mortgage inflows. We calculate net flows into each mortgage type as the change in outstanding amount from the current month minus the outstanding amount in the previous month.¹⁵ The large shift towards IO loans implies that a large fraction of Danish households refinanced into new interest-only mortgages and that this reform did not just affect new buyers.

We examine the same trend in IO mortgage uptake among homebuyers only in Fig. 6. Specifically, the figure plots the share of homebuyers for each year who use an IO mortgage between 2003 and 2010 among the households where we can match the mortgage to the homebuyer at the time of their housing purchase. Between 2003 and 2004, the share of homebuyers with an IO mortgage goes from below 20 to above 40 percent, a share that further increases to approximately 60 percent from 2006 and onwards. Post-financial crisis, IO mortgages remained widely popular. This stands in contrast to experiences in the United States, where Amromin et al. (Forthcoming) and Barlevy and Fisher (2011) report that these products essentially disappeared once house

¹⁵ Note that this does not directly correspond to origination of new mortgages, but is instead a net flow measure for each mortgage type. Since our data on mortgage borrowing suffers from survivorship bias, we are more comfortable using the aggregate lending in each type.

Table 1
Municipality-level IO loan predictors.

	(1)	(2)	(3)	(4)	(5)
Sales Price	0.0938*** (0.00618)				0.0808*** (0.00732)
Pre-Reform House Price Growth		0.0762*** (0.00834)			0.0236** (0.00785)
Square Meter House Price Growth 2002 to 2007			0.0206 (0.0112)		0.0272*** (0.00536)
Income Growth t to $t+1$				0.0271* (0.0111)	−0.00477 (0.00594)
Observations	97	97	97	97	97

Notes: Robust standard errors in parenthesis. Sales Price is the average sales price for each municipality in 2002. Pre Reform House Price Growth is calculated as the percentage increase in square meter house prices from 1998 to 2002 for each municipality. House Price Growth from 2002 to 2007 is the percentage growth rate in square meter prices over the time period for each municipality. Income growth is calculated as the average income growth for all homebuyers from the year of sale until one year after.

prices fell during the Great Recession. While the data in the early periods is subject to survivorship bias, the data for 2009 and 2010 is not, as we observe all mortgage debt and all housing transactions during these years. This indicates that IO mortgages remained a popular choice among homebuyers even after house prices fell.

As noted above, IO loans were not just theoretically a popular choice among low income households, but potentially favored by borrowers across the wealth distribution. We plot the share of IO mortgages in the income, wealth and age distribution for buyers, using data from the time of home purchase. Specifically, the top panel in Fig. 7 plots the fraction of households with an IO loan across borrower income deciles.¹⁶ Given that a household holds a mortgage, IO loans were only slightly more popular among low income households compared to households with high incomes. The difference is not large, however, as even high income households are attracted to these types of mortgage products. Note that this corresponds to results from the United State (Amromin et al. Forthcoming). The middle panel plots the share of IO mortgages in the wealth distribution. Again, we observe a relatively uniform distribution, with slightly higher penetration in the top and bottom quintile. The bottom panel shows that the fraction of IO loans is slightly increasing in age, where older households are more likely to have an IO loan, conditional on them holding a mortgage. Fig. B1 shows that the result for the full population is similar, but is slightly more U-shaped with both younger and older households being more likely to hold an IO mortgage. Young and old households are also more likely to benefit more from choosing an IO loan. First, young households likely have less liquid cash and larger debt levels as they had less time to reduce principal through amortization payments. By the reasoning above, the benefit of choosing an IO loan is increasing in debt. Further, young households likely have growing incomes and a larger need for consumption smoothing. Second, a similar consumption smoothing argument holds for older households. A household above the retirement age wishes to use their savings to increase their consumption. Noting that amortization payments are a form of savings, an interest-only mortgage allows retired households to reduce their savings and to increase their consumption.¹⁷

We use the sample of homebuyers from 2003 to 2010 to calculate municipality-level predictors of IO mortgage use. The top panel of Fig. 8 shows that there is a strong relationship between the price level in 2002 and IO loan penetration in 2009. This likely reflects the fact that the value of an IO loan depends on the size of the mortgage, which is strongly correlated with the sales prices. To see this, note that amortization payments are calculated as a fraction of the principal balance.

Using the interest rate from October, 2003, a household that borrowed \$100,000 with a fixed rate IO loan would reduce their first year costs by \$1350, or by \$110.25 per month. A household that instead borrowed \$300,000 using the same mortgage would reduce their first year costs by \$4060 or \$338 per month. Regardless of why the household chooses to get an IO mortgage, the value of an IO mortgage, compared to a traditional loan, is increasing in mortgage size, matching the pattern in Fig. 8. We provide more evidence on the link between higher borrowing and IO mortgage share below.

We also plot IO loan penetration against pre-treatment house price growth in the middle panel, which previous research has used as a measure of expectations of future house price growth (Brueckner et al., 2016; Dokko et al., 2015). The figure shows that there is a strong correlation between pre-treatment house price growth and IO loan penetration in 2009. However, as we will see later this correlation is much weaker once we account for price levels. Finally, we plot IO mortgage use against house price growth from 2002 to 2007 in the bottom panel to capture house price growth from prior to the reform until the peak in house price levels. The figure shows that there is a positive but weak correlation between house price growth during the boom and IO mortgage use.

Table 1 provides regression results for the municipality-level predictors. All regressors are standardized to ease interpretation. We include the Sales Price as the initial payment reductions related to IO mortgage choice are a function of the mortgage size (and thus sales price). We also include the pre-reform house price growth to proxy for expectations of future capital gains, house price growth from 2002 to 2007 to proxy for speculative motives during the boom, and the average income growth from t to $t + 1$ to proxy for income expectations. Columns (1)–(2) show that both Sales Price, pre-treatment house price growth and income growth are positively correlated with IO loan penetration. House price growth between 2002 and 2007, however, is not significant. When we include all variables in one regression in Column 4, Sales Price is strongly significant and is approximately 3 times larger than the other coefficients. Sales Price is thus the strongest predictor of IO mortgage use on the municipality level.

We provide additional results on IO mortgage predictors for individual buyers in Tables 2 and 3. We begin by showing summary statistics for Non-IO and IO-mortgage holders in Columns 1 and 2 of Table 2. We also provide a t -test for differences in means in Column 3, and highlight some important differences between the two groups. Households with an IO mortgage are on average older and have more years of education. Furthermore, they have higher disposable income. IO holders have higher mortgage and total debt compared to Non-IO holders, lower liquid wealth, higher interest-payments relative to income, and purchase more expensive properties, both in absolute terms and relative to income.

¹⁶ We provide results for the full population in Fig. B1 in Appendix B.

¹⁷ This may be especially true for retired households who have saved in other assets or via pensions.

Table 2
Summary statistics – mortgage type.

	(1)	(2)	(3)
Non-IO	IO	T-test of (2)–(1)	
Demographic Characteristics			
Age	38.35 (10.69)	39.47 (11.93)	1.12*** [18.19]
Years of Education	14.89 (2.42)	15.06 (2.35)	0.17*** [13.07]
Family Size	2.44 (1.20)	2.53 (1.21)	0.09*** [14.29]
Number of Children	0.75 (0.98)	0.83 (1.00)	0.08*** [14.20]
Employment ratio during the year	0.97 (0.09)	0.98 (0.08)	0.01*** [12.75]
Retired	0.04 (0.19)	0.05 (0.22)	0.01*** [9.04]
Financial Characteristics			
Disposable Income	296,465.13 (199,268.99)	312,303.10 (282,907.31)	15,837.97*** [11.66]
Income Growth t to t+1	−0.10 (0.38)	−0.15 (0.44)	−0.05*** [−22.06]
Income Growth t to t+3	−0.30 (0.56)	−0.46 (0.59)	−0.16*** [−50.67]
Income Growth t-1 to t	0.09 (0.24)	0.10 (0.25)	0.00*** [3.44]
Income Growth t-3 to t	0.31 (0.54)	0.30 (0.55)	−0.01* [−2.33]
Mortgage Debt	1,067,362.47 (724,079.31)	1,440,741.96 (1,036,087.43)	373,379.49*** [75.24]
Total Debt	1,326,605.58 (963,462.24)	1,854,354.97 (1,543,522.34)	527,749.39*** [73.33]
Log Liquid Wealth	11.24 (1.54)	11.15 (1.71)	−0.08*** [−9.39]
Liquid Wealth to Income	0.40 (0.59)	0.43 (0.70)	0.03*** [9.34]
Total Interest Payments to Income	0.10 (0.06)	0.12 (0.07)	0.02*** [55.11]
Housing Characteristics			
Transaction Price	1,434,613.85 (905,358.87)	1,783,017.19 (1,203,715.65)	348,403.34*** [59.23]
Sales Price to Income	4.95 (2.12)	5.75 (2.36)	0.80*** [64.49]
Observations	58797	82279	141076

Notes: Characteristics of households with an amortizing mortgage (Column 1) IO mortgage (Column 2). Age is defined as the age of the oldest buyer. Family size is the total number of adults in the household. The employment ratio is the fraction of the year that the members of the households worked full-time. Retired is a dummy equal to one if at least one of the buyers is retired. Disposable income is total labor income minus taxes, transfers, interest-payments, and the rental value of housing. Income growth is the change in income from the specified time periods. Mortgage debt is the market value of mortgage debt in the current year. Total debt is mortgage debt plus bank debt. Liquid wealth is the sum of bank deposits, stocks and bonds. Liquid wealth to income is liquid wealth divided by disposable income, winsorized at the 99th percentile. Interest-payments to income is total interest payments on mortgage and bank debt divided by income, winsorized at the 99th percentile. Transaction price is the purchase price for the property, and Sales Price to Income is the Transaction Price divided by Disposable Income.

In Table 3 we provide results for all homebuyers from 2003 to 2009 (columns 1–4) and for homebuyers between 2004 and 2007 (columns 5–8). We split the results to ensure that our results are not unduly driven by choices made during the housing market decline in 2008 and 2009. All values are included for the year when we observe the housing purchase, and are either averages, sums or maximum values for households where we observe multiple buyers. The table investigates different explanations for why a household might choose an IO mortgage, starting with the loan value. All regressions include year fixed effects, demographics controls are included where indicated, and we cluster standard errors at the municipality level. Similar to the explanation above, we find that a higher Loan Value strongly predicts IO mortgage share in all columns. This is consistent with our intuition that IO mortgages are more valuable if possible amortization payments are higher. Furthermore, we find that disposable income, once we control for other

variables, is negatively correlated with choosing an IO mortgage. Sales Price is not statistically significant once we include loan value. Finally, we do not find that income growth is a strong predictor of IO mortgage use, in contrast to Cocco (2013). All results are consistent between the two different periods.

We provide evidence on income, liquid wealth holdings and age in Fig. 9. IO mortgage holders have higher disposable income and lower liquid wealth. While the age distribution is relatively similar, we do observe that IO mortgage holders are somewhat older compared to Non-IO mortgage holders.

Finally, the top panel of Fig. 10 plots the distribution of mortgage size for IO and Non-IO mortgages, showing IO mortgages generally are larger than Non-IO mortgages. In the middle panel we plot the average mortgage size for an IO and Non-IO mortgage over time, showing that this fact holds over time. The bottom panel shows that the relative size

Table 3
Individual-level IO loan predictors.

(1)	All Years				2004–2007			
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Loan Value	0.162*** (0.00649)	0.190*** (0.00645)	0.210*** (0.00922)	0.210*** (0.00906)	0.175*** (0.00964)	0.217*** (0.00975)	0.236*** (0.0110)	0.234*** (0.0109)
Log Disposable Income	−0.0791*** (0.0108)	−0.0985*** (0.00863)	−0.0945*** (0.00995)	−0.0933*** (0.00957)	−0.0969*** (0.0151)	−0.129*** (0.0124)	−0.128*** (0.0151)	−0.119*** (0.0142)
Log Sales Price	0.0332** (0.0107)	0.0254* (0.0102)			0.0290* (0.0126)	0.0224 (0.0117)		
Income Growth t to $t + 1$			0.00948 (0.0137)				−0.0107 (0.0224)	
Income Growth t to $t + 3$				0.0163 (0.0106)				0.0243 (0.0134)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Demographic Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Observations	79372	78937	79026	79026	30333	30264	30281	30281
Adjusted R-Squared	0.10	0.11	0.11	0.11	0.05	0.06	0.06	0.06

Notes: The left hand side is a dummy variable equal to one if one of the buyers had an IO mortgage. Loan value and disposable income is the sum of loan value for buyers, and income growth is the growth in rate in disposable income for the buyers over the stated time period. Robust standard errors in parenthesis. Loan Value is the mortgage value at origination. Columns 1–4 include all observations from 2003 to 2010, whereas columns 5–8 restrict the sample to housing purchases between 2004 and 2007. Demographic controls include family size, age, the employment ratio during the year, years of education, number of children and family size. All regressions include year dummies.

of an IO and Non-IO mortgage varies somewhat over time, but that it appears to be relatively stable. IO mortgages are on average between 1.16 and 1.27 times larger than Non-IO mortgages.

Overall, these characteristics match results on IO mortgage use reported in other studies. For instance, Amromin et al. (Forthcoming) report a higher share of complex mortgages (which includes IO mortgages) among households with higher house value to income and with higher income levels. Finally, Barlevy and Fisher (2011) report that IO mortgages were generally larger in size compared to other mortgage products.

3.2. Comparison to IO mortgages in other countries

In the United States and the United Kingdom IO mortgages were once a popular choice, but have since largely disappeared. This section discusses similarities and differences between IO mortgage use in Denmark, the United States and elsewhere.

For the United States, Amromin et al. (Forthcoming) find that IO mortgages made up a sizable fraction of mortgage origination during the early 2000s, with a peak in 2006/2007.¹⁸ Similar to our results for Denmark, Amromin et al. (Forthcoming) also report that IO mortgages were prominently used among households with higher incomes, higher house values and higher house value to income ratios. Dokko et al. (2011) report that IO mortgages were more common among Alt-A borrowers, not subprime borrowers, and Barlevy and Fisher (2011) report that IO mortgages were larger in size compared to Fixed Rate and Adjustable Rate mortgages, and that they were more prominently used in areas that experienced greater house price growth, showing the same pattern as appears in our Fig. 8.

With the financial crisis, the reputation of IO loans in the United States faltered, especially given their association with subprime mortgages. Subsequently, US regulators, like the Consumer Financial Protection Bureau (CFPB), singled out IO loans as risky for borrowers and the mortgage finance system.¹⁹ In the United Kingdom, most IO mortgages were endowment-mortgages, where savings were to be invested into stocks and bonds. These mortgages were popular prior to the 2000s, making up over half of mortgage origination in certain years

(Cocco, 2013). After the stock market crash in 2000 regulators sent out a letter with projections of whether the savings would be sufficient to repay the loan at maturity, and many households were projected to have a shortfall. IO mortgages in the UK were thus not directly comparable to IO mortgages in Denmark, which would have no projected shortfall due to the repayment schedule, provided full transparency regarding payments and did not involve speculation in risky assets.

However, while IO mortgages have essentially disappeared in the United States, they remain common in Denmark. A report commissioned by the Danish government and chaired by Jesper Rangvid at Copenhagen Business School investigates the causes and consequences of the financial crisis in Denmark. The report states that while many causes contributed to the financial crisis in Denmark, a primary cause was Danish bank's increased usage of short-term liquidity from international capital markets, and not the activities of the mortgage banks.²⁰

Importantly, the Danish financial system is divided into standard banks with deposits and financial services and mortgage banks, who intermediate mortgage bonds between borrowers and investors. The report states that mortgage credit institutions were generally not widely affected by the financial crisis, and were not a primary cause of the crisis. When liquidity dried up in 2008, several Danish banks faced severe financing problems, but these financing issues did not affect the mortgage banking sector.

The mortgage industry in Denmark responded to the financial crisis in part by raising the fees for interest-only mortgages and by raising additional capital, but did not remove these products from the portfolio (Rangvid et al., 2013). Mortgage banks also did not experience large losses on their mortgage portfolios, even as house prices fell dramatically (Rangvid et al., 2013). The report states that “the housing price bubble did affect the level of economic activity, but it has not led to any appreciable degree of losses for the mortgage credit institutions”. The report does not recommend abolishing interest-only mortgages, instead suggesting that the mortgage banks should be subject to more regulatory oversight to ensure that they are not overly exposed to single customers with risky loans.

¹⁸ See also statistics reported in Table 1 in Justiniano et al. (2017).

¹⁹ <https://www.consumerfinance.gov/about-us/newsroom/consumer-financial-protection-bureau-issues-rule-to-protect-consumers-from-irresponsible-mortgage-lending/>.

²⁰ Other contributors included a favorable macroeconomic environment, low interest rates, inadequate corporate governance and risk-seeking behavior on parts of financial institutions.

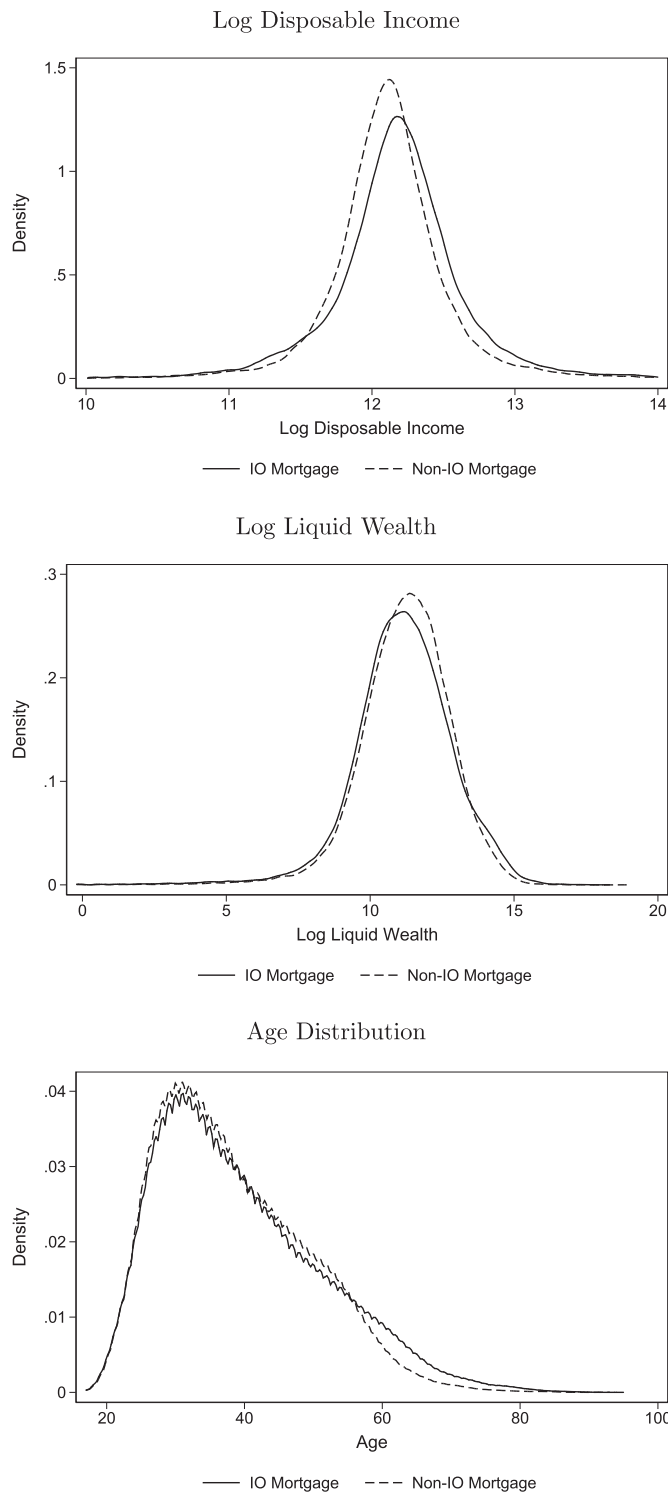


Fig. 9. Densities Household Characteristics by Mortgage Type. *Notes:* All figures plots kernel density plots for households with an IO mortgage (solid line) and with a Non-IO mortgage (dashed line). The top panel plots Log Disposable Income, the middle panel plots Log Liquid Wealth, and the bottom panel plots age.

4. Results

We now turn towards evaluating the impact of the introduction of interest-only mortgages on the housing market. We will show three main results. First, homeownership rates remained constant for all groups and IO loans had no observable impact on homeownership rates.

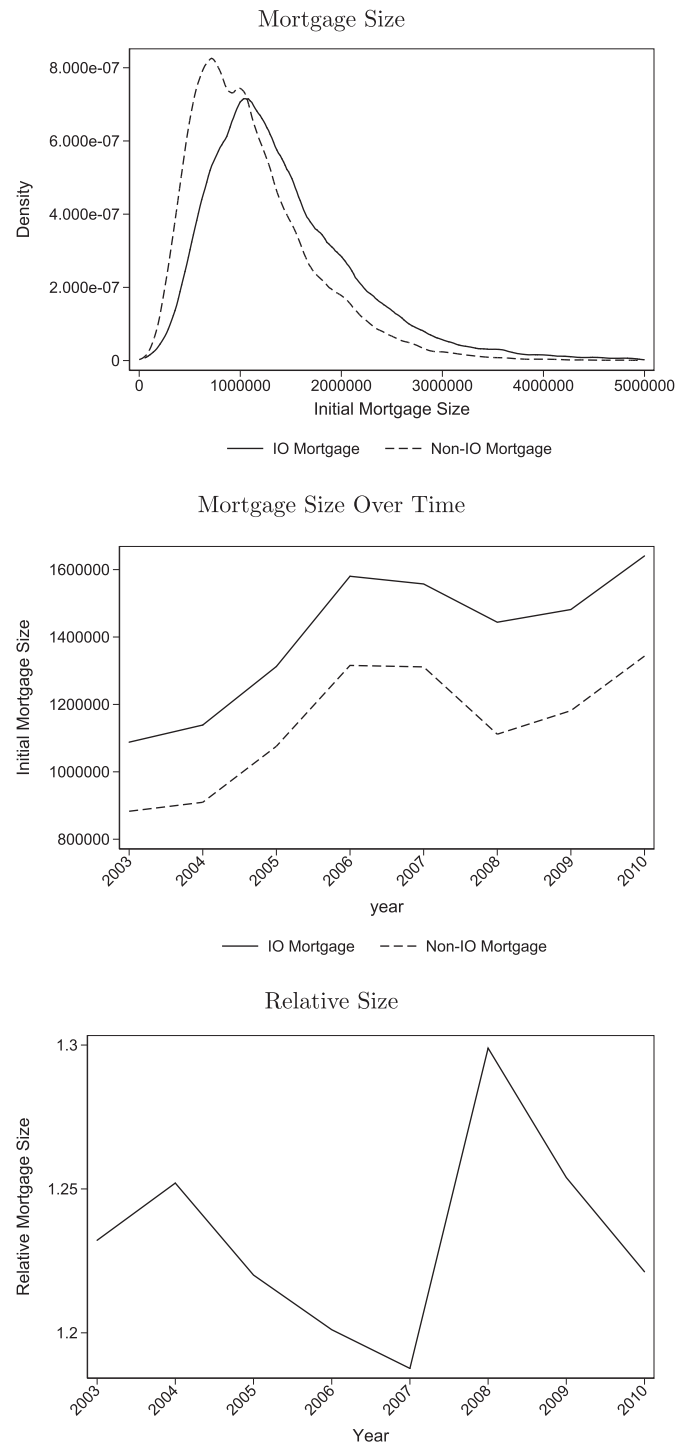


Fig. 10. IO and Non-IO Mortgage Size. *Notes:* The first figure plots a kernel density for the mortgage loan size at origination for homebuyers with an IO mortgage (solid line) and with a Non-IO mortgage (dashed line). The middle figure plots the average mortgage loan size at origination for both groups over time, and the bottom figure plots the ratio between the average mortgage size at origination for IO mortgage holders and Non-IO mortgage holders.

Second, we corroborate these aggregate level results by searching for any changes in the composition of buyers along all observable dimensions. We find that the characteristics of purchasers change very little after the introduction of IO loans. If anything, the distribution shifts towards *higher* income households. Third, house prices adjust upwards with higher demand, keeping the cost for purchasing a unit of housing constant in the immediate aftermath of the reform. Together, these

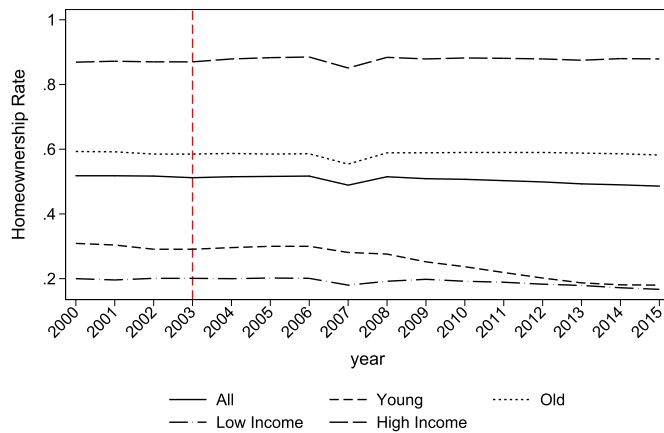


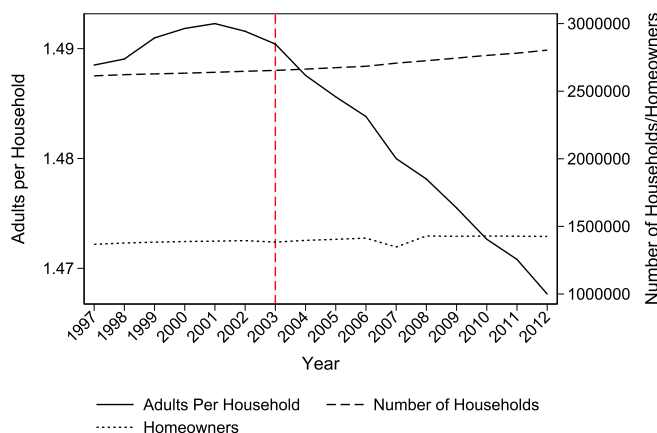
Fig. 11. Homeownership Rates. Notes: Homeownership rates are calculated as the fraction of individuals with positive amounts of registered housing wealth. Young are all individuals below 35 years of age in the current year, and Old are individuals 35 years of age or older. Low income individuals are in bottom three deciles of income in the current year, and High Income are in the top three deciles.

results suggest that introducing IO loans had little discernible impact on who purchased housing, and in the end little impact on homeownership rates.

4.1. Homeownership and interest-only mortgages

We begin by showing that the aggregate homeownership rate is essentially unchanged over time, and that there is no increase in the homeownership rate for low income households. Fig. 11 provides homeownership rates over time for different groups of households. As the figure shows, the change over time in homeownership rates is small, and does not accelerate after IO loans are introduced. In particular, there is no discernible short-term increase in homeownership for low income households, the intended recipients of the reform. While homeownership rates for young and low income households decline over time, this decline becomes apparent well after the reform was implemented, starting in 2006. Table A1 in Appendix A shows the same result in table form. Again, the share of individuals who own a property is very stable across time, and the share does not significantly change after IO loans were introduced.

Despite observing no change in the aggregate share, there could be a reallocation between groups if one group is especially affected by



Homeownership Factors

Fig. 12. Decomposition of Homeownership. Notes: The left hand side plots the number of households, homeowners (left axis) and the number of adults per households (right axis) over time using the full sample of households in Denmark. The right hand side plots the year over year change for each variable.

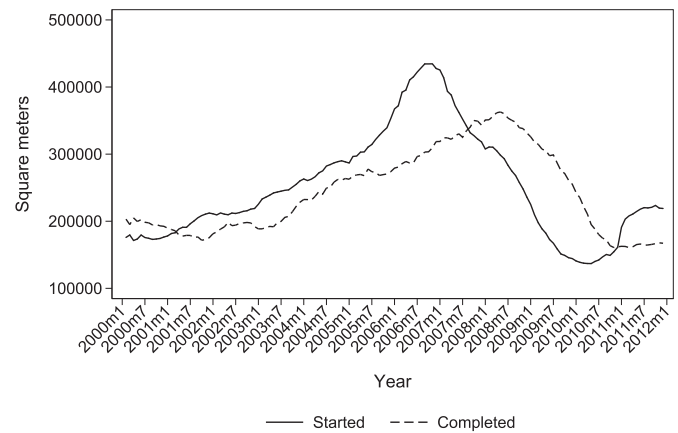
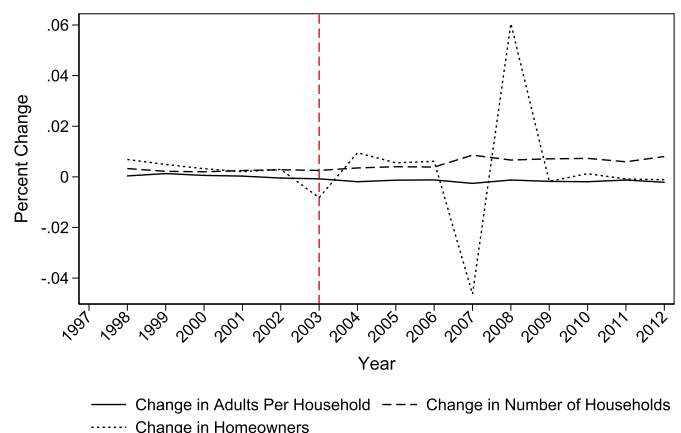


Fig. 13. Construction Activity. Notes: The figure plots a 12-month moving average of completed and started construction activity in Denmark over time. Source: Denmark Statistics.

the introduction of IO loans. For instance, if low income households were severely constrained by amortization payments, IO loans could increase their purchasing power sufficiently to ensure that they could purchase housing. Note that a particular group would have to receive a *disproportional* increase in affordability compared to another group for there to be any change in homeownership rates. If all groups of households benefit equally, the relative rates of homeownership would remain constant.

We also examine homeownership rates among different age subsets of the population in Fig. 11. Specifically, we divide the population into young (below 35 years of age) and old (35 years of age and above) households. Once again, we see little change over time in homeownership rates among either young or old households. For young households, the homeownership rate is approximately 30 percent throughout the period, although it decreases after 2006. Among old households 59 percent own a property over the whole sample period. Overall, there is no change in the homeownership around the policy period. We provide additional results in Table A2 in Appendix A. Specifically, we examine homeownership rates in areas where house price levels are high and thus IO loans are more valuable. Once again we find no changes in the homeownership rates among low income or young households around the IO loan policy.

In Fig. 12 we decompose the change in the homeownership rate into three separate factors. The homeownership rate could change because



Change in Homeownership Factors

Table 4
Buyer characteristics in 2002 and 2004.

2002	(1) 2004	(2) T-test of (2)–(1)	(3)
Demographic Characteristics			
Age	40.63 (13.69)	40.93 (13.53)	0.30*** [3.85]
Years of Education	14.29 (2.62)	14.46 (2.55)	0.16*** [11.16]
Family Size	2.43 (1.21)	2.46 (1.21)	0.03*** [4.42]
Number of Children	0.74 (0.99)	0.76 (1.00)	0.03*** [4.69]
Number of Adults	1.70 (0.46)	1.70 (0.46)	0.00 [1.43]
Employment Ratio	0.97 (0.10)	0.96 (0.11)	–0.01*** [–9.52]
Retired	0.07 (0.26)	0.07 (0.26)	0.00 [1.75]
Income and Wealth Characteristics			
Disposable Income	250,152.68 (328,176.34)	281,309.79 (271,591.62)	31,157.11*** [18.40]
Future Income Growth	–0.00 (0.24)	0.01 (0.25)	0.01*** [9.59]
Past Income Growth	0.08 (0.26)	0.10 (0.26)	0.01*** [10.06]
Mortgage Debt	1,049,274.05 (2,317,137.16)	1,146,539.69 (1,924,079.06)	97,265.64*** [8.12]
Total Debt	1,374,001.50 (2,998,349.67)	1,551,193.59 (2,517,820.36)	177,192.09*** [11.38]
Log Liquid Wealth	10.80 (1.88)	11.02 (1.83)	0.22*** [20.54]
Liquid Wealth to Income	0.42 (0.74)	0.47 (0.77)	0.05*** [10.79]
Interest Payments to Income	0.11 (0.07)	0.10 (0.07)	–0.01*** [–33.77]
Housing Characteristics			
Transaction Price	1,126,991.67 (896,312.53)	1,296,735.31 (1,047,483.08)	169,743.64*** [30.57]
Sales Price to Income	4.67 (2.50)	4.76 (2.54)	0.09*** [6.02]
Leverage	0.88 (0.53)	0.84 (0.55)	–0.03*** [–10.49]

Notes: Characteristics of households who purchase housing in 2002 and 2004. Age is defined as the age of the oldest spouse. Family size is the total number of adults in the household. The employment ratio is the fraction of the year that the members of the households worked full-time. Disposable income is total labor income minus taxes, transfers, interest-payments, and the rental value of housing. Future income growth is the change in income from time t to time $t + 4$. Past income growth is the income growth from $t - 2$ to t . Mortgage debt is the market value of mortgage debt in the current year. Total debt is mortgage debt plus bank debt. Liquid wealth is the sum of bank deposits, stocks and bonds. Interest-payments to income is defined as total interest payments on mortgage and bank debt divided by income. Leverage is the tax value of housing divided by mortgage debt.

of a change in the number of homeowners, a change in the number of households, and a change in the number of adults per household. The left panel in Fig. 12 plots the absolute levels for the number of homeowners, the number of households and the number of adults per household, whereas the right hand side plots the year-over-year change in each respective variable. Overall, we observe little change in the number of households and the number of homeowners. We observe a small decrease in the change of the number of homeowners in 2003, which is followed by an uptick 2004. The magnitudes, however, are small. We also observe that the number of adults per households has been steadily decreasing since 2001, although the magnitude of the decline seems relatively small.²¹

²¹ We observe a sharp decline in the number of homeowners in 2007, followed by a large increase in 2008. We believe that this is related to a municipality-reform in 2007, that especially affected the housing registers. The number of homeowners returns to trend again in 2008. Note that the decline occurs prior to the financial crisis in Denmark and is therefore likely not related to occurrences in the financial markets.

It is relevant to discuss how the introduction of a new mortgage product, such as IO loans, may affect homeownership rates. As a first approximation, the homeownership rate depends on the share of owner-occupied housing in the total housing stock. In order to generate a large increase in homeownership, the number of owner-occupied properties must increase relative to the stock of rental properties. While it is possible that a mortgage product (or a subsidy) directed towards low-income households could induce a supply response, the constant homeownership rate among low-income households found in our above empirical work suggests that this did not in fact occur. The homeownership rate may also rise if IO loans enable faster household formation, but again we do not see any evidence in the long-term trends.

Moreover, IO loans were introduced during a period of increasing construction activity in Denmark. Fig. 13 plots started and completed construction activity over our time period. Newly started construction activity starts to pick up around the time of the reform, and peaks in late 2006. Completed construction changes less rapidly over time, likely due to construction time, but still shows an increase compared to the pre-reform period. Completed construction peaks in early 2008, a time

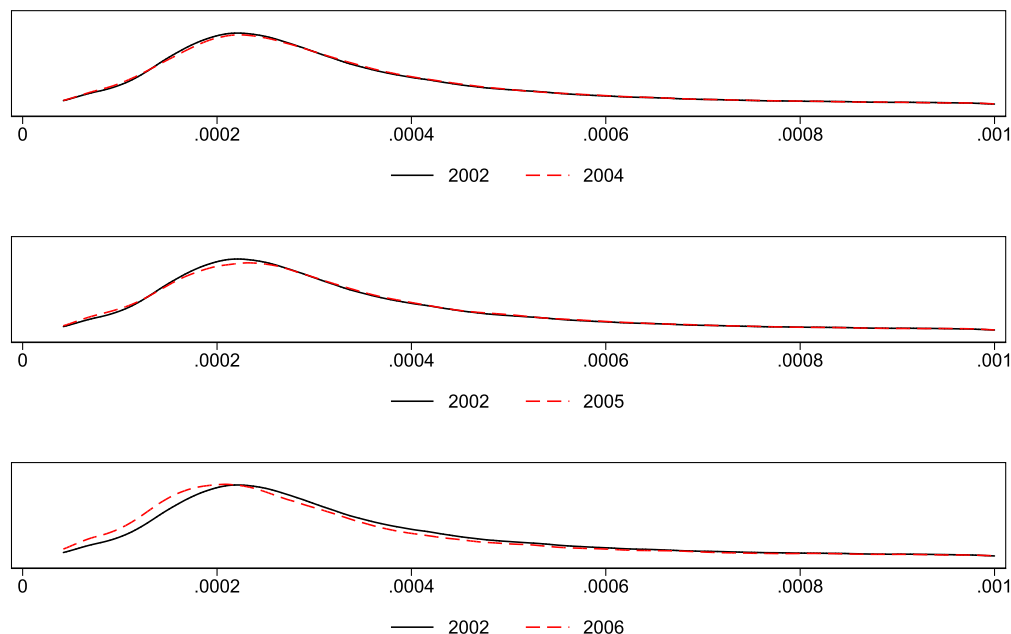


Fig. 14. Distributions For Buyers. *Notes:* Kernel density plots for selected variables. The black line plots the distribution for 2002 and the red line plots the distribution in years 2004–2006. Kolmogorov-Smirnov test for equality of distribution presented in the top corner. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

period also characterized by low house price growth. However, even with this large increase in construction we do not observe any change in the homeownership rate for young or low income households, suggesting that the IO mortgage reform did not induce a supply response targeted towards these particular groups.

If the aggregate homeownership rate is unchanged, then any change for one subset of the population would have to be counterbalanced by a decrease in the homeownership rate for another group. Indeed, due to the nature of housing market transactions, the low income group would have to experience an increase in purchasing power so that they could outbid higher earning households. Given the high share of IO loans across the income distribution, it is reasonable to argue that IO loans are valuable to a large share of the population. In that case, there is no change in the *relative* purchasing power of any group, meaning homeownership rates are unchanged. This is reminiscent of the result that the mortgage interest-deduction has no impact on homeownership rates (surveyed in Gale et al., 2007).²² The evidence so far suggests that the introduction of IO loans had no impact in the short or long run on aggregate homeownership or on any particular subgroup.

We continue by comparing households who purchase owner-occupied housing before and after the introduction of interest-only mortgages. Even though the homeownership rate (the stock of owners) was unchanged, there may be an increase in the number of transactions (the flow) by a particular group. Hence, we examine households along various dimensions to determine if any new groups of households gained access to owner-occupied housing. Table 4 compares summary statistics in 2002 and 2004, before and after the introduction of IO loans, for all buyers. Buyers in 2004 were older, more educated, had higher incomes, purchased more expensive housing, and had higher levels of mortgage debt and total debt. The difference in debt reflects both higher incomes and lower interest rates in 2004 compared to 2002, which yields lower interest payments to income ratios for buyers in 2004. In addition, the buyers in 2004 had higher income growth over the next four years relative to buyers in 2002. This higher income

growth likely reflects business cycle effects and cohort effects, as the Danish economy was sluggish in the early part of the 2000s, but entered into an upturn later. In total, these results do not support the notion that interest-only mortgages helped credit constrained or low-income households enter the housing market. Instead the average buyer appears to be richer and older, contrary to the purpose of affordability reform.

The above averages may not be informative for the impact of interest-only mortgages if the reform had an impact in the tails of the distribution. Fig. 15 therefore plots the distribution of income, income growth, financial wealth and total wealth for all household who purchase a property along with a Kolmogorov-Smirnov test for equality of distributions (see Abadie, 2002).²³ The figure plots each distribution in 2002, when interest-only mortgages were not available, and in subsequent years. For example, the top panel plots the distribution of age for buyers in 2002 (black solid line) and in 2004 (red dashed line), the first full year when IO loans were available. We do not use 2003 to avoid anticipation effects and so that transactions just following the reform do not affect the results. Moreover, using these two years minimizes the chance that changes in house prices or macroeconomic factors affect the analysis. Any leftward shifts in these distribution would imply that the cash-strapped, younger households targeted by the reform attained access to owner-occupied housing. Instead, the distributions in Fig. 15 are remarkably stable between 2002 and 2004, implying that there were no changes in the composition of buyers following the reform. There is a slight shift towards higher income and wealthier households in 2005 and 2006, again not showing an increase in homeownership among low-income or credit constrained households. None of the results are sensitive to choosing either a different baseline year or a different comparison year. As we will show later, the results are also robust to using only first-time buyers or households in municipalities that experienced a boom in house prices.

²³ The null hypothesis in the test is that the samples are drawn from the same distribution. The alternative hypothesis that we test in the first line (2002 Smaller) is that the 2002 distribution is smaller, and the alternative hypothesis in line two is that the 2004 distribution is smaller. The alternative hypothesis in the third line is that the distributions are different.

²² See Gruber et al. (2017) for a study on the mortgage interest deduction in Denmark.

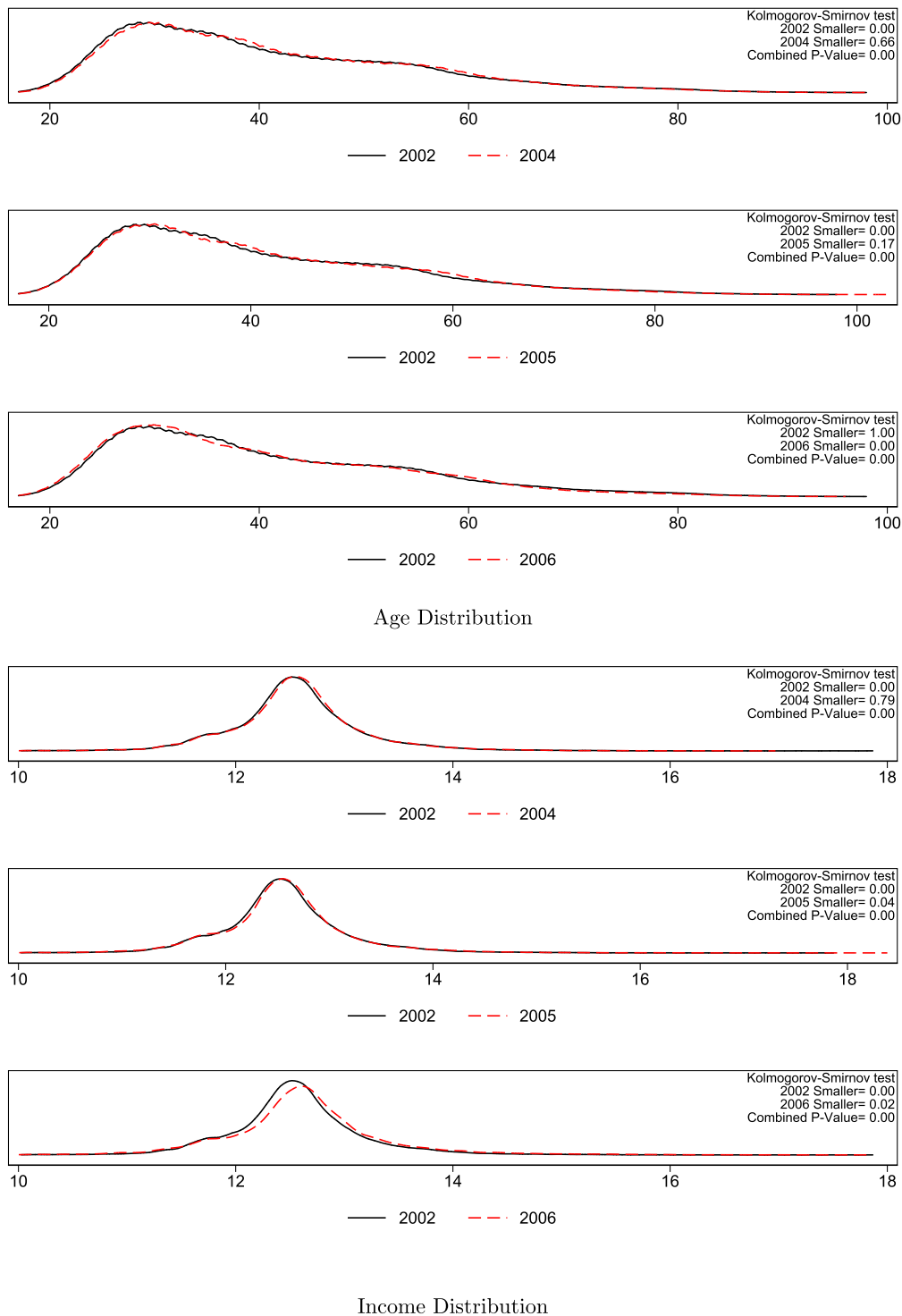


Fig. 15. Distribution of House Size to Income for Buyers. *Notes:* Kernel density plots for selected variables. The black line plots the distribution for 2002 and the red line plots the distribution in years 2003–2006. Kolmogorov-Smirnov test for equality of distribution presented in the top corner. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Overall, the results presented here are consistent with the results for homeownership rates. There is no shift in the distributions towards households with lower income, lower age or lower wealth. In fact, the age distributions shift towards older households and the income and liquid wealth distribution shifts towards higher income and wealthier households in 2004, 2005 and 2006. A majority of housing purchases are done by households around the age of 30 before and after the reform, but there is no noticeable shift towards younger households. Affordability concerns are especially important for younger households,

who do not disproportionately benefit from IO loans.

Fig. 14 examines an alternative channel through which IO loans can affect buyers: Households may use interest-only mortgages to purchase a larger house relative to current income (Gerardi et al., 2010). In that case, we should see that the distribution of home size to income shifts to the right in Fig. 14. As before, however, we do not observe any substantial shifts in the distributions from 2002 to 2004 or any later year. Thus, households did not purchase more housing with the introduction of IO loans.

Income and Wealth Distributions For First-Time Buyers

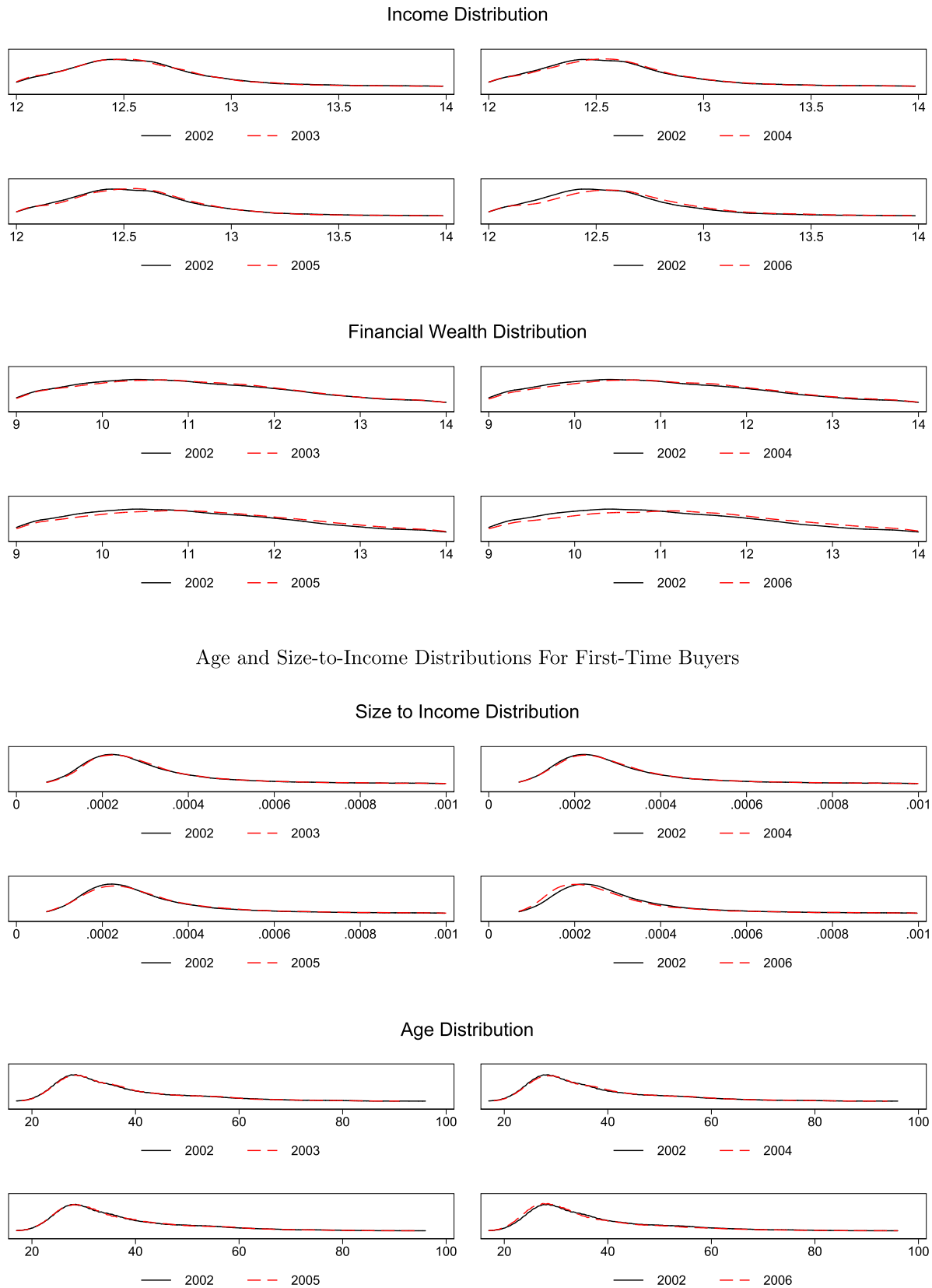
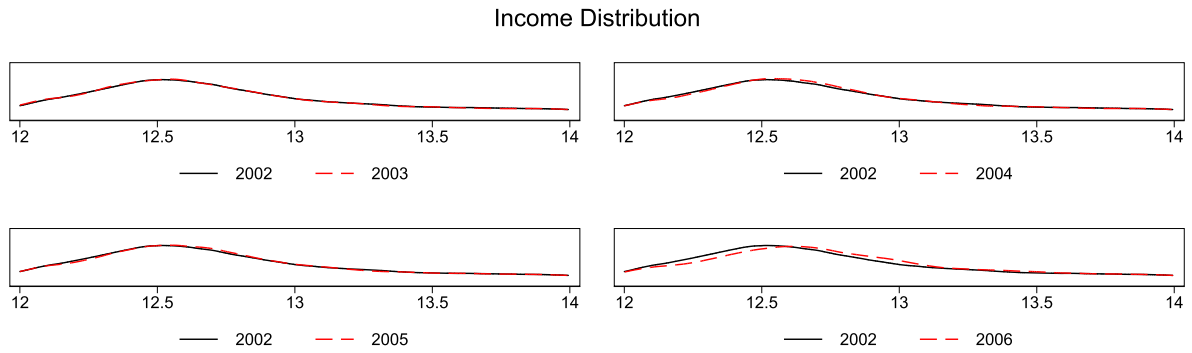


Fig. 16. Distributions For First-Time Buyers. *Notes:* Kernel density plots for selected variables. The black line plots the distribution for 2002 and the red line plots the distribution in 2004, 2005 and 2006. Kolmogorov-Smirnov test for equality of distribution presented in the top corner. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Income and Wealth Distributions For Buyers in Boom Municipalities



Age and Size-to-Income Distributions For Buyers in Boom Municipalities

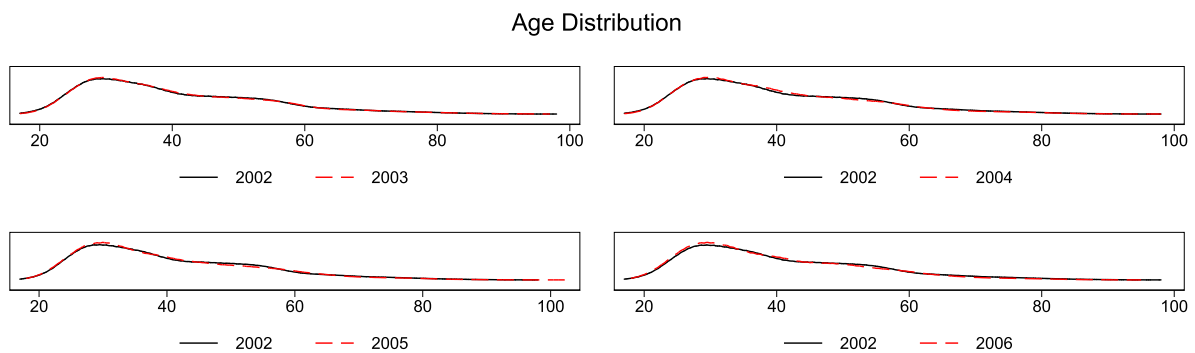
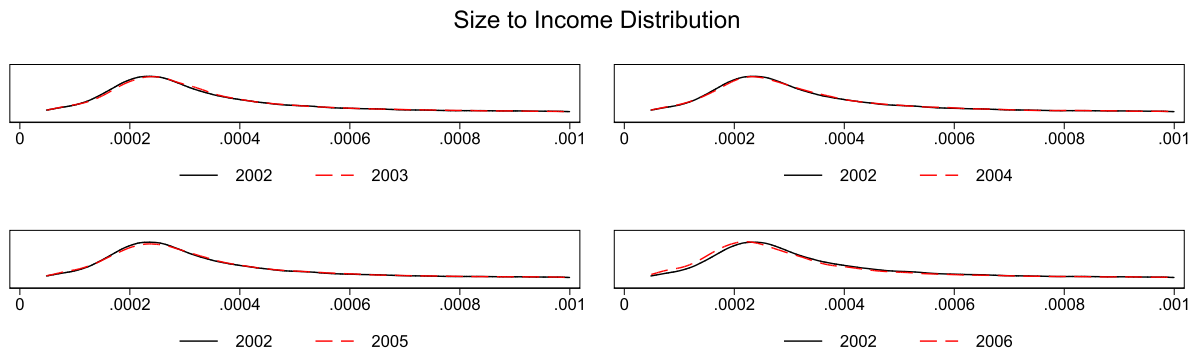


Fig. 17. Distributions For Buyers in Boom Municipalities. *Notes:* Kernel density plots for selected variables. The black line plots the distribution for 2002 and the red line plots the distribution in 2004, 2005 and 2006. Kolmogorov-Smirnov test for equality of distribution presented in the top corner. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

4.2. Interpretation of the IO loans and homeownership rate result

Recall that there was a large increase in transactions following the legalization of IO loans and that a large fraction of mortgage debt is interest only, suggesting that the IO loans changed both the mortgage and housing markets in Denmark. However, the results for the income and wealth distributions are not consistent with IO loans allowing previously constrained households access to the housing market. If anything, we observe a shift towards higher income and wealthier households. As the unchanged homeownership rates for low and high income households from Fig. 11 show, the introduction of IO loans did not lead to a relative increase in housing transactions for any population subgroup. Instead, the results in Fig. 15 suggest that housing transactions expanded proportionally across the age, income and wealth distributions.

Why is there no relative shift in who purchases housing? The sizable fraction of Danish households who hold an IO loan suggests that these products are valuable, either because they relieve credit constraints for the part of the population that is constrained (see Gorea and Midrigan, 2017), or because they allow unconstrained households to increase diversification by saving in alternative assets (Cocco, 2013). Indeed, because IO loans retain the option to repay the mortgage, they may be valuable due to increased flexibility even if the household intends to reduce principal within the first 10 years (Piskorski and Tchistyi, 2010). If a large number of households value these products, the introduction of IO loan simply increases purchasing power across the distribution, leaving the relative share of transactions unchanged. In other words, because all households value these products, credit constrained buyers do not receive a large enough increase in their purchasing power to outbid other buyers on the market. This instead suggests that prices will increase. As noted above, an increasing share of IO loans is correlated with rising house prices.

4.3. Robustness checks

In this section we test whether the previous results are sensitive to different subsamples. First, we examine first-time buyers, defined as households who have no registered housing wealth in the past two years (e.g. those that do not own a house). The results are provided in Fig. 16. Overall, the results are consistent with the results in Fig. 15 for the age, income, and liquid wealth distributions. Young first-time buyers did not enter the housing market in 2004 at a higher rate relative to 2002. If anything, there is even a slight but statistically insignificant shift towards older first-time buyers in 2005 and 2006.

Second, the value of IO loans depends on household budget constraints related to amortization payments. Since amortization payments are calculated as a fraction of mortgage debt, IO loans are more valuable in areas where borrowing needs are high. As shown in Fig. 8, the fraction of households with IO loans is higher in the areas around Copenhagen and other large cities. To investigate whether the introduction of IO loans had a differential impact in these cities, we plot distributions for buyers in municipalities that experienced the largest increases in house price during the boom. Specifically, we rank municipalities according to growth in sales price from 2002 to 2006 and use municipalities in the top quintile in Fig. 17. Once again, the overall pattern is similar, and we do not observe that the introduction of IO loans had an impact on credit constrained households.

5. Conclusion

This paper analyzes a 2003 Danish law change that legalized interest-only mortgages. Relative to traditional mortgages, IO loans dramatically reduce first year mortgage payments through the deferment of amortization payments. By legalizing IO loans, the Danish government attempted to aid young and cash constrained households in their pursuit of homeownership. Assuming inelastic supply in the short-run, this goal is only feasible if the purchasing power of the targeted group increases relative to the distribution. We argue that IO loans created a broad-based outward shift in demand, leaving relative purchasing power and homeownership rates across groups unchanged.

Using the universe of Danish loans and detailed administrative data, we examine the uptake of IO loans before and after their introduction. Our research shows that a substantial portion of households across Denmark, including the young, old, poor, and wealthy borrowed via IO mortgages. In fact, the penetration of IO loans was remarkably consistent across various population subgroups.

Households may value interest-only mortgages for a multitude of reasons. Young cash-constrained households at the beginning of their earnings lifecycles likely prefer interest-only loans as they aid in consumption smoothing, while the wealthy may channel deferred amortization payments into other assets with higher expected returns or diversification benefits. Regardless of why households valued IO loans, the high penetration of IO loans across the age, income and wealth distributions suggests that amortization payments are a cost that a large share of the population would prefer not to pay. Thus, our empirical work finds a large increase in transactions following the introduction of IO loans, but no change in homeownership rates for any subset of the population. The IO mortgage reform instead coincided with an increase in prices. However, while it is striking that no group seemingly benefitted in terms of homeownership rates from the reform, the lack of a natural control group makes this result suggestive rather than conclusive.

Generally, our work highlights the potential unintended consequences of affordability policies. In the Danish case, the affordability reform was targeted at a small subset of the population and expected to have no impact on the broader housing market. Yet a substantial number of households in Denmark choose an IO mortgages, either because they were cash-constrained or because they valued the diversification benefits of IO loans. Together, the uptake of IO loans across these two groups coincided with a large increase in transactions and house prices at the time of the reform but no immediate change in homeownership rates, the opposite of the policy's intended effect. Instead, the reform seems to have benefited existing homeowners, who could refinance to the new mortgage without being negatively affected by rising house prices.

A Appendix. Tables

Table A1

Homeownership rates.

Year	All Households	Young	Old	Low Income	High Income
2000	0,52	0,31	0,59	0,20	0,87
2001	0,52	0,30	0,59	0,20	0,87
2002	0,52	0,29	0,59	0,20	0,87
2003	0,51	0,29	0,59	0,20	0,87
2004	0,52	0,30	0,59	0,20	0,88
2005	0,52	0,30	0,59	0,20	0,88
2006	0,52	0,30	0,59	0,20	0,89
2007	0,49	0,28	0,55	0,18	0,85
2008	0,52	0,28	0,59	0,19	0,88
2009	0,51	0,25	0,59	0,20	0,88
2010	0,51	0,24	0,59	0,19	0,88
2011	0,50	0,22	0,59	0,19	0,88
2012	0,50	0,20	0,59	0,18	0,88
2013	0,49	0,19	0,59	0,18	0,88
2014	0,49	0,18	0,59	0,17	0,88
2015	0,49	0,18	0,58	0,17	0,88

Notes: Homeownership rates are calculated as the fraction of individuals with positive amounts of registered housing wealth. Young are all individuals below 35 years of age in the current year, and Old are individuals 35 years of age or older. Low income individuals are in top bottom three deciles of income in the current year, and High Income are in the top three deciles.

Table A2

Homeownership rates in high price areas.

Year	All Households	Young	Old	Low Income	High Income
2000	0,49	0,29	0,55	0,14	0,83
2001	0,49	0,29	0,55	0,14	0,83
2002	0,50	0,29	0,55	0,15	0,84
2003	0,49	0,28	0,55	0,15	0,83
2004	0,50	0,28	0,55	0,15	0,85
2005	0,50	0,29	0,55	0,16	0,85
2006	0,50	0,28	0,56	0,16	0,86
2007	0,49	0,26	0,55	0,15	0,84
2008	0,50	0,25	0,56	0,16	0,85
2009	0,50	0,23	0,56	0,17	0,85
2010	0,49	0,21	0,56	0,16	0,85
2011	0,49	0,19	0,56	0,16	0,85
2012	0,49	0,18	0,56	0,15	0,85
2013	0,48	0,17	0,56	0,15	0,85
2014	0,48	0,16	0,56	0,14	0,85
2015	0,48	0,17	0,55	0,14	0,85

Notes: Homeownership rates are calculated as the fraction of individuals with positive amounts of registered housing wealth. Young are all individuals below 35 years of age in the current year, and Old are individuals 35 years of age or older. Low income individuals are in top bottom three deciles of income in the current year, and High Income are in the top three deciles.

B Appendix. Figures

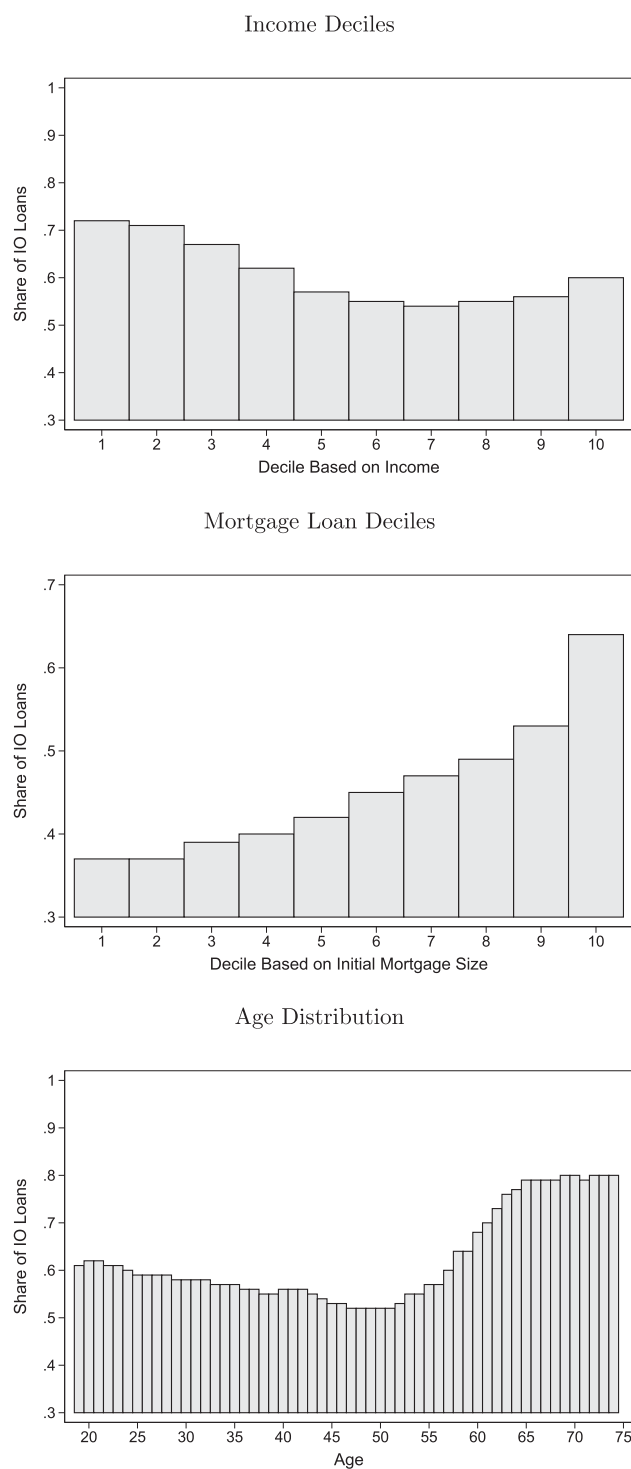


Fig. B1 Fraction of IO Loans Among All Borrowers. *Notes:* All figures plots the IO loan share among borrowers. The top figure divides the population into deciles based on disposable income. The middle figure divides the population into deciles based on initial mortgage loan balance. The bottom figure divides the population into age groups.

Appendix C. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.regsciurbeco.2018.06.004>.

References

- Abadie, Alberto, 2002. Bootstrap tests for distributional treatment effects in instrumental variable models. *J. Am. Stat. Assoc.* 97 (457), 284–292.
- Amromin, Gene, Huang, Jennifer, Sialm, Clemens, & Zhong, Edward. Forthcoming. Complex Mortgages. *Review of Finance*.
- Andersen, Steffen, Campbell, John Y., Nielsen, Meisner, Kasper, Ramadorai, Tarun, 2014. Inattention and Inertia in Household Finance: Evidence from the Danish Mortgage Market. Available at: SSRN 2463575.
- Association of Danish Mortgage Credit Banks, 2011. Boligejerne Har Styr Pa Deres Afdragsfrie Realkreditlan.
- Barlevy, Gadi, Fisher, Jonas DM., 2011. Mortgage Choices and Housing Speculation. (Tech. rept).
- Brueckner, Jan K., Calem, Paul S., Nakamura, Leonard I., 2016. House-price expectations, alternative mortgage products, and default. *J. Money Credit Bank.* 48 (1), 81–112.
- Campbell, J.Y., 2013. Mortgage market design. *Rev. Finance* 17 (1), 1–33.
- Chambers, Matthew S., Garriga, Carlos, Schlagenhaut, Don, 2009. The loan structure and housing tenure decisions in an equilibrium model of mortgage choice. *Rev. Econ. Dynam.* 12 (3), 444–468.
- Cocco, Joao F., 2013. Evidence on the benefits of alternative mortgage products. *J. Finance* 68 (4), 1663–1690.
- Dokko, Jane, Doyle, Brian M., Kiley, Michael T., Kim, Jinill, Sherlund, Shane, Sim, Jae, Van den Heuvel, Skander, 2011. Monetary policy and the global housing bubble. *Econ. Pol.* 26 (66), 237–287.
- Dokko, Jane K., Keys, Benjamin J., Relihan, Lindsay E., 2015. Affordability, Financial Innovation, and the Start of the Housing Boom. (Tech. rept).
- Gale, William G., Gruber, Jonathan, Stephens-Davidowitz, Seth I., 2007. Encouraging homeownership through the tax code. *Tax Notes* 115, 1171–1189.
- Garmaise, Mark J., 2013. The attractions and perils of flexible mortgage lending. *Rev. Financ. Stud.* 26 (10), 2548–2582.
- Garmaise, Mark J., 2017. Alternative mortgage contracts and affordability - overview talk. In: Conference on Housing Affordability.
- Gerardi, Kristopher S., Rosen, Harvey S., Willen, Paul S., 2010. The impact of deregulation and financial innovation on consumers: the case of the mortgage market. *J. Finance* 65 (1), 333–360.
- Ghent, Andra C., Kudlyak, Marianna, 2011. Recourse and residential mortgage default: evidence from US states. *Rev. Financ. Stud.* 24 (9), 3139–3186.
- Glaeser, Edward L., Gyourko, Joseph, Saiz, Albert, 2008. Housing supply and housing bubbles. *J. Urban Econ.* 64 (2), 198–217.
- Gorea, Denis, Midrigan, Virgiliu, 2017. Liquidity Constraints in the Us Housing Market. Tech. rept. National Bureau of Economic Research.
- Gross, David B., Souleles, Nicholas S., 2002. Do liquidity constraints and interest rates matter for consumer behavior? Evidence from credit card data. *Q. J. Econ.* 117 (1), 149–185.
- Gruber, Jonathan, Jensen, Amalie, Kleven, Henrik, 2017. Do People Respond to the Mortgage Interest Deduction? Quasi-Experimental Evidence from Denmark. Tech. rept. National Bureau of Economic Research.
- International Monetary Fund, 2011. Housing Finance and Financial Stability - Back to Basics?. (Tech. rept. USA).
- Justiniano, Alejandro, Primiceri, Giorgio E., Tambalotti, Andrea, 2017. The Mortgage Rate Conundrum. Tech. rept. National Bureau of Economic Research.
- Kaplan, Greg, Violante, Giovanni L., 2014. A model of the consumption response to fiscal stimulus payments. *Econometrica* 82 (4), 1199–1239.
- Kaplan, Greg, Violante, Giovanni L., Weidner, Justin, 2014. The Wealthy Hand-to-mouth. *Brookings papers on economic activity*, pp. 77–153.
- Lusardi, Annamaria, Mitchell, Olivia S., 2007. Financial literacy and retirement preparedness: evidence and implications for financial education. *Bus. Econ.* 42 (1), 35–44.
- Ministry of Economic and Business Affairs, 2007. Nye Tider P Boligmarkedet. (Tech. rept).
- Piskorski, Tomasz, Tchistyi, Alexei, 2010. Optimal mortgage design. *Rev. Financ. Stud.* 23 (8), 3098–3140.
- Politiken, 2003. Afdragsfri Lan Kan Fornys I Det Uendelige. 16 September. Last accessed: 12 May 2015.
- Poterba, James M., 1984. Tax subsidies to owner-occupied housing: an asset-market approach. *Q. J. Econ.* 729–752.
- Rangvid, Jesper, Grosen, Anders, Østrup, Finn, Møgelvang-Hansen, Peter, Jensen, Hugo Frey, Thomsen, Jens, Schütze, Peter, Galbo, Julie, Ølgaard, Christian, Frederiksen, Niels Kleis, et al., 2013. The Financial Crisis in Denmark – Causes, Consequences and Lessons. Tech. rept. Erhvervs-og Vækstministeriet.