The Impact of the Financial Crisis on Homeowners' Portfolio Choice

Ran S. Lyng*
Aarhus University

This Version: January, 2018

Abstract

This paper examines the mediating effect of the recent financial crisis on the relationship between house value fluctuation and households' liquid portfolio choice. To isolate exogenous variation in homeowners' home equity and mortgage debt before and after the crisis, I use a new regional level construction cost index along with other commonly used house price determinants as instruments. Using an administrative register-based panel data for the entire Danish population in the period 2004 – 2012, I find that the effect of housing on households' risky asset holdings is asymmetric before and after the crisis. The elasticity of risky asset shares with respect to mortgage debt and home equity is -0.31 and 0.28 respectively in pre-crisis period. On the other hand, whereas for the post-crisis period, the elasticity of risky asset shares with respect to mortgage debt and home equity is -0.37 and 0.34 respectively. Suppose an average household had spent 10% more on housing, the estimates suggest that they would hold 6% less in risky shares pre-crisis and 7% less post-crisis. Homeowners rebalance their liquid portfolio to a larger extent in response to their housing value fluctuation after the financial crisis, adding an additional effect that is likely to exacerbate the instability of an already tumultuous financial system.

JEL classification: D14; G11; R21; G01
Keywords: Portfolio choice; Personal finance; Housing; Homeowner; Financial Crises

*Department of Economics and Business Economics, Aarhus University, *Fuglesangs Allé 4, DK–8210 Aarhus V, Denmark, Building 2630-11; Email: rsun@econ.au.dk.* I would like to thank Jason Allen, Jie Zhou, Miguel Molico, Kfir Eliaz, Brain Peterson, Radomir Todorov, Yaz Terajima, Evren Damar, Teodora Paligorova, Chris Mitchell, Gino Cateau, Barbara Bukhvalova, John Kennes, Julia Nafziger, Stefan Hirth, and the seminar participants at the Bank of Canada, NFN Nordic Finance Workshop, as well as faculty and PhD students from University of Western Ontario, Igor Livshits, Audra Bowlus, Lance Lochner, Yifan Gong, Sha (Sarah) Wang, Yuxi Yao for helpful comments and suggestions. I would also like to thank Statistics Denmark for providing the data. Support from Aarhus University and Oticon Fonden is gratefully acknowledged.

1 Introduction

Housing is a dominant asset in a majority of household portfolios. Unlike financial assets, housing is illiquid, subject to house price risk, and is costly to adjust. Due to these salient features, economics theories predict homeowners will rebalance their liquid portfolio (bonds and risky assets) in response to house value fluctuations. Whether homeowners rebalance their liquid portfolio to the same extent following property value increases and decreases has, however, never been studied. The recent financial crisis is an ideal setting to study this research question because during the crisis, housing markets around the globe hit a turning point. Many countries have since experienced their first annual decline in house prices in the past decade. Over the same period, equity markets worldwide experienced sharp declines. If homeowners rebalance their liquid portfolio to a larger extent after the crisis, this additional effect is likely to exacerbate the instability of an already tumultuous financial system.

The aim of this paper is to examine whether the recent financial crisis has altered the relationship between housing and households' portfolio choice, and how. For the portfolio choice measures, I focus on risky asset participation (the extensive margin) and risky asset shares decision (the intensive margin). To isolate exogenous variation in homeowners' home equity and mortgage debt before and after the crisis, I use a new self-constructed regional level construction cost index as well as other commonly used house price determinants as instruments. Using a rich administrative register-based panel data from Denmark during the period 2004 - 2012, I am able to follow the same household for 9 calendar years and control for a broad spectrum of confounding variables, such as household demographics, extensive history on labor income, asset and debt holdings, and thereby provide credible estimates on the causal effect of housing on portfolio choice before and after the crisis, respectively.[1]

Theoretical studies predict that housing has a negative effect on households' demand for risky assets because of illiquidity and increased risk exposure (Grossman and Laroque, 1990; Flavin and Yamashita, 2002). Results from empirical studies, however, give limited support for theoretical predictions.[2] Chetty, Sandor and Szeidl (henceforth CSS) address the discrepancy in the empirical literature, and point out that first, it is critical to decompose property value into home equity and mortgage debt, as the two components have opposite-signed effect on households' demand for risky assets, and second, previous studies failed to identify the potential bias from endogeneity in housing choices. CSS

[1]The financial crisis in Denmark started in summer 2008 following the bankruptcy of Roskilde Bank. Since then, the Danish banking and housing sector have both suffered large losses. This will be discussed in more detail in Section 3.1.

[2] Fratantoni (1998) finds that the elasticity of risky asset share with respect to mortgage debt is negative. Yamashita (2003) documents that households who have a high proportion of net-worth tied up in housing hold a lower proportion of risky assets. Heaton and Lucas (2000) and Cocco (2005) show in cross-sectional OLS regressions, the risky asset share is positively correlated to mortgage debt.

isolates exogenous variations, to some extent, in the two components of housing. They show that for homeowners, an increase in mortgage debt decreases the shares of liquid wealth held in stocks, whereas an increase in home equity increases the risky shares of liquid wealth. Fougère and Poulhes (2012) replicate CSS's study using 2010 French data and found similar qualitative results. Quantitatively they find the wealth effect of holding more home equity always dominates the risk of owning a more expensive house. They explain this discrepancy as a result of high adjustment costs associated with housing in France. Michielsen, Mocking, and Veldhuizen (2016) use 2006-2010 panel data from the Netherlands, and find no significant relation between housing and risky asset shares.

This paper is different from previous studies on three aspects. First, previous studies focus on the relationship between housing and portfolio choice. However, no one has considered whether the recent financial crisis has altered this relationship. Second, previous studies mostly relied on the analysis of cross-sectional survey data, this paper exploits administrative register-based panel data that covers the entire Danish population for 9 calendar years, and has little measurement error. Finally, building on CSS's methodology, I construct regional level construction cost index as a new instruments to deal with endogenous housing variables.

The main finding of this paper is that the effect of housing on households' risky asset holdings is asymmetric before and after the 2007-2008 financial crisis, along both the extensive and the intensive margin, with a higher elasticity of risky asset shares with respect to both home equity and mortgage debt in the post-crisis period. The size of the pre-crisis estimates is comparable to CSS study using the US data. While the larger post-crisis elasticity is consistent with the interpretation that the financial crisis has imposed a great deal of uncertainty on households' labor income process and wealth. In order to reduce the probability of becoming credit constrained in the future and for liquidity concerns, households reduce more of their risky asset holdings when having to spend the same percentage more on housing. Policy makers should note this asymmetric effect and possibly implement policies to reduce this additional distress on the stock market coming from households' response to the housing market.

Several theoretical papers (Cocco (2005), Chetty, Sándor, and Szeidl (2017) and Chetty and Szeidl (2007)) guide my empirical model. Regarding the extensive participation margin, theories predict that housing will reduce equity market participation, due to fixed equity market participation costs and background risks in leveraged real estate. Regarding the intensive allocation margin, there are three theoretical channels that describe different incentives for households to hold a riskier or safer position: the diversification benefits (Yao and Zhang, 2005), the debt retirement channel (Becker and Shabani, 2010), and the liquidity demand hypothesis (Fratantoni, 2001; Hu, 2005).[3] The

[3]Section 2 provides more details on these three channels and other theoretical considerations.

first two channels suggest that housing has a positive effect on the risky asset share of liquid wealth conditional on participation, whereas the third channel argues for the opposite. The financial crisis has imposed a great deal of uncertainty on households' labor income process and wealth. Theory suggest that homeowners will exit the stock market more after the crisis. As to the risky asset shares decision, liquidity demand and debt retirement channel are more likely to be amplified after the crisis, while diversification effect is likely to be weakened.

I derive data from several different administrative registers made available by Statistics Denmark: demographic information from the Danish Civil Registration System (CPR Registeret), income and financial information from the Danish Tax Authority (SKAT), and housing information from Real Estate Statistics Register (Ejendomsstatistik Registeret). This sample contains 22,191,686 household-level observations from 2004 to 2012, among which 12,313,173 observations are homeowners. The exceptional quality of the data for the purpose of studying portfolio decisions is well-documented, see Christiansen, Joensen, and Rangvid (2008). The panel structure of the data ensures that both observed and unobserved (assuming time invariant) household characteristics, calendar year fixed effect and regional fixed effect that presents uniformly to all households, for example, interest rate, credit supply, mortgage regulation, and regional economic condition etc., will not bias the results.

To explore variations in both cross section and time dimension, as well as comparing the results with previous studies, the first identification strategy is to pool each household's information together over different points in time.[4] Similar to the results from previous studies where endogeneity of housing is not accounted for, mortgage debt is found to be *positively* correlated to risky asset holding and increase in home equity is associated with less risky asset holding. I then exploit the panel structure of the data. Using a panel data fixed effect model, I directly address selection effects from heterogeneous households.[5] Consistent with theoretical predictions, the results show that housing has a negative effect on households' demand for risky assets.

Despite the right signs of the coefficients, the results from the simple models should not be interpreted as a causal relationship, but rather a combined effect of measured and unmeasured confounders.[6] To overcome the concerns of endogeneity of property

[4]For the extensive margin, following convention, I apply a logistic regression for its flexible nature in not making many assumptions regarding linearity, normality, homoscedasticity, and measurement level. For the intensive margin, I provide results for a variety of specifications, including a baseline regression where only the 4 variables of interest - property value, home equity, and their interactions with an after crisis indicator - are included; then adding background controls and fixed effects; conditional on equity market participation; households with positive home equity; households with positive mortgage debt, and with cluster-robust standard errors.

[5]I allow households' behavior to be correlated through time, thereby reporting cluster-robust standard errors.

[6]Unmeasured confounders will cause the variables of interest, i.e., property value and home equity, to be correlated with the error term and lead to biased estimates in the traditional methods mentioned above.

value fluctuations, I use 2SLS IVs analysis in this paper to isolate exogenous variation in "mortgage debt" and "home equity" before and after the crisis. Four instruments are selected for the four endogenous regressors: (i) Regional level construction cost index; (ii) Regional level average house price per square meter; (iii) Municipality level average market property value after crisis; and (iv) Municipality level average household mortgage debt after crisis. I consider those four variables as plausible instruments for changes in property values because those are well-documented factors that drive house price dynamics (see, i.e. Tsatsaronis and Zhu (2004), Égert and Mihaljek (2007), and Capozza, Hendershott, Mack, and Mayer (2002)), and also because those are less likely to be correlated with homeowners' risky asset holdings compared to other important house price determinants, i.e. macroeconomic environment.

The first instrument "regional level construction cost index" is a self-constructed variable, which is calculated by multiplying "Number of Employees in Construction Industry / Total Number of Employees" from each region with "National Level Construction Cost for Residential Housing". Construction cost is a crucial long-term factor that affect house prices (Tsatsaronis and Zhu, 2004). However, national level construction cost alone is likely to affect households' risky asset holdings through channels other than "home equity" and outstanding "mortgage debt", i.e., tax schemes or macroeconomics environment. Consequently, I measure the employee concentration for construction industry in each region and interact this variable with the national construction cost (sum of material and labor costs) to construct a regional level construction cost index. Workers in construction industry generally have special education and certification or license (i.e., plumbers and electricians). Employee concentration in each region may affect construction workers' ability to respond effectively to changes in the economy or affect construction firms' ability to attract workers, ergo affect construction labor cost. Other instruments have been used in the literature before (Chetty, Sándor, and Szeidl, 2017; Fougère and Poulhes, 2012).

I show those instruments are strongly correlated to pre-crisis and post-crisis home equity and mortgage debt in first-stage regressions. In particular, a unit increase in the construction cost index is associated with DKK100,300 (p-value 0.0030) and DKK144,400 (p-value 0.0064) increase in mortgage debt outstanding before and after the crisis respectively. With respect to home equity wealth, a unit increase in the construction cost index is associated with DKK106,800 (p-value 0.0024) and DKK178,800 (p-value 0.0042) increase before and after the crisis respectively. In addition, Kleibergen-Paap rk LM,

Besides the confounders, other source of endogeneity may also raise concerns about causal inferences. One concern is simultaneity: housing and liquid portfolio compositions are usually jointly determined. In Cocco (2005) model, households simultaniously decide upon how much wealth should be allocated in housing, whether they are going to borrow against their house and how to allocate their liquid portfolio. This prevent any causal interpretation from housing to portfolio choice using the simpler regression models. A second concern is reverse causality: return from risky asset investments can be used to pay down mortgage debt (holding property value fixed, this means increase in home equity) in case of liquidity demand, creating a channel where risky asset holdings affect housing.

Sanderson-Windmeijer chi-squared and F test statistics reject the null of under identification and weak identification. The test statistics are robust in absence of i.i.d. error (See Table 7).

To assess the exclusion restriction of the instruments, I study the reduced-form relationships on the 4 instruments. Here, I focus on the relationship between the regional construction cost index, which is not used as instruments for housing choices in previous literature, and households' demand for risky assets. The result shows that controlling for covariates, the construction cost appears to be credibly orthogonal to portfolio choice (with coefficient 0.006 and p-value 0.832). The selection of other instruments and the discussion of exclusion restriction will be elaborated in Section 4.2.

I use the two-stage least squares instrumental variable method to access the causal effect of home equity and mortgage debt on households' risky asset holdings, before and after the crisis. For the extensive margin, the point estimate of property value coefficient implies that a DKK 100,000 increase in property value, holding home equity fixed, reduces the possibility of participating in risky asset investment by 0.925 percentage points before the crisis, a 2.17% decrease relative to its mean (42.72%). Post-crisis estimates imply that a DKK 100,000 increase in property value, holding home equity fixed, reduce the participation possibility by 0.588 percentage points, a 1.32% decrease relative to its mean (44.60%). The point estimates of home equity suggest that both before and after the crisis, the wealth effect of holding more home equity slightly dominates the risk of owning a more expensive house. But the magnitude of the differences are so small, that the effects from the two housing components almost cancel out.

As to the risky asset shares decision, the point estimate implies that the elasticity of risky asset shares with respect to *mortgage debt* is -0.31 and -0.37 before and after the crisis respectively. The elasticity with respect to *home equity* is 0.28 and 0.34 before and after the crisis respectively. Conditional on stock market participation, the effect of house value fluctuations on households' risky asset holdings is even larger.[7]

To clarify the interpretation of the point estimates, I discuss three counterfactual scenarios. First, I show that before the crisis, if an average household had spent 10% more on housing, they would hold 6% less in risky shares. Second, I show that after the crisis, if an average household had spent 10% less on housing, they would hold 7% more in risky shares. Finally, I consider how much risky shares an average household would hold, had they had no mortgage debt nor home equity. I show that without housing wealth and liability, an average household would hold 4.52 percentage points more in risky asset shares before the crisis (a 36% relative increase) and 3.83 percentage points more after the crisis (a 35% relative increase).

[7]Conditional on stock market participation, the elasticity of risky asset shares with respect to mortgage debt is -0.68 and -0.71 before and after the crisis respectively. The elasticity of risky asset shares with respect to home equity before and after the crisis is 0.68 and 0.67 respectively.

One concern with the above-described results is that the regressions do not adequately control for wealth effect, and that the negative effect of mortgage debt on risky asset holdings could be driven by less wealthy homeowners owning fewer stocks. I test the effect of housing on households' liquid portfolio for wealthier households who are in the top 10% and top 50% of family disposable income levels. Consistent with the main findings, increases in mortgage debt have a negative effect on wealthy households' demand for risky assets, and the magnitude of the estimates for wealthier households are higher compared to the corresponding estimates for the entire population both before and after the crisis.

Another concern is that life-cycle trends of risky asst holding drive my findings. I split the sample into three age groups, that are 28-38, 39- 48 and 49-59. If the main finding is driven by life-cycle trends, I would expect elder households to hold less risky assets compared to younger households. But in fact, the results show elder households increase risky asset shares more than younger households in response to the same amount of increase in home equity wealth.

Overall, the results from this paper provide evidence that housing has an asymmetric effect before and after the financial crisis, with higher elasticity of risky asset shares in the post-crisis period. Understanding the relationship between property value and the demand of risky assets has important policy implications. First of all, it gives insights in channels between the housing market and the stock market. Second, it helps to explain how money moves between two important market tiers of our economy: housing as a non-market tier and stock as a market tier. Finally, households' decisions on housing and financial investment have a great influence on business cycle dynamics and the stability of the financial system. Furthermore, investigating this relationship in the Danish context suggest how policy could influence the link between the housing market and the stock market in a country that have strong pension, social safety net and mortgage system.

It should be noticed that housing, besides its direct consumption benefits, enables consumption smoothing by protecting households against adverse events and provides a mean to increase long term consumption through potentially sizable investment return. The results of this paper apply to Denmark, a country that has a well developed pension system, adequate social safety nets (i.e. unemployment benefits, remuneration including contributions to a life insurance scheme and insurance against sickness, accident and death) and convenient and low cost mortgage refinancing and prepayment terms. Precautionary saving is less compelling here compared to a country that lacks these facilities. As a result, households are able to optimize their private wealth to a higher extent, not having to be bounded by keeping wealth in housing as a private pillar safety net or social insurance. Therefore, the elasticity of risky asset share with respect to mortgage debt and home equity should be lower in a country where households face stricter mortgage prepayment terms and have fewer social safety nets available to them. Indeed, compare

to CSS's result using the US data, the elasticity is higher in this study.

The rest of the paper is structured as follows. The next section reviews structural models developed to understand the effect housing on household's portfolio choice. Section 3 presents the Danish institutional context, where Danish households' assets and debts and mortgage model will be discussed, and data. Section 4 describes presents the research designs and empirical results. And finally section 5 concludes.

2 Theoretical Consideration

A rich theoretical and empirical literature has studied household portfolio choices along both the extensive participation margin (the decision to hold a certain type of financial asset) and the intensive allocation margin (the share of financial wealth held in a given asset), see Guiso, Haliassos, and Jappelli (2002), Campbell (2006) , and Guiso and Sodini (2013), among others. Household portfolio decisions are found to be affected by a variety of factors including risk preferences, financial characteristics, demographic characteristics, background risk, information and participation costs, etc. A number of studies have investigated the channels through which housing affects household portfolio choices of liquid wealth. Earlier models predict that housing tends to reduce the demand for risky assets because it increases a household's exposure to risk and illiquidity (Grossman and Laroque, 1990; Flavin and Yamashita, 2002). Recent theoretical contributions have included more complexity by relying on simulation models (Cocco, 2005; Yao and Zhang, 2005). These theoretical predictions guide my empirical model.

Regarding the extensive participation margin, theories predict that housing will reduce equity market participation. When there are information and/or other types of participation costs (e.g., set-up fees, monitoring costs, etc.) associated with risky asset investment, homeowner will benefit less from participation due to low liquid wealth after committed mortgage payment. Equity market participation cost could be either a one-time or a per-period cost. Previous studies by Basak and Cuoco (1998); Vissing-Jorgensen (2002); Haliassos and Michaelides (2003); Gomes and Michaelides (2005); Alan (2006) have suggested that costs can significantly impact stock market participation. In addition, leveraged real estate represents a significant background risk, which reduces homeowners' willingness to take on stock market risk. Due to these two reasons, housing has a negative effect on the risky asset participation rate.

Regarding the intensive allocation margin, a number of papers identify three channels that describe different incentives for households to rebalance their liquid wealth toward both riskier or safer positions. First, Yao and Zhang (2005) study how households optimally choose their portfolios of liquid wealth when they also decide whether to rent or own housing using a life-cycle model. When indifferent between owning and renting, they

show that investors choose substantially different portfolio compositions when owning a house versus when renting a house. When owning a house, investors reduce the equity proportion in their total wealth (bonds, stocks, and home equity), reflecting the substitution effect of home equity for risky stocks, but they hold a higher equity proportion in their liquid financial portfolio (bonds and stocks). This reflects the diversification benefit due to a low correlation between stock and housing returns and the high equity risk premium that makes holding stocks relatively attractive.

Second, Becker and Shabani (2010) explore the debt retirement channel and argue that when households hold mortgage debt after a house purchase, conditional on equity participation, they should increase the equity share of their liquid wealth. This is because the mortgage interest rate is higher than the return on safe assets (i.e., risk-free rate). Given that homeowners participate in stock markets, they should invest their liquid wealth mostly in stocks, but not in risk-free assets. Otherwise, they can be better off by using the liquid wealth to pay back the mortgage debt, as retirement of mortgage debt offers households a return equal to the interest rate on their mortgage loan, which is almost always greater than the return to investing in the risk-free asset.

Third, Fratantoni (2001) and Hu (2005) emphasize the importance of liquidity demand. They argue that homeowners, after a house purchase, face expenditure risk due to committed mortgage payments over a long horizon. When the labor income is uncertain, there is a liquidity demand for financial assets even when the fixed mortgage rate is higher than the rate of return on risk-free bonds. Therefore, homeownership has a negative impact on the risky asset share, as bonds provide liquidity to make mortgage payments in case of income shortfalls.

Based on the discussions above, the first two channels suggest that housing has a positive effect on the risky asset share of liquid wealth conditional on participation, whereas the third channel argues for the opposite.

The financial crisis has imposed a great deal of uncertainty on households' labor income process and wealth. With higher volatility in house prices, background risk increases significantly for a leveraged real estate position. Under a higher risk exposure in both housing and stock market and a fixed participation cost to entry, I expect homeowners' willingness to participate in risky asset investments to be reduced. As to the risky asset shares decision, diversification effect is likely to be weakened. Because after the crisis, stock and housing market return exhibit greater correlation. When house price is positively associated with stock price, house price risk generates a negative hedging demand for stocks. Through weakened diversification channel, homeowners are expected to hold less risky shares in their liquid portfolio. On the other hand, debt retirement channel and liquid demand are likely to be amplified after the crisis. Risk-free rate and mortgage rate both fall. Conditional on participation, homeowners have greater incentive to invest

more in risky asset to earn a higher return through debt retirement channel. Last but not the least, greater uncertainty in labor income increases the possibility for homeowners to default on their mortgage debt, and also to become credit constrained in the future. In order to avoid these adverse consequences, I expect homeowners to reduce their risky share holdings.

3 Data and Institutional Context

3.1 Institutional Context

The 2007-2008 financial crisis originated in the United States in the subprime mortgage market, and thereafter rapidly spread across all countries, with both advanced and emerging economies, as well as across different sectors. Due to a transparent and well regulated lending market, Denmark did not experience the subprime crisis. However, because of the equity market contagion (e.g., Bekaert, Ehrmann, Fratzscher, and Mehl (2014)), Danish economy was also hit by the crisis.

According to Ministry of Business and Growth Denmark (Erhvervs og Vækstministeriet), the financial crisis in Denmark started in summer 2008 following the bankruptcy of Roskilde Bank. Since then, the Danish banking sector has suffered large losses and many banks found themselves in serious solvency problems. The Danish government intervened by taking over distressed banks, giving guarantees to the sector. In light of government guarantees, traditional bank runs did not occur. Instead, many banks faced liquidity challenges as a result of an increasing degree of financing from foreign capital market prior to the crisis.[8]

[Figure 1 is here, see end of paper]

At the beginning of 2004, house price to income ratio in Denmark was 77% of the US price-income ratio (see Figure 1). It raised to 1.14 times of the US ratio during the second quarter of 2008. House price to rent ratio follows a similar pattern. House prices in Denmark has been on the rise since 1993. This upturn lasted for 14 years, peaked in 2007 and resulted in a 176% increase in real price (Skaarup and Bødker, 2009). During my sample period, both residential and commercial housing market saw considerable overheating throughout the first part of 2000s due to the introduction of new mortgage loan types[9] which allows home buyers to benefit from the low interest rates (Skaarup and

[8]Prior to the crisis, Danish bank's market financing shifted from traditional deposit-financed lending to an increase degree of foreign market financing, which includes market-based deposits from other credit institutions, money market funds and bond issuance.

[9]Mortgage loan types in Denmark: fixed-rate mortgage bond or cash loan; Adjustable-rate mortgage F1, F3, F5 and F10; Adjustable rate, F1/2, bond loan; Adjustable-rate with flexible maturity; Adjustable-rate with interest rate ceiling loan; Loan from banks not mortgage institution; Most of the above allow for 10 years interest-only period (deferred amortization).

Bødker, 2009; Abildgren, Buchholst, Qureshi, and Staghøj, 2011; Dam, Hvolbøl, Pedersen, and Birch, 2011). Dam, Hvolbøl, Pedersen, and Birch (2011) shows that if new loan types had not been introduced, the increase in real house prices from the fourth quarter of 1999 to the peak of 2007 would have been 40 percent as opposed to the actual increase of 71 percent.

From 2004 to the third quarter of 2007, house price index in Denmark increased by over 67% in nominal terms, reached the highest point in history. Dam, Hvolbøl, Pedersen, and Birch (2011) describes the housing market in this period as a genuine house price bubble with unrealistic expectations of future house prices. When the bubble burst, house prices fell substantially because the prices had risen to a level far above fundamental values. Homeowners then experienced large real capital losses in 2008 and the first half of 2009 (Dam, Hvolbøl, Pedersen, and Birch, 2011). To facilitate international comparison, Figure 2 shows Danish and American Case-Shiller house price index during the sample period.

[Figure 2 is here, see end of paper]

Freeze of tax amount for property value tax on owner occupied dwellings might be another reason that caused the real increases in house prices (Dam, Hvolbøl, Pedersen, and Birch, 2011). Denmark has three types of property taxes: land tax (Grundskyld), service tax (Dækningsafgift) and property value tax (Ejendomsvaerdiskat), all of which are levied by municipalities and counties (for details, see Müller (2000)). Dam, Hvolbøl, Pedersen, and Birch (2011) isolated the effect of property tax freeze and found (i) if home buyers only takes into account of the current property tax, real house prices would have risen by approximately 5 percentage points less from 2002 to the peak of 2007; (ii) if home buyers considers both current and future housing costs, real house prices would have risen by approximately 9 percentage points less from the fourth quarter of 1999 to the peak of 2007, had the tax not been frozen.

Danish housing market experienced a similar boom and bust period as the US. All Danish mortgage institutions, however, survived the crisis owing to the lesser extent of foreclosures in Denmark (Rasmussen, Madsen, and Poulsen, 2014) and several institutional and regulatory differences between the Danish and the US mortgage systems. Maximum lending limits (Loan-to-Value limits) for Danish mortgage are set up for each type of properties and documented in the Act on Mortgages and Mortgage Bonds §5.[10] For owner-occupied houses, cooperative houses and housing projects, mortgage loans can

[10]Lov om realkreditlån og realkreditobligationer m.v. finanstilsynet. Lov nr. 454 af 11. juni 2003 is available in Danish here: https://www.finanstilsynet.dk/AttachedFiles/%7B07a5ca67-9613-4ac2-a9ed-df786a2f5e7b%7D.%7Ba2fd5696-0b38-407b-9429-954fc7ace0e4%7D.lov-454-af-10062003-realkreditlaen.pdf ; Lov nr. 959 af 21/08/2015 is available in Danish here: https://extranet.finanstilsynet.dk/lovinfo/Lov.aspx?ItemId=0C7D28EF-5D75-49F6-AC6B-CDB0F072EAC3

represent up to 80 percent of the property value. The rest of the 20 percent can be borrowed from a bank with a rate that is typically higher than mortgage rate and lower than consumer loan rate. Mortgage rate and down payment is individual-specific and based on the assessment of a particular case. During the sample period, individuals are not required to provide any down payment.[11]

A standard Danish mortgage contract allows households to borrow long-term (up to 30 years) at fixed rates with an option to make penalty-free prepayments. Borrowers have the option to redeem their mortgage loans at any time without negotiating the price, that is prepayment can always be made at current market prices, or repay at a price of 100 (par). This debt restructuring environment allows mortgage borrowers in Denmark to benefit from a decline in interest rates, to avoid the lock-in effect from a potential increase in the market value of his debt, and to enjoy tax deduction on mortgage payment. On top of those, deregulation and mortgage banks' adoption of new technologies in the 1990s gave rise to a wide range of loan types and a broad range for borrowers to choose from. Borrowers can refinance their mortgages to reduce their interest rate, extend loan maturity without cashing out, even when they have negative home equity.

Under the traditional Danish mortgage model, mortgage banks follows a balance principle, where the funding and loan side has to be an exact match at any given time. This ensures minimization of liquidity and refinancing risks in the Danish mortgage credit system. Following this principle, the Danish mortgage banks operate mortgage lending under a "pass-through" system, where mortgage institutions and banks act as intermediaries in between the investors and borrowers. This balance principle is enforced by the Mortgage Loan Act since the introduction of the Danish mortgage system in 1797. EU imposed a covered bond legislation to implement a new set of rules from the EU – the Capital Requirements Directive – into Danish law. Taking this opportunity, the Danish parliament made further adjustments of the Danish mortgage market. Since then, commercial banks start to be able to fund their lending against mortgages on real property by issuing covered bonds. A new balance principle is made to segregate the loan and the underlying bonds completely. "The par rule" is proposed where loans not directly linked to listed bonds may be prepaid at a price of 100 (par). The Danish covered bond legislation came into force on 1st July 2007. It is a breakaway from the traditional Danish mortgage model based on the principle of matching loans and bonds. But mortgage banks decided to maintain the match funding principle.[12]

[11] A new rule requires individuals to put down at least 5 percent of the value of the property for down payment irregardless of the person's credit rating, taking effect from November 1st 2015.

[12] For more details on the supply side of Danish mortgage see: The Danish Mortgage Banks' Federation, Frankel, Gyntelberg, Kjeldsen, and Persson (2004), Willemann and Svenstrup (2006) and Rasmussen, Madsen, and Poulsen (2014)

3.2 Sample

This paper exploits administrative register-based panel data from Statistics Denmark that covers the entire Danish population for 9 calendar years throughout the period 2004 - 2012. Statistics Denmark is a state institution who collects and compiles impartial statistics on Danish society. The primary source of the financial data is Danish tax authorities. Every individual in Denmark pays taxes on both labor and capital income. Gross earnings for employed individuals are directly reported by the employer to the tax authorities. Most components of capital income are directly reported by individual's banks or other affiliated financial institutions. Therefore, household financial information provided objectively by Danish tax authorities is considered to have little measurement error, and therefore more reliable than survey data. Furthermore, using data for the entire population eliminates the concern of attrition bias which often presents in survey data and ensures that our results do not suffer from sampling error. The large sample size increases the external validity of the results and allows me to perform various sub-sample test while having enough observations in each specification for robust inferences. The detailed information available for each individual provides a broad spectrum of control that captures the background risk to the largest extent. And the panel data structure allows me to track the same individual over 9 years and account for time-invariant unobserved household heterogeneity which is a pervasive problem in cross-sectional analysis.

I have access to annual data on individual's demographics, extensive history on labor and capital income, liquid wealth holding and real estate information. Since home purchase and asset allocation are usually shared decisions made within household, research unit of this paper is set at household level. Individuals are grouped into households using a family identifier provided by Statistics Denmark. Household is defined as a single person or a couple with or without children. Couples include all married couples, registered partnerships and cohabiting couples. The sample contains 22,191,686 household-level observations throughout the 9 years period, among which 12,313,173 observations are home owners.

Main sample is defined as follows: (i) All non-homeowners are excluded from the sample (ii) I require households' age to be ranged from 28 to 59. The reasons are twofold. First, it is to eliminate the effect of remaining in full-time education and early-retirement schemes on households portfolio choice. Secondly, it is to avoid collinearity between property value and home equity for households with no outstanding mortgage debt, which is especially worrisome for retired households. (iii) I select a number of demographics and financial characteristics as control variables based on portfolio choice theories (see: Haliassos and Bertaut (1995); Guiso, Haliassos, and Jappelli (2002); Hong, Kubik, and Stein (2004); Christiansen, Joensen, and Rangvid (2008); Van Rooij, Lusardi, and Alessie

(2011)): age, age^2, marital status, number of children[13], highest education obtained[14], labor income after tax and deductions, compulsory pension savings, bank loans[15], net wealth[16], profit and losses from stock investment. The outcome variable is risky asset share[17] of liquid wealth which measures the riskiness of household portfolio. The panel is then balanced based on selections of the covariates and outcome variables in the period 2004 to 2012. These restrictions leave me with 4,221,417 observations, which are 473,580 unique households.[18]

[Table 1 is here, see end of paper]

Descriptive statistics is shown in Table 1. I report mean, median and standard deviation for the main sample at the base year 2004 and mean for before (2004-2007) and after (2008-2012) the financial crisis period respectively. The average household in the sample at the base year is: 45 years old and has 12 to 14 years of education (between high school or apprenticeship education and short-cycle higher education), household labor income after tax and deductions is DKK 601,613, has DKK 390,501 bank loans, household net wealth is DKK 980,226, makes a profit of DKK 16,896 in risky investment, owns liquid wealth of DKK 345,993 of which DKK 75,269 is risky. 77% of them are married and have on average 1.25 children. 43.76% of households are stockholders. Among those who

[13]Children include all people under 25 who is the child of at least one other person in the household. Furthermore, the person is only counted as a child in the household, if he/she does not have children of his/her own and have never been part of a couple in a marriage or registered partnership.

[14]Education is defined in categories: 1 denotes lower than primary education; 2 denotes primary education, 9 years of schooling; 3 denotes preparatory courses, 10 years of schooling; 4 denotes upper secondary education, 11 years of schooling; 5 denotes high school and apprenticeship education, 12 years of schooling; 6 denotes shorter cycle higher education, 14 years of schooling; 7 denotes vocational bachelors education, 15 years of schooling; 8 denotes a bachelor's degree, 16 years of schooling; 9 denotes a master's degree, 18 years of schooling; 10 denotes a PhD, 20 years of schooling.

[15]Bank loans include consumer loans and the proportion of a loan for a house which is not covered by mortgage. Maximum lending limits for Danish mortgage are set up for each type of properties and documented in the Act on mortgages and mortgage bonds § 5. For owner-occupied homes, cooperative homes and housing projects, mortgage loans can represent up to 80 percent of the property value. The rest of the 20 percent can be borrowed from a bank with a rate that is typically higher than mortgage rate and lower than consumer loan rate. During the sample period, individuals are not required to provide any down payment by law. Mortgage rate and down payment is individual-specific and based on the assessment of a particular case. From November 1st 2015, a new rule requires individuals to put down at least 5 percent of the value of the property for down payment irregardless of the person's credit rating.

[16]Net wealth includes property value, bank deposits, shares, bonds, mortgage deducted debts in different financial institutions including mortgage and consumer debt. This measure doesn't include value of cars, boats, cash and share purchases in cooperative housing.

[17]Risky asset share is defined as market value of stocks and risky mutual fund investments by the end of the year divided by liquid wealth. Liquid wealth consist of market value of stocks and risky mutual fund investments, market value of bond and bank deposits by the end of the year.

[18]79% of the households in the main sample have 2 adults. The average number of children per households is 1.25. Household head's age, marital status, number of children and highest educational attainment is used as household demographics. Household financial information, such as labor income, bank loans, compulsory pension savings, net wealth, property value, home equity, liquid wealth, risky asset holding, et cetera, are a sum of the corresponding variable for all individuals within the same household.

participate in stock market, on average 26.36% of their liquid wealth is invested in risky asset. The average household's market property value is DKK 2,655,792, among which DKK 1,298,192 is home equity. This implies an average household has an LTV of a little over 50%.

For the before crisis period, the market property value for an average household is DKK 2,449,064[19], among which DKK 1,250,907 is home equity and DKK 1,198,157 is mortgage debt. Stock market participation rate is 42.72%. Conditional on participation, share of risky asset is 29.16%. After the crisis, an average household owns a house that worth DKK 2,821,174 and has DKK 1,336,020 in home equity. Stock market participation rate is higher than before crisis period (44.60%). However, conditional on participation, risky asset share in total liquid wealth is 5 percentage points lower than before crisis period. All differences before and after the crisis are statistically significant.

StatBank (Statistikbanken) provides a wide range of statistics on national, regional and municipality level. In order to construct instruments for the endogenous regressors, I first obtain national level construction costs for residential housing during the period 2004 - 2012, which includes both material and labor costs. While the first measure only generates variations at the national level, ideally I would obtain regional level construction cost index. However, such measure is not available. So I obtain regional level[20] total number of employees and number of employees in construction industry. This is to measure the concentration of construction labors in a certain region, which is an important predictor of local construction labor cost. I then construct the first instrument by interacting the national and the regional construction cost. I also obtain regional level average house price per square meter; municipality level average market property value; and municipality level average household mortgage debt as instruments.

4 Empirical Strategy

In this paper, I develop two identification strategies to estimate the effects of housing on households' portfolio choice of liquid wealth, before and after the crisis. The empirical strategy is inspired by CSS. I assume homeowners' demand for risky asset depends on the fluctuations of property value, which is reflected through home equity and mortgage debt, and a vector of household characteristics, as illustrated by the following specification:

[19]This is 4.33 times of average yearly household labor income after tax and deductions

[20]There was a municipality reform (Strukturreformen/Kommunalreformen) in 2007, where 271 municipalities were merged into 98 municipalities which belongs to 5 regions. After January 1st, 2007, there are 5 regions in Denmark: Region Hovedstaden (with 29 municipalities); Region Sjælland (with 17 municipalities); Region Syddanmark (with 22 municipalities); Region Midtjylland (with 19 municipalities) and Region Nordjylland (with 11 municipalities). In order to maintain consistensy, I changed all 271 municipalities code in the data into 98 new municipalities for all municipalities before 2007 and then grouped them into the 5 regions according to "Strukturaftalen". See the map in Appendix, Figure 4

$$Y_{it} = \alpha_i + \beta \text{property value}_{it} + \gamma \text{home equity}_{it} + \eta \text{property value}_{it} * \text{after crisis}_{it} + \lambda \text{home equity}_{it} * \text{after crisis}_{it} + \delta X_{it} + \varepsilon_{it}, \forall i$$

where β , γ, η and λ are the parameters of interest. β and γ are the pre-crisis effect of mortgage debt and home equity on households' risky asset holding, while $\beta + \eta$ and $\gamma + \lambda$ are the effect of the two components of housing respectively in the post-crisis period. For the extensive margin decision, the dependent variable is a dummy indicating whether or not a household holds risky assets. For the risky asset shares decision, Y_{it} is risky asset share as defined in Footnote 17. X_{it} denotes a vector of control variables, including age, age^2, marital status, number of children, highest education obtained, labor income after tax and deductions, compulsory pension savings, bank loans (exclude mortgage debt), net wealth (including real asset), profits or losses of stocks and risky mutual fund investments.

4.1 Pooled OLS and Panel Data Fixed Effect Model

In order to explore variations in both cross section (across households) and time (with-in households) dimension, as well as comparing the results with previous studies, the first identification strategy is to ignore the panel data structure, i.e. pool each household's information together over different points in time. For risky market participation decision, I view the problem in a latent variable framework and adopt a logit model. One advantage of logit model is that it does not make assumptions regarding linearity, normality, homoscedasticity, and measurement level. In addition, I assume a household's behavior to be correlated through time, thereby reporting cluster-robust standard error. Parameters of interest are estimated using maximum likelihood estimation. For the risky asset shares decision, OLS is used to estimate the parameters of interest. I provide results for a variety of specifications: a baseline regression where only the 4 variables of interest are included; then household characteristics, year and regional fixed effect are added in the regression; stockholders; households with positive home equity; household with positive mortgage debt and finally with cluster-robust standard error.

I then exploit the panel structure of the data. For the risky market participation decision, I use fixed effect logit model. Parameters of interest are estimated by maximum likelihood estimation. Whereas for risky shares decision, I rely on estimates using fixed-effects model. This is to directly address selection effects from heterogeneous households. I control for household, region[21] and calender-year fixed effect, such that time-invariant household heterogeneity (i.e. higher order labor income risk), regional economic condition (i.e. local planning of land use, construction industry concentration) and aggregate calendar-year variations (i.e. macroeconomic condition: interest rate, stock market re-

[21]Danish national house price fluctuations are mainly driven by a few big cities. Figure 3 plots the national house prices for one family house during the period 2004-2012. Then show house prices in a few municipalities that grouped by their respective region.

turn, credit supply and mortgage regulation) which may potentially affect both housing value and household portfolio decisions, will not bias our result. I assume households' behavior to be correlated through time, thereby reporting cluster-robust standard error[22], clustering at household level. The results should be interpreted within a household over time, not across households, i.e. for a given household, as property value or home equity varies across time by DKK 1 million before or after the financial crisis, the risky asset participation rate (or risky asset shares) increase or decrease by X units.

4.2 Instrumental Variable Method (2SLS)

This paper estimates the causal effect of housing on households' demand for risky asset. The first identification strategy operates on an important assumption that the explanatory variables in the model do not explain any variation in the error term. Without such assumption, the estimators from the first identification is neither consistent nor unbiased Previous studies show that results from simple cross-sectional regressions are often biased (for example, find: Heaton and Lucas (2000) and Cocco (2005)). Suppose by considering the panel data structure, allowing for household heterogeneity and controlling for macroeconomic condition at a given year and a given region could reduce the bias and gives us the right sign. The result should still be treated with caution. Because this causal relationship may be obscured by combined effect of measured and unmeasured confounders.

Unmeasured confounders will cause the regressors of interest, i.e. property value and home equity, to be correlated with the error term. Therefore, lead to a failure of zero conditional mean assumption in the first identification strategy. For example, Cocco (2005) shows the unobserved labor income risk may have caused the risky asset shares to be positively correlated to mortgage debt; Calvet, Campbell, and Sodini (2007) investigates two main source of household investment inefficiency: not participating in risky asset markets and holding under-diversified portfolios. Those investment mistakes may also affect their housing decisions, i.e. where and when to buy a house, how much down payment to pay; Chetty and Szeidl (2007) studies two channels through which housing commitment affects risk preferences; Vestman (2013) assigns two different risk aversion coefficients to two types of households with higher and lower saving motives. Then he shows that both housing wealth and liquid wealth over the life-cycle display better fit of the life-cycle profiles. He also suggests to improve the model by introducing a bequest motive for individuals older than 45 years old, suggesting another confounder that may affect both housing and liquid wealth.

[22]Cluster-adjusted standard error account for correlation or heteroscedasticity for the same households through time. It focuses on variance. Fixed-effects estimation takes into account unobserved time-invariant heterogeneity. It focuses on shifted mean.

Besides the omitted-variable bias, several other factors can also cause the violation of the zero conditional mean assumption. One factor is simultaneity: housing and financial investment are usually jointly determined, which is a more realistic assumption adopted in Cocco (2005) model. Another factor is reverse causality: return from risky asset investment can be used to pay down mortgage debt (holding property value fixed, this means increase in home equity) in case of liquidity demand.

In the presence of endogeneity problem[23], two-stage least squares instrumental variable method is used in this paper to isolate exogenous variations in "property value" and "home equity" both before and after the crisis. Let S_{it} denote a vector of the endogenous regressors, and Z_{it} for a scalar of instruments. After controlling for a spectrum of covariates, a valid instrument has to satisfy the following assumptions: (i) $Cov(S_{it}, Z_{it}) = 0$ the instrument has to be correlated with the endogenous regressors, mortgage debt and home equity before and after the financial crisis. This condition can be tested in the first stage[24]; (ii) $Cov(\varepsilon_{it}, Z_{it}) \neq 0$ the instrument has to be uncorrelated with the error term.

There are 4 endogenous regressors in the estimation equation: property value$_{it}$, home equity$_{it}$, property value$_{it}$ $*$ after crisis$_{it}$ and home equity$_{it}$ $*$ after crisis$_{it}$. I constructed 4 instruments according to the two assumptions: (i) Regional level (Number of Employees in Construction Industry / Total Number of Employees) * National level construction cost for residential housing; (ii) Regional level average house price per square meter; (iii) Municipality level average market property value after crisis; and (iv) Municipality level average household mortgage debt after crisis.

Exclusion Restriction. Tsatsaronis and Zhu (2004) discuss long-term and short-term factors that drive real house price dynamics. The long term factors include construction cost, land supply elasticities, tax regime, macroeconomic environment, real income growth and shifts in demographics. The short term factors taking into consideration the local characteristics of housing markets, such as transaction costs associated with a house purchase[25], local land development schemes and the length of the construction phase and mortgage regulations. Among those factors, some are more important drivers, for example construction costs, land supply elasticities, macroeconomic environment, than others, for

[23] A Durbin-Wu-Hausman test for endogeneity rejects the null that the OLS estimator is consistent and fully efficient, therefore confirms the four explanatory variables: home equity and mortgage debt before and after the crisis are endogenous.

[24] First stage regression results are shown in "Results" section. First-stage test statistics are heteroskedasticity-robust. The Durbin-Wu-Hausman endogeneity test has a p-value less than 0.01, suggesting that there is a significant difference between IV and OLS estimates, and reject the use of OLS and in favor of IV. The underidentification test (Kleibergen-paap rk Langrange Multiplier (LM) test) statistics reject the null hypothesis with p<0.01, meaning the matrix of reduced form coefficients has full rank. As to weak instruments test, Stock-yogo weak identification F test assumes i.i.d. errors, which is not satisfied in this paper. I then rely on Cragg-Donald F test using Kleibergen-paap rk Wald statistic, which is robust in absence of i.i.d. error. The test statistics (166.11) exceed the tabulated critical value (47.28), hence reject the null hypothesis that the equation is weakly identified.

[25] such as VAT, stamp and registration duties or inheritance taxes. This factor largely affects the liquidity of the housing market.

example the length of the construction phase. Those that has strong correlations with the endogenous regressors are preferred choices as instruments in order to avoid inconsistent estimates from weak instruments. Among those factors that are strongly correlated to the endogenous regressors, some are less likely to affect the outcome variable, i.e. households' risky asset holding, directly or through other omitted variables than others. For example, macroeconomic conditions affect stock market returns and labor income processes, thereby affecting households' demand for risky assets. On the other hand, households are less likely to make portfolio decisions based on construction costs for housing. Those factors that are less likely to be directly or indirectly correlated to the outcome variable are the preferred choice as an instrument. Others can work together with included exogenous regressors in the main estimation equation to control for confounding factors.

The intuition behind the selection of each instrument is explained as follows: (i) interaction between regional level $\frac{\text{Number of Employees in Construction Industry}}{\text{Total Number of Employees}}$ and national level construction cost for residential housing. Suppose there is an aggregate shock on construction cost (material and labor) at the national level, for regions that have greater supply in construction workers, the total construction cost will face less adjustment. And for those regions that have less employees in construction industry, the regional cost will covary with national cost to a larger extent. This instrument avoid any potential correlation with unmeasured confounders at the municipality and household level, because the variations only come from the national and regional level. Those factors at the national and regional level that might directly affect household portfolio choice are controlled by calender-year and regional fixed effects. (ii) Regional level average house price per square meter. (iii) Municipality level average market property value after crisis; and (iv) Municipality level average household mortgage debt after crisis. The selection of these three instruments follow the intuition from CSS's first research design using "FHFA[26] state house price index in current year". Similarly, I control for year and regional fixed effects to account for potentially direct effect from instruments on households' liquid portfolio choice. Using 98 municipality dummies instead of the 5 regional dummies has little effect on the estimated coefficients[27], which suggests the resulting estimates are unlikely to be driven by omitted variable at the municipality level.

In order to further explore the effect of unmeasured confounders on household portfolio choice at the municipal and regional level, I study the reduced-form relationships on the 4 instruments. The first reduced-form relationship shows that controlling for covariates, the first instrument related to construction cost appears to be credibly orthogonal to portfolio choice (with coefficient 0.006 and p-value 0.832). The second reduced-form relationship shows that homeowners who live in a region with higher house prices hold less risky assets,

[26]Federal Housing Finace Agency. This house price index is a weighted, repeat-sales index.

[27]Coefficient β and γ both changed 0.001, p-value still <0.01. Coefficient η and λ stay the same, with p-value still <0.01

controlling for covariates. If regional house price correlates to omitted variable, i.e. higher order labor income risks, this instruments should give a upward bias to the reduced-form regression, because higher wealth leads to a higher risky asset holding. However, the coefficient shows a negative relationship between high house prices and risky asset holdings. Therefore, conditional on covariates and fixed effects, the second instrument is orthogonal to unobserved determinants of the outcome variable. The third reduced-form relationship shows that after the crisis homeowners who live in a municipality where property value is higher hold more risky assets. And finally, the last reduced-form relationship shows that after the crisis homeowners who live in a municipality where households borrow more mortgage debt hold less risky assets. The third finding suggests homeowners with higher housing wealth and liability (Property value = home equity + mortgage debt) hold more risky assets. The fourth finding suggests mortgage debt reduces risky asset holding. Jointly, the third and fourth finding also suggest home equity increases risky asset holding, which is consistent with the result in Table 4. Using the municipality fixed effects instead of regional fixed effects has little change on the estimates of the reduced-form regressions, suggesting the instruments are unlikely to be correlated with any omitted variable at the municipality level. Therefore, the last two instruments are selected to isolate exogenous variations in home equity and property value at the municipality level.

5 Results

In this section, I first report findings from the traditional methods (OLS and Panel data fixed effects model), then from 2SLS IV analysis. To clarify the interpretation of the coefficients, I discuss three counterfactual scenarios. Finally, I perform robustness checks to test the validity of the point estimates.

5.1 Results of Pooled OLS and Panel Data Fixed Effect Model

Column 1 and 2 of Table 2 report coefficients and the odds ratio for a logistic regression on the effect of property value and home equity on risky asset participation decision. Property value and home equity before and after the crisis are log transformed values. I control for background risks, household, country and regional fixed effects, and report cluster robust standard errors. Holding home equity fixed, the result shows that increases in property value, which is essentially increases in mortgage debt, have a positive effect on risky asset market participation both before and after the crisis. This is inconsistent with theoretical predictions (see: Cocco (2005)). Column 3 to 8 show results for the risky shares decision. Starting from a baseline regression of the risky asset shares in liquid wealth on property value and home equity without any background control nor fixed effects, I find a positive relationship between property value and risky asset shares both before and

after the crisis, similar to the findings in Heaton and Lucas (2000) and Cocco (2005). Adding background controls and fixed effects do not change the results significantly. To facilitate comparisons with previous studies, I also test this relationship in sub-samples: stockholders (44.24% of the main sample); households with positive home equity (91.55% of the main sample); household with positive mortgage debt (89.50% of the main sample) and finally with cluster-robust standard error. However, property value still appears to be positively associated with risky asset shares throughout all the specifications. Using OLS regressions on Danish data gives the same wrong signed results as shown in some previous empirical studies.

[Table 2 is here, see end of paper]

Identification of the causal effect of housing on household portfolio choice often faces two main challenges: selection bias and endogeneity. I address the selection effect by taking advantage of the panel structure of the data set. Table 3 reports results from panel data fixed-effects estimation. Column 1 and 2 report coefficients and the odds ratio for fixed effect logistic regression of the risky asset participation rate on property value and home equity. Controlling for background risks and the three fixed effects, as well as allowing for households' behavior to be correlated through time, I find property value to be negatively associated with the stock market participation rate, holding home equity fixed, which is consistent with Cocco (2005)'s prediction that homeownership crowds out stock holdings. Column 3 to 6 report estimates from regressions of risky asset shares on property value and home equity for the main sample, stockholders only, households with positive home equity, and household with positive mortgage debt, respectively. Here too, the coefficients of property value are negative and statistically significant with $p < 0.01$ across all specifications. The magnitude of the coefficients, however, vary across different sub-samples. The largest effect of property value on risky shares comes from the stockholders, which is 2 times of the average effect from the population in both before and after the crisis period.

[Table 3 is here, see end of paper]

5.2 Results of Instrumental Variable Method (2SLS)

Table 4 reports estimates from two-stage least squares instrumental variable analysis. Column 1 to 4 show first stage regressions for property value, home equity, after crisis indicator interacted with property value and after crisis indicator interacted with home equity on the four instruments.[28] Intuitively, column 1 tells us that higher construction cost is correlated to higher property value. Higher per square meter regional house

[28] First stage test statistics is discussed in Section 4, see footnote 24

price indicates higher property value for houses in that area. Column 2 shows that for homeowners, holding mortgage debt fixed, increases in property value raise home equity. Column 3 tells us that after the crisis, households who live in a municipality with higher property value tend to have a more expensive house themselves. Higher mortgage debt borrowed at the municipality level predicts higher property value. And finally, column 4 shows that municipality level average property value after the crisis is positively correlated to home equity in the same period. By definition, holding property value fixed, mortgage debt is negatively associated with home equity.

[Table 4 is here, see end of paper]

Column 5 of Table 4 shows the two-stage least squares estimates of β , γ, η and λ for risky asset shares decision, where property value and home equity before and after the crisis are instrumented by construction costs, house prices and mortgage debts at the regional and municipality level. I control for household, current year and regional fixed effects as well as background risks, such as age, age^2, marital status, number of children, highest education obtained, labor income after tax and deductions, compulsory pension savings, bank loans (exclude mortgage debt), net wealth (including real asset), profits or losses of stocks and risky mutual fund investments. The point estimate of property value coefficient implies that a DKK 100,000 increase in property value, holding home equity fixed[29], decreases risky asset share by 0.328 percentage points before the crisis, which is a DKK 1,014 decrease in value at the sample mean during the same period. Considering the mean risky asset share in liquid wealth before the crisis is 12.57%, this is a 2.61% relative decrease. $\beta + \eta$ is the point estimate for property value after the crisis. It implies that a DKK 100,000 increase in property value, holding home equity fixed, decreases risky asset share by 0.269 percentage points after the crisis, which is a DKK 1,010 decrease in value at the sample mean. Given the mean risky asset share in liquid wealth after the crisis is 10.89%, this is a 2.47% relative decrease. The elasticity of risky asset share with respect to property value (mortgage debt) is -0.31 and -0.37 before and after the crisis respectively.

On the other hand, the point estimate of home equity coefficient implies that a DKK 100,000 increase in home equity raise risky asset share by 0.281 percentage points before the crisis, which is a DKK 896 increase in value at the sample mean. Given the mean risky asset share in liquid wealth before the crisis is 12.57%, this is equivalent to a 2.24% relative increase. $\gamma + \lambda$ is the point estimate for property value after the crisis. It implies that a DKK 100,000 increase in home equity raise risky asset share by the same percentage points after the crisis. Due to the different sample mean, this translates to a DKK 1,055 increase in value. Given the mean risky asset share in liquid wealth after the crisis is

[29]Property value = home equity + mortgage debt, holding home equity fixed, increase in property value is essentially increase in mortgage debt.

10.89%, this is a 2.58% relative increase. The elasticity of risky asset share with respect to home equity before and after the crisis is 0.28 and 0.34 respectively.

Column 6 replicates the model in column 5 with the same fixed effects and background controls, conditional on stock market participation. Using the same instruments, the result implies that a DKK 100,000 increase in property value, holding home equity fixed, decreases risky asset share by 1.644 percentage points before the crisis. Considering the mean risky asset share in liquid wealth for stockholders before the crisis is 29.16%, this is equivalent to a 5.64% relative decrease. $\beta + \eta$, the point estimate for property value after the crisis, implies that a DKK 100,000 increase in property value, holding home equity fixed, decreases risky asset share by 1.162 percentage points after the crisis. Given the mean risky asset share in liquid wealth for stockholders after the crisis is 24.21%, this is a 4.80% relative decrease. Conditional on participation, the elasticity of risky asset share with respect to mortgage debt is -0.68 and -0.71 before and after the crisis respectively.

The point estimate of home equity coefficient implies that a DKK 100,000 increase in home equity raise risky asset share by 1.579 percentage points before the crisis. Given the mean risky asset share in liquid wealth for stockholders before the crisis is 29.16%, this is equivalent to a 5.41% relative increase. $\gamma + \lambda$, the point estimate for property value after the crisis, implies that a DKK 100,000 increase in home equity raise risky asset share by 1.208 percentage points after the crisis. Given the mean risky asset share in liquid wealth after the crisis is 24.21%, this is a 4.99% relative decrease. Conditional on participation, the elasticity of risky asset share with respect to home equity before and after the crisis is 0.68 and 0.67 respectively.

In column 7, I estimate a fixed effect model analogous to column 5 using log-transformed values instead of levels for property value and home equity before and after the crisis. Then those 4 log-transformed endogenous variables are instrumented by logs of the four instruments. The result should be interpreted as 1 percentage change in property value/ home equity will lead to x amount of changes in risky asset share. Consistent with previous findings with levels independent variables, increases in property value decrease risky asset shares and increases in home equity raise risky asset shares, with different magnitude before and after the crisis.

Counterfactuals. To facilitate a better understanding of the point estimates, I discuss three counterfactuals. In the first counterfactual scenario, I consider how much risky shares an average household would hold, had they spent 10% more on housing before the crisis. The mean of market property value before the crisis is DKK 2,449,064 (Table 1, column 4). Taking the coefficient β from Table 4, column 5, holding home equity and all other covariates fixed, this implies that risky asset share of liquid wealth would have been $2.449064 \times 3.279 \times 0.1 = 0.80$ percentage points less on average before the crisis. Given the mean risky asset share in liquid wealth before the crisis is 12.57%, this is equivalent

to a 6.39% relative decrease. An average household would hold 6% less in risky shares had they spent 10% more on housing before the crisis.

In the second counterfactual scenario, I consider how much risky shares an average household would hold, had they spent 10% less in housing after the crisis. The mean of market property value after the crisis is DKK 2,821,174 (Table 1, column 5). Given the coefficients $\beta + \eta$ in Table 4, column 5, holding home equity and all other covariates fixed, this implies that risky asset share of liquid wealth would have been $2.821174 \times 2.687 \times 0.1 = 0.76$ percentage points higher on average after crisis, which is a 6.97% increase relative to the mean of risky asset share in liquid wealth after the crisis 10.89%. An average household would hold 7% more in risky shares had they spent 10% less on housing after the crisis.

Finally, I consider how much risky shares an average household would hold, had they had no mortgage debt nor home equity. Given the mean property value (DKK 2,449,064) and home equity (DKK 1,250,907) before the crisis, the net impact of this scenario on risky asset shares before the crisis would have been $2.449064 \times 3.279 - 1.250907 \times 2.806 = 4.52$ percentage points. This translates to a 35.96% increase relative to its mean before the crisis. Similarly, the net impact of no home equity and no mortgage debt on risky asset shares after the crisis would have been $2.821174 \times 2.687 - 1.33602 \times 2.806 = 3.83$ percentage points, a 34.88% relative increase.

Column 8 of Table 4 show the two-stage least squares estimates of β , γ, η and λ for the extensive margin. Here, I replicate the regression in column 5, but change the outcome variable to a dummy indicator of risky asset holding. The point estimate of property value coefficient implies that a DKK 100,000 increase in property value, holding home equity fixed, reduces the possibility of participating in risky asset investment by 0.925 percentage points before the crisis, which is a DKK 2,861 decrease in value. Given the mean risky asset participation rate before the crisis is 42.72%, this is a 2.17% relative decrease. Post-crisis estimates imply that a DKK 100,000 increase in property value, holding home equity fixed, reduce the participation possibility by 0.588 percentage points after the crisis, which is a DKK 2,207 decrease in value. Given the mean risky asset participation rate after the crisis is 44.60%, this is a 1.32% relative decrease. Regarding home equity, the point estimates implies that a DKK 100,000 increase, increases the possibility of participating in risky asset investment by 0.983 percentage points before the crisis, which translates to a DKK 3,040 increase in value. Given the mean risky asset participation rate before the crisis is 42.72%, this is a 2.30% relative increase. Post-crisis estimates imply that a DKK 100,000 increase in home equity, increase the participation possibility by 0.673 percentage points after the crisis, which translates to a DKK 2,526 increase in value. Given the mean risky asset participation rate after the crisis is 44.60%, this is a 1.51% relative increase. The difference between before and after crisis is small

but is significantly different from zero with p<0.01.

5.3 Robustness Check

This section conducts robustness checks for the main identification strategy. I test the stability of the estimates over wealth (top 10% and top 50% of family disposable income households) and life-cycle trends. [30]

5.3.1 by Wealth

One concern with the main identification is that it didn't adequately control for wealth effect and the negative effect of mortgage on risky asset holding could be driven by less wealthy homeowners owning fewer stocks. I therefore exam this relationship for wealthier households who are in the top 10% and top 50% of family disposable income levels.

Column 1 and 2 of Table 5 replicate the analysis in column 5 of Table 4 with the same set of background controls as well as household, current year and regional fixed effects, but split the sample by top 10% and top 50% of family disposable income levels. Consistent with the main findings, increases in property value, holding home equity fixed, have a negative effect on households' demand for risky assets. Whereas home equity has a positive effect on risky asset holdings. The magnitude of the estimates for wealthier households are significantly higher compared to the corresponding estimates for the entire population with respect to property value and home equity both before and after the crisis.

[Table 5 is here, see end of paper]

Column 3 of Table 5 replicates the analysis in column 8 of Table 4 with the same set of background controls and the three fixed effects, for those families with lower than median disposable family income. The results are consistent with the main findings. Also in line with Cocco (2005) model, increases in house price risk reduce risky asset participation rates and this reduction is more pronounced for lower wealth households.

5.3.2 by Age

Another concern is that life-cycle trends of risky asst holding drive my findings. I split the sample into three age groups, that are 28-38, 39- 48 and 49-59.

[30] I also test the robustness of the main results in the following specifications: (i) including younger and elder households, i.e. from age 25 to 66; (ii) exclude year 2007; (iii) exclude year 2007 and 2008; (iv) change the measure of property value on the right hand side: instead of using "market property value" and "home equity" wealth before and after the crisis on the right hand side, I divide the four variables of interest by "liquid wealth". (v) I run the 2SLS regressions for before crisis and after crisis period separately. My main findings are robust to the above mentioned specifications. Results are available upon request.

Column 1-3 of Table 6 replicate the two-stage least squares analysis in column 5 of Table 4 with the full set of covariates and the fixed effects. Results from age group 39-48 and 49-59 are consistent with the main findings, where mortgage debt has a negative effect on risky shares and increases in home equity raise risky asset shares both before and after the crisis. If the main finding is driven by life-cycle trends, I would expect the estimates in Table 6 to show that elder households hold less risky assets compared to younger households. But in fact, the results show elder households increase risky asset shares more than younger households in response to the same amount of increase in home equity wealth.

[Table 6 is here, see end of paper]

Column 4-6 of Table 6 replicate the two-stage least squares analysis in column 8 of Table 4 with the full set of covariates as well as the fixed effects. The main sample is split into three different age groups. The result is consistent with the main findings. The negative effect from mortgage debt on risky asset participation is always almost cancelled out by the wealth effect of home equity. These effects remain after the crisis, however with different magnitude.

For households who are between 28-38, holding home equity fixed, increases in property value decrease risky asset shares, which is consistent with the main findings. Home equity shows no significant relationship with risky asset shares. It seems plausible that young households generally hold highly leveraged mortgage positions, face higher uncertainty in their future labor income processes, and plan to increase house size later in life because of marriage and children. Therefore, they might want to keep home equity wealth as an insurance against any future borrowing constraints related to moving. Besides, younger households usually hold a highly leveraged mortgage position compared to older households. It is usually optimal for them to pay back their mortgage debt rather than investing in risky asset market if there are extra funds available, since mortgage debt often carries the highest interest rate and the retirement of mortgage debt offers households a sizable return equal to the interest rate on their mortgage loan.

6 Conclusion

This paper investigates the causal relationship between housing and households' portfolio choice of liquid wealth for homeowners before and after the financial crisis. The empirical model in this paper builds on the theoretical contributions of Cocco (2005), Chetty, Sándor, and Szeidl (2017) and Chetty and Szeidl (2007). CSS identifies three channels through which exogenous increases in property value reduce the risky shares, which are increased illiquidity, increased exposure to house price risk and reduced present value of

lifetime wealth. Chetty and Szeidl (2007) show that commitments affect risk aversion, suggesting an asymmetrical effect of housing on portfolio choice before and after the crisis.

I find robust evidence that housing has a significant effect on household liquid portfolio choice, and with asymmetrical effects before and after the crisis. For the extensive margin, results show that increases in mortgage debt reduce risky asset participation, and whilst increases in home equity raise risky asset participation both before and after the crisis, but with different magnitude. For risky shares decision, before the crisis, a DKK 100,000 increase in mortgage debt decreases risky asset shares by 0.328 percentage points before the crisis, which is a DKK 1,014 decrease in value and a 2.61% relative decrease. Whereas a DKK 100,000 increase in home equity raise risky asset shares by 0.281 percentage points, which is a DKK 896 increase in value and a 2.24% relative increase. The elasticity of risky asset shares with respect to mortgage debt and home equity before the crisis is - 0.31 and 0.28 respectively. After the crisis, a DKK 100,000 increase in mortgage debt decreases risky asset share by 0.269 percentage points, which is a DKK 1,009 decrease in value and a 2.47% decrease relative to its mean. Whereas a DKK 100,000 increase in home equity raise risky asset share by the same percentage points, and amount to a DKK 1,055 increase in value and a 2.58% relative increase. The elasticity of risky asset share with respect to mortgage debt and home equity before the crisis is -0.37 and 0.34 respectively.

The results are consistent with theoretical predictions. Despite the different institutional context between Denmark and the US, the results are consistent with CSS findings. In CSS study, the elasticity of risky asset shares with respect to home equity wealth and outstanding mortgage debt is 0.3 and -0.2 respectively, using cross-sectional survey data from 1990-2008.

This paper focuses on homeowners' portfolio choice. In another paper with co-author, we focus on those who switched from renters to homeowners. There, we study the impact of a house purchase on households' portfolio choice of liquid wealth. Using the same register-based panel data from Denmark that spans from 2002 - 2012, we estimate the temporal patterns of households' liquid wealth, risky asset participation (the extensive margin), and the conditional risky asset share (the intensive margin) through the period from 3 years before to 3 years after house purchase. Our results suggest that of the three channels identified in previous literature that could affect the conditional risky share after house purchases, the diversification benefits and the debt retirement channels dominate the concern of liquidity demand. Liquidity demand, however, does have a larger effect on the portfolio choice of poorer households after a house purchase.

References

Abildgren, K., B. V. Buchholst, A. Qureshi, and J. Staghøj (2011): "Real Economic Consequences of Financial Crises," *Danmarks Nationalbank, Monetary Review*, 3, 1–49.

Alan, S. (2006): "Entry Costs and Stock Market Participation over the Life Cycle," *Review of Economic Dynamics*, 9(4), 588–611.

Basak, S., and D. Cuoco (1998): "An Equilibrium Model with Restricted Stock Market Participation," *Review of Financial Studies*, 11(2), 309–341.

Becker, T. A., and R. Shabani (2010): "Outstanding Debt and Household Portfolio," *Review of Financial Studies*, 23(7), 2900–2934.

Bekaert, G., M. Ehrmann, M. Fratzscher, and A. Mehl (2014): "The global crisis and equity market contagion," *The Journal of Finance*, 69(6), 2597–2649.

Calvet, L. E., J. Y. Campbell, and P. Sodini (2007): "Down or out: Assessing the welfare costs of household investment mistakes," *Journal of Political Economy*, 115(5), 707–747.

Campbell, J. (2006): "Household Finance," *Journal of Finance*, 61(4), 1553–1604.

Capozza, D. R., P. H. Hendershott, C. Mack, and C. J. Mayer (2002): "Determinants of real house price dynamics," Discussion paper, National Bureau of Economic Research.

Chetty, R., L. Sándor, and A. Szeidl (2017): "The effect of housing on portfolio choice," *The Journal of Finance*, 72(3), 1171–1212.

Chetty, R., and A. Szeidl (2007): "Consumption Commitments and Risk Preferences," *Quarterly Journal of Economics*, 122(2), 831–877.

Christiansen, C., J. S. Joensen, and J. Rangvid (2008): "Are economists more likely to hold stocks?," *Review of Finance*, 12(3), 465–496.

Cocco, J. F. (2005): "Portfolio choice in the presence of housing," *Review of Financial studies*, 18(2), 535–567.

Dam, N. A., T. S. Hvolbøl, E. H. Pedersen, and P. Birch (2011): "The Housing Bubble that Burst: Can House Prices be Explained? And Can Their Fluctuations be Dampened?," *Danmarks Nationalbank Monetary Review 1st Quarter Part.*

Égert, B., and D. Mihaljek (2007): "Determinants of house prices in central and eastern Europe," *Comparative economic studies*, 49(3), 367–388.

Flavin, M., and T. Yamashita (2002): "Owner-occupied housing and the composition of the household portfolio," *American Economic Review*, pp. 345–362.

Fougère, D., and M. Poulhes (2012): "The Effect of Housing on Portfolio Choice: A Reappraisal Using French Data," .

Frankel, A., J. Gyntelberg, K. Kjeldsen, and M. Persson (2004): "The Danish mortgage market," *BIS Quarterly Review*, p. 95.

Fratantoni, M. C. (1998): "Homeownership and investment in risky assets," *Journal of Urban Economics*, 44(1), 27–42.

——— (2001): "Homeownership, committed expenditure risk, and the stockholding puzzle," *Oxford Economic Papers*, pp. 241–259.

Gomes, F., and A. Michaelides (2005): "Optimal Life Cycle Asset Allocation: Understanding the Empirical Evidence," *Journal of Finance*, 60(2), 869–904.

Grossman, S. J., and G. Laroque (1990): "Asset Pricing and Optimal Portfolio Choice in the Presence of Illiquid Durable Consumption Goods," *Econometrica*, 58(1), 25–51.

Guiso, L., M. Haliassos, and T. Jappelli (eds.) (2002): *Household Portfolios*. MIT Press.

Guiso, L., and P. Sodini (2013): "Household Finance: An Emerging Field," in *Handbook of the Economics of Finance*, ed. by G. M. Constantinides, M. Harris, and R. M. Stulz, vol. 2, chap. 21, pp. 1397–1532. Elsevier.

Haliassos, M., and C. Bertaut (1995): "Why Do So Few Hold Stocks?," *Economic Journal*, 105, 1110–1129.

Haliassos, M., and A. Michaelides (2003): "Portfolio Choice and Liquidity Constraints," *International Economic Review*, 44(1), 143–177.

Heaton, J., and D. Lucas (2000): "Portfolio choice in the presence of background risk," *The Economic Journal*, 110(460), 1–26.

Hong, H., J. D. Kubik, and J. C. Stein (2004): "Social interaction and stock-market participation," *The journal of finance*, 59(1), 137–163.

Hu, X. (2005): "Portfolio choices for homeowners," *Journal of Urban Economics*, 58(1), 114–136.

Michielsen, T., R. J. Mocking, and S. Veldhuizen (2016): "Home Ownership and Household Portfolio Choice," .

Müller, A. (2000): *Property taxes and valuation in Denmark*. publisher not identified.

Rasmussen, K. M., C. A. Madsen, and R. Poulsen (2014): "Can home-owners benefit from stochastic programming models? A study of mortgage choice in Denmark," *Computational Management Science*, 11(1-2), 5–23.

Skaarup, M., and S. Bødker (2009): "House prices in Denmark: are they far from equilibrium?," *Danish Ministry of Finance Working Paper*.

Tsatsaronis, K., and H. Zhu (2004): "What drives housing price dynamics: cross-country evidence," *BIS Quarterly Review*, (March), 65–78.

Van Rooij, M., A. Lusardi, and R. Alessie (2011): "Financial literacy and stock market participation," *Journal of Financial Economics*, 101(2), 449–472.

Vestman, R. (2013): "Limited Stock Market Participation Among Renters and Home Owners," Discussion paper, Society for Economic Dynamics.

Vissing-Jorgensen, A. (2002): "Towards an Explanation of Household Portfolio Choice Heterogeneity: Nonfinancial Income and Participation Cost Structures," *NBER Working Paper No. 8884*.

Willemann, S., and M. Svenstrup (2006): "Reforming Housing Finance," *Journal of Real Estate Research*.

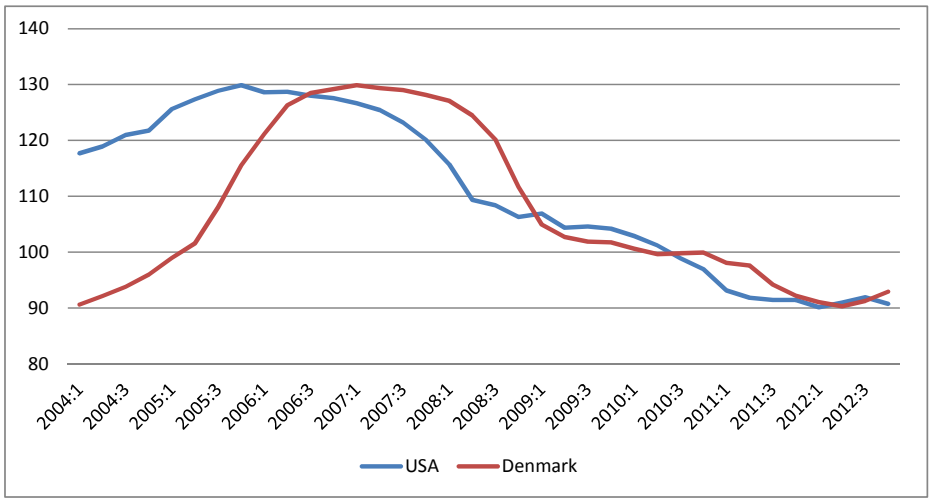
Yamashita, T. (2003): "Owner-occupied housing and investment in stocks: an empirical test," *Journal of Urban Economics*, 53(2), 220–237.

Yao, R., and H. Zhang (2005): "Optimal Consumption and Portfolio Choices with Risky Housing and Borrowing Constraints," *Review of Financial Studies*, 18(1), 197–239.

Appendix

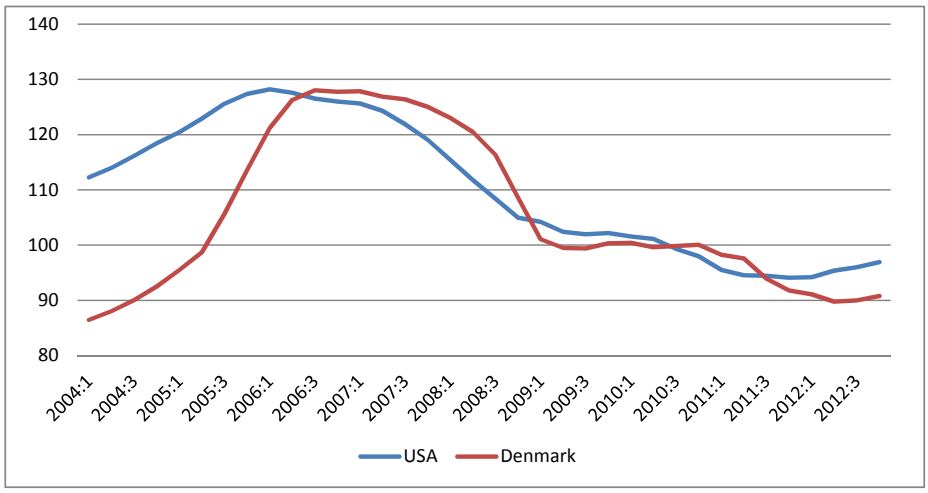
Figure 1: House Price to Income Ratio

A. Price-to-Income Ratio



Source: OECD, Price-Income ratio is calculated as nominal house prices divided by nominal disposable income per head, index based in 2010

B. Price-to-Rent Ratio



Source: OECD, Price to rent ratio is calculated as nominal house prices to rent prices, index based in 2010

Figure 2: Danish and American Case-Shiller House Price Index

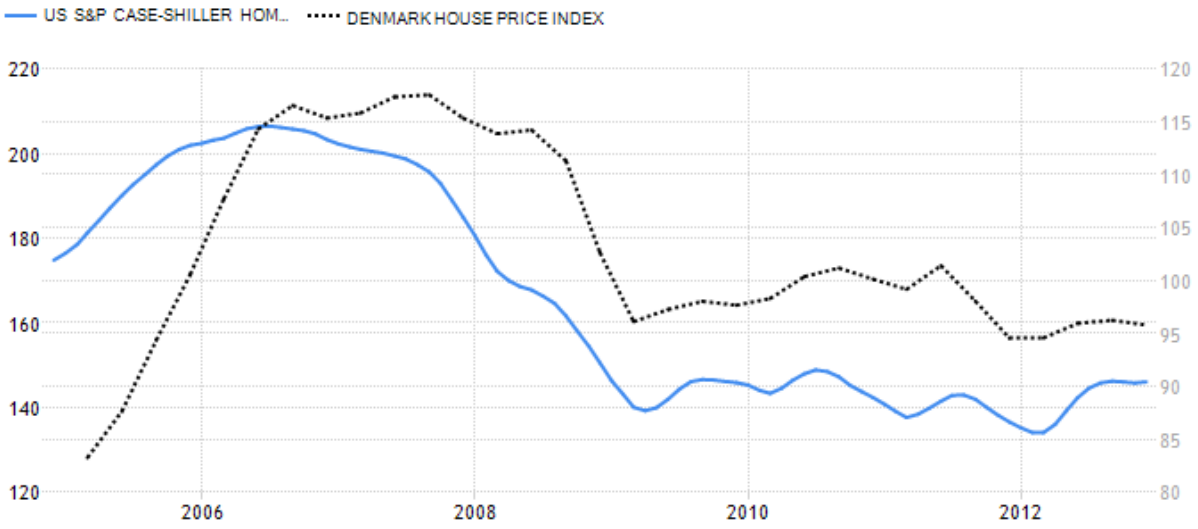
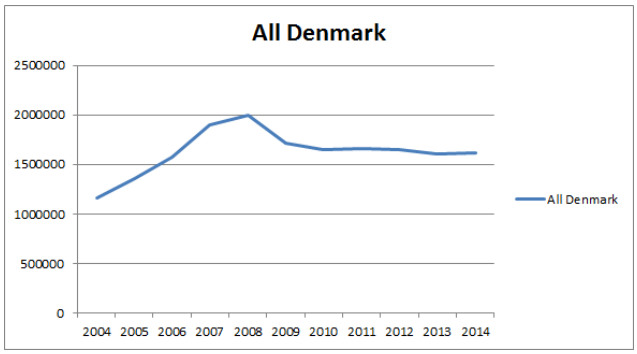
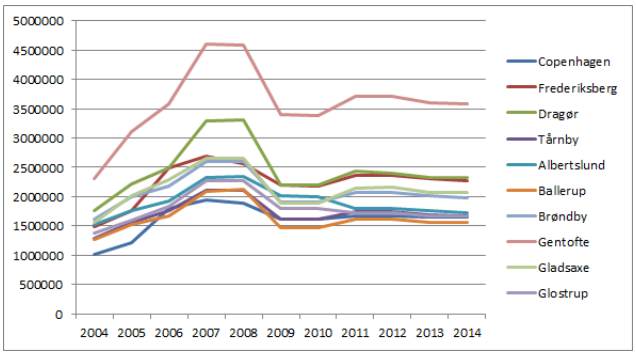


Figure 3: Municipality Level House Price 04 -14 (by Region)

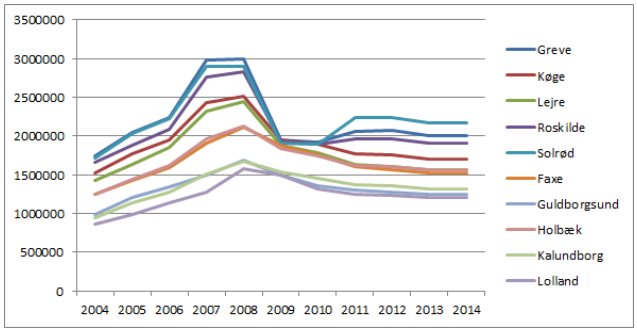
(a) All Denmark



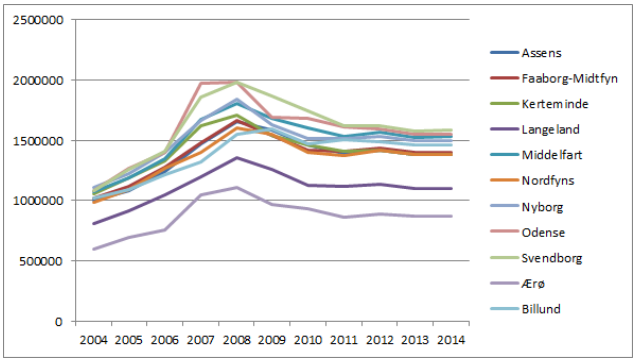
(b) Capital Region



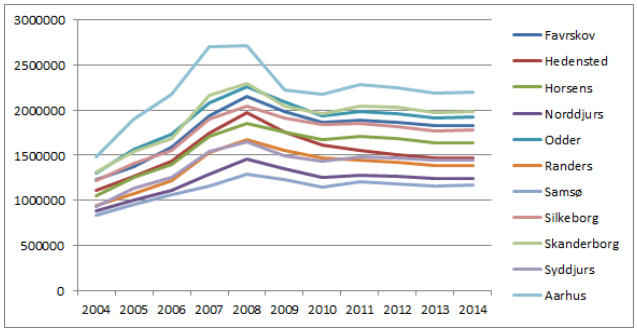
(c) Region Sjælland



(d) Region Syddanmark



(e) Region Midtjylland



(f) Region Nordjylland

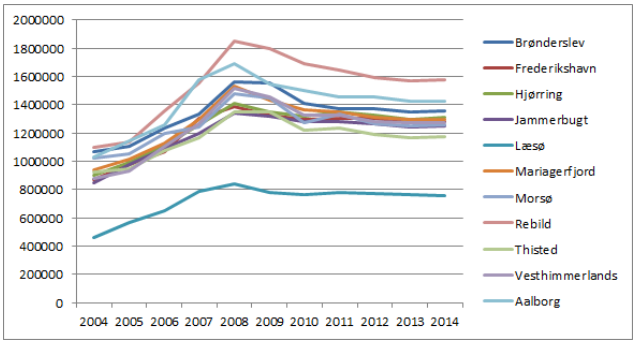


Table 1

Descriptive Statistics for the Main Sample

	(1) Mean	(2) Median	(3) Stadard Deviation	(4) Before Crisis Mean	(5) After Crisis Mean	(6) Difference
Demographics:						
Age	44.54	45.00	7.10	42.04	46.54	***
Married	0.77	1.00	0.42	0.75	0.79	***
Education	5.56	6.00	2.11	5.52	5.60	***
Number of Children	1.25	1.00	1.11	1.34	1.18	***
Housing Wealth:						
Market Property Value	2,655,792	1,823,945	4,712,375	2,449,064	2,821,174	***
Home Equity	1,298,192	783,091	3,117,019	1,250,907	1,336,020	***
Income & Debt						
Compulsory Pension Contribution	8,548	0	34,629	5,708	10,820	***
Labor Income	601,613	591,038	372,300	565,507	630,498	***
Bank Debts	390,501	153,620	1,347,200	346,165	425,971	***
Net Wealth	980,226	547,312	3,936,064	882,436	1,058,459	***
Stock Income	16,896	0	508,296	15,859	17,726	***
Household Portfolio:						
Liquid Wealth	345,993	115,350	2,634,764	309,269	375,373	***
Risky Asset	75,269	0	2,115,090	72,756	77,279	**
Safe Asset	270,724	95,890	1,178,962	236,513	298,094	***
Stockshare (unconditional)	11.64%	0%	22.15%	12.57%	10.89%	***
Stockshare % (conditional)	26.36%	16.24%	26.89%	29.16%	24.21%	***
Stock Market Participation Rate	43.76%	0%	49.60%	42.72%	44.60%	***

* Note: This Table reports summary statistics based on our main sample of 4,221,417 observations and 473,580 unique households. All households are home owners. Where applicable, values are in Danish Kroner (DKK) and measured at the end of the year. All financial variables are at household level. Net wealth includes property value, bank deposits, shares, bonds, mortgage deducted debts in different financial institutions including mortgage and consumer debt. This measure doesn't include value of cars, boats, cash and share purchases in cooperative housing. Column 1 reports the mean of each variable at the end of the base year 2004. Column 2 and 3 report the median and standard deviation at the base year. Column 4 and 5 report the mean of each variable before and after the crisis respectively. Before crisis is defined as 2004-2007 and after crisis is 2008-2012. Column 6 uses t-test statistics to show whether the difference in mean before and after crisis is statistically significant. *** denotes significant at 1% level, ** denotes significant at 5% level and * denotes significant at 10% level.

Table 2

Pooled OLS Regression Estimates

	Dependent Variable: Stockholder		Dependent Variable: Stockshare (%)					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Coefficients	Odds Radio	Baseline	Fixed Effects	Stockholders	Positive Home Equity	Positive Mortgage Debt	Cluster Household
Property Value			0.431***	0.448***	0.311***	0.500***	0.536***	0.448***
(DKK mio)			(0.00878)	(0.00902)	(0.0134)	(0.0107)	(0.00939)	(0.0370)
Home Equity			0.312***	-0.155***	-0.315***	-0.252***	-0.509***	-0.155
(DKK mio)			(0.0123)	(0.0132)	(0.0201)	(0.0156)	(0.0149)	(0.199)
Property Value * After Crisis			-0.123***	-0.149***	-0.0333**	-0.228***	-0.165***	-0.149***
(DKK mio)			(0.0102)	(0.0102)	(0.0150)	(0.0121)	(0.0105)	(0.0283)
Home Equity * After Crisis			-0.138***	-0.0217	0.0339	0.0927***	-0.0310**	-0.0217
(DKK mio)			(0.0147)	(0.0147)	(0.0223)	(0.0175)	(0.0156)	(0.0690)
Ln (Property Value)	0.152***	1.164***						
(DKK mio)	(0.00428)	(0.00498)						
Ln (Home Equity)	0.388***	1.474***						
(DKK mio)	(0.00675)	(0.00995)						
Ln (Property Value) * After Crisis (DKK mio)	-0.0289***	0.972***						
	(0.00493)	(0.00479)						
Ln (Home Equity) * After Crisis (DKK mio)	0.00684*	1.007*						
	(0.00356)	(0.00358)						
Controls	X	X		X	X	X	X	X
Current Year FE	X	X		X	X	X	X	X
Regional Fixed Effect	X	X		X	X	X	X	X
Cluster-Robust SEs	X	X						X
Observations	4,221,417	4,221,417	4,221,417	4,221,417	1,867,527	3,864,584	3,778,312	4,221,417
R-Squared	0.053	0.053	0.012	0.026	0.026	0.026	0.026	0.026

*Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Specification 1-2 and 4-8 include control variables: age, marital status, number of children, highest education obtained, labor income after tax and deductions, statutory pension savings, financial liabilities (exclude mortgage debt), net wealth (include real asset). Specification 4-8 include an additional control: profits or losses of stocks and risky mutual fund investments. Specification 1-2 report results for the effect of housing on stock market participation decision (extensive margin). Dependent variable is stock share. Specification 3-8 report results for the effect of housing on households demand for risky asset (intensive margin). Dependent variable is market value of stocks and risky mutual fund investments divided by total financial asset. Total financial asset consist of market value of stocks and risky mutual fund investments, market value of bond and bank deposits. Specification 1,2 and 8 report cluster robust standard errors for the whole sample, clustering at household level.

Table 3

Panel Data Fixed Effect Regression Estimates

	Dependent Variable: Stockholder		Dependent Variable: Stockshare (%)			
	(1)	(2)	(3)	(4)	(5)	(6)
	Coefficients	Odds Ratio	Population	Stockholders	Positive Home Equity	Positive Mortgage Debt
Property Value			-0.248***	-0.500***	-0.186***	-0.346***
(DKK mio)			(0.0254)	(0.0421)	(0.0273)	(0.0309)
Home Equity			0.640***	1.014***	0.496***	0.891***
(DKK mio)			(0.0547)	(0.0932)	(0.0556)	(0.0692)
Property Value * After Crisis			0.133***	0.273***	0.0936***	0.174***
(DKK mio)			(0.0162)	(0.0244)	(0.0185)	(0.0189)
Home Equity * After Crisis			-0.203***	-0.222***	-0.143***	-0.230***
(DKK mio)			(0.0313)	(0.0379)	(0.0336)	(0.0410)
Ln (Property Value)	-0.0881***	0.916***				
(DKK mio)	(0.00746)	(0.00683)				
Ln (Home Equity)	0.168***	1.182***				
(DKK mio)	(0.0159)	(0.0189)				
Ln (Property Value) * After	-0.279***	0.757***				
Crisis (DKK mio)	(0.0106)	(0.00798)				
Ln (Home Equity) * After	0.121***	1.129***				
Crisis (DKK mio)	(0.00713)	(0.00805)				
Controls	X	X	X	X	X	X
Household-Current Year FE	X	X	X	X	X	X
Regional Fixed Effect	X	X	X	X	X	X
Cluster-Robust SEs	X	X	X	X	X	X
Observations	862,869	862,869	4,221,417	1,867,527	3,864,584	3,778,312
R-Squared			0.014	0.043	0.015	0.014
Number of Households	101,339	101,339	473,580	262,015	470,679	450,039

*Note: Cluster Robust Standard errors in parentheses, clustering at household level *** p<0.01, ** p<0.05, * p<0.1. All specifications include control variables: age, marital status, number of children, highest education obtained, labor income after tax and deductions, statutory pension savings, financial liabilities (exclude mortgage debt), net wealth (include real asset). Specification 3-6 include an additional control: profits or losses of stocks and risky mutual fund investments. Specification 1-2 report results for the effect of housing on stock market participation decision (extensive margin). Dependent variable is stock share. 369564 households are dropped because their participation status never changed in the entire sample period. Specification 3-6 report results for the effect of housing on households demand for risky asset (intensive margin). Dependent variable is market value of stocks and risky mutual fund investments divided by total financial asset. Total financial asset consist of market value of stocks and risky mutual fund investments, market value of bond and bank deposits.

Table 4

Instrumental Variable: 2-Stage Least Sqaures Regression Result

	IV First Stage				Dependent Variable: Risky share (%)			Risky asset holder
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Property Value (DKK mio)	Home Equity (DKK mio)	PV (DKK mio) * After Crisis	HE (DKK mio) * After Crisis	Population	Stockholders	Logs	Participation Rate
Property Value					-3.279***	-16.44***		-0.0925***
(DKK mio)					(0.736)	(1.712)		(0.0127)
Home Equity					2.806***	15.79***		0.0983***
(DKK mio)					(1.000)	(2.105)		(0.0171)
Property Value * After Crisis					0.592**	4.824***		0.0337***
(DKK mio)					(0.285)	(0.643)		(0.00482)
Home Equity * After Crisis					0.128	-3.713***		-0.0310***
(DKK mio)					(0.340)	(0.772)		(0.00574)
Ln (Property Value)							-9.065***	
(DKK mio)							(0.519)	
Ln (Home Equity)							0.599***	
(DKK mio)							(0.0853)	
Ln (Property Value) * After Crisis							0.995***	
(DKK mio)							(0.182)	
Ln (Home Equity) * After Crisis							-0.153***	
(DKK mio)							(0.0591)	
Regional Construction Cost Index	0.1003***	0.1068***	0.0441***	0.0720***				
	(0.0030)	(0.0024)	(0.0064)	(0.0042)				
Regional Average house price per square meter	0.0007***	0.0005***	-0.0004*	-0.0003**				
	(0.0000)	(0.0000)	(0.0000)	(0.0000)				
Municipality level average market property value	-0.1930***	-0.1845***	0.9246***	0.7548***				
	(0.0049)	(0.0041)	(0.0087)	(0.0063)				
Municipality level average household mortgage debt	0.2663***	0.0445***	0.2911***	-0.3863***				
	(0.0095)	(0.0084)	(0.0171)	(0.0126)				
Controls	X	X	X	X	X	X	X	X
Household-Current Year FE	X	X	X	X	X	X	X	X
Regional Fixed Effect	X	X	X	X	X	X	X	X
HAC Ses	X	X	X	X	X	X	X	X
Observations	4,221,210	4,221,210	4,221,210	4,221,210	4,221,210	1,850,676	4,221,210	4,221,210
Number of Households	473,373	473,373	473,373	473,373	473,373	245,164	473,373	473,373

*Note: Heteroskedasticity and autocorrelation consistent standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Column 1-4 report first stage regressions for 2-stage least squares regression on the whole population. Column 5 reports result for the second stage of the regression. The dependent variable is market value of stocks and risky mutual fund investments divided by liquid wealth. Liquid wealth consists of market value of stocks and risky mutual fund investments, market value of bond and bank deposits. All specifications include control variables: age, marital status, number of children, highest education obtained, labor income after tax and deductions, statutory pension savings, bank debt (exclude mortgage debt), net wealth (include real asset), profits or losses of stocks and risky mutual fund investments. Column 6 reports 2SLS result for stockholders only. In column 7, the endogenous regressors are in logs and the instruments used in this specification are log transformed indices. Column 8 reports estimates for risky asset participation decision. The dependent variable is stockholder. In Column 5 - 8, the four explanatory variables reported are jointly significant at 1% level in each column. In Column 5 - 8, property value before crisis is significantly different from property value after criris at 1 % level in each column. In column 5, home equity before crisis is significantly different from home equity after crisis at 5% level. In Column 6 - 8, home equity before crisis is significantly different from home equity after crisis at 1% level.

Table 5

Instrumented: 2SLS for High Wealth Households

	Dependent Variable: Stockshare (%)		Stockholder (participation)	
	(1)	(2)	(3)	(4)
	Top 50%	Top 10%	Top 50%	Top 10%
Property Value	-27.92***	-23.93***	-0.127***	-0.0339***
(DKK mio)	(3.679)	(9.269)	(0.0117)	(0.00469)
Home Equity	30.99***	28.45***	0.293***	0.0211***
(DKK mio)	(4.205)	(10.47)	(0.0319)	(0.00557)
Property Value * After Crisis	8.585***	12.70**	0.0405***	0.00890**
(DKK mio)	(1.506)	(5.036)	(0.00463)	(0.00356)
Home Equity * After Crisis	-10.58***	-18.79***	-0.00402	-0.00361
(DKK mio)	(2.125)	(7.250)	(0.0103)	(0.0366)
Controls	X	X	X	X
Household-Current Year FE	X	X	X	X
Regional Fixed Effect	X	X	X	X
HAC SEs	X	X	X	X
Observations	2,096,723	412,275	2,096,723	412,275
Number of Households	158,014	18,482	158,014	18,482

*Note: Heteroskedasticity and Autocorrelation Consistent standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. All specifications include control variables: age, age-squared, marital status, number of children, highest education obtained, labor income after tax and deductions, statutory pension savings, bank debt (exclude mortgage debt), net wealth (include real asset), profits or losses of stocks and risky mutual fund investments. Column 1 and 2 report the effect of housing on the demand for risky asset for households with family disposable income in top 50 percentile and top 10 percentile respectively. The dependent variable is market value of stocks and risky mutual fund investments divided by liquid wealth. Liquid wealth consists of market value of stocks and risky mutual fund investments, market value of bond and bank deposits. Column 3 and 4 report the effect of housing on risky asset participation decision before and after the crisis.

Table 6

Instrumented: 2SLS by Age Category

	Dependent Variable: Stockshare (%)			Stockholder (Participation)		
	(1)	(2)	(3)	(4)	(5)	(6)
	28-38 years old	39-48 years old	49-59 years old	28-38 years old	39-48 years old	49-59 years old
Property Value (DKK mio)	-3.120*	-5.549***	-6.729***	-0.0945***	-0.0941***	-0.142***
	(1.597)	(1.228)	(1.564)	(0.0184)	(0.0203)	(0.0257)
Home Equity (DKK mio)	0.576	5.219***	6.866***	0.170***	0.102***	0.150***
	(0.930)	(1.590)	(1.930)	(0.0297)	(0.0262)	(0.0320)
Property Value * After Crisis (DKK mio)	0.230	1.440***	0.211	0.0360***	0.0310***	0.0420***
	(0.451)	(0.473)	(0.537)	(0.00804)	(0.00760)	(0.00875)
Home Equity * After Crisis (DKK mio)	-0.386	-1.663***	1.135*	-0.0207*	-0.0304***	-0.0352***
	(0.615)	(0.609)	(0.606)	(0.0111)	(0.00967)	(0.00978)
Controls	X	X	X	X	X	X
Household-Current Year FE	X	X	X	X	X	X
Regional Fixed Effect	X	X	X	X	X	X
Heteroskedasticity-Robust SEs	X	X	X	X	X	X
Observations	940,951	1,827,492	1,369,981	940,952	1,827,493	1,369,982
Number of Households	158,870	201,383	67,831	158,870	201,383	67,831

*Note: Heteroskedasticity-robust Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. All specifications include control variables: age, marital status, number of children, highest education obtained, labor income after tax and deductions, compulsory pension savings, bank debt (exclude mortgage debt), net wealth (include real asset), profits or losses of stocks and risky mutual fund investments. Column 1-3 report the effect of housing on the demand for risky asset by age category for risky asset share decision. The dependent variable is market value of stocks and risky mutual fund investments divided by liquid wealth. Liquid wealth consists of market value of stocks and risky mutual fund investments, market value of bond and bank deposits. Column 4-6 report the risky asset participation decision. The dependent variable is a dummy on whether the household is a stockholder.

Figure 4: Pre 2007 municipalities mapping into Post 2007 municipalities

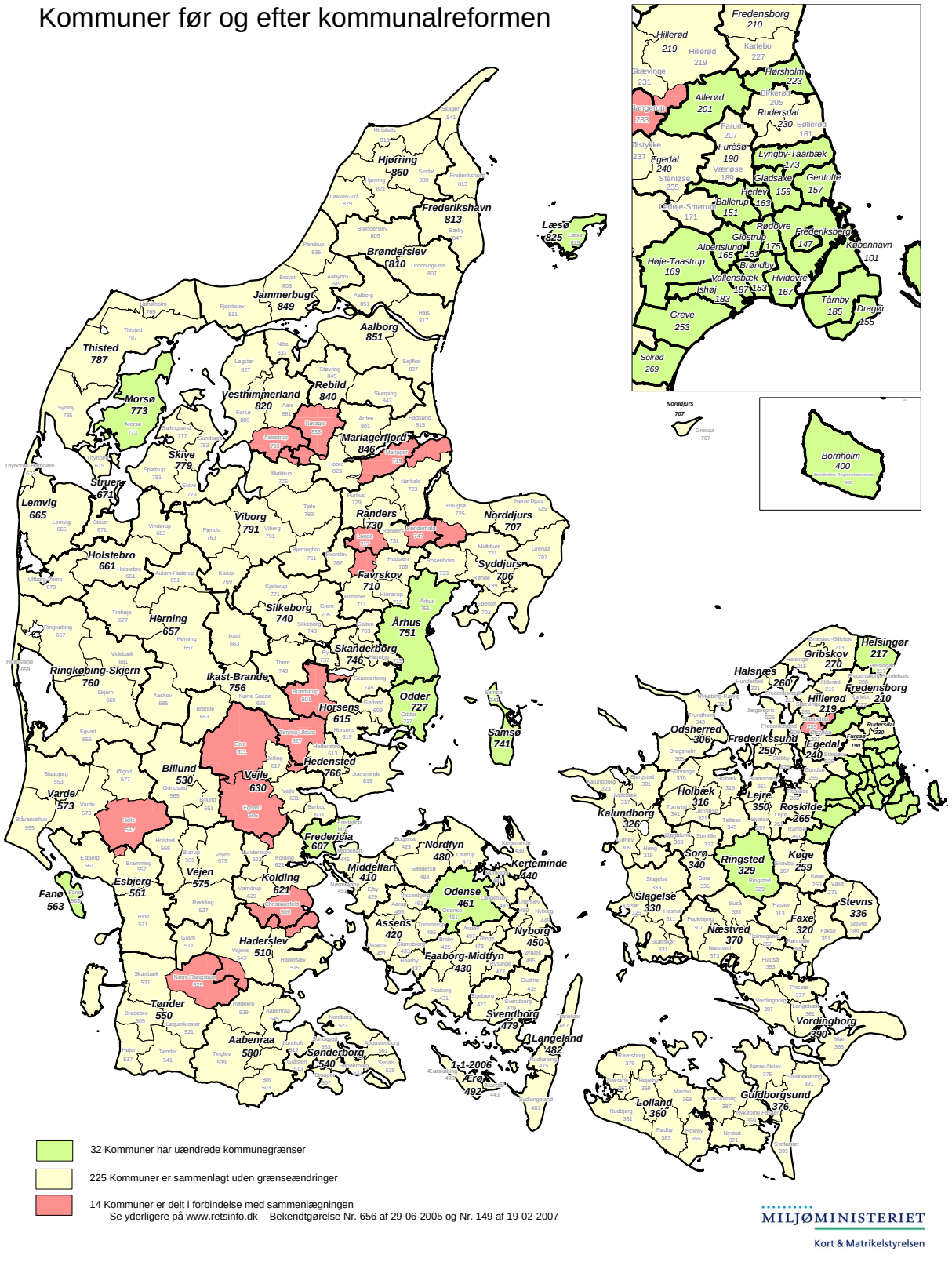


Table 7: IV First Stage Statistics

IV First-Stage Statistics

	(1) Property Value	(2) Home Equity	(3) PV After Crisis	(4) HE after Crisis
F test of excluded instruments:	433.80 p-val=0.0000	1020.15 p-val=0.0000	1045.29 p-val=0.0000	1115.16 p-val=0.0000
Sanderson-Windmeijer multivariate F test of excluded instruments:	297.65 p-val=0.0000	329.30 p-val=0.0000	393.35 p-val=0.0000	465.17 p-val=0.0000
Sanderson-Windmeijer multivariate Chi-sq (1) test* of excluded instruments:	297.66 p-val=0.0000	329.31 p-val=0.0000	393.35 p-val=0.0000	465.18 p-val=0.0000

*Note: First-stage test statistics cluster-robust. SW F statistics is test of weak identification of individual endogenous regressors. It is constructed by "partialling out" linear projections of the remaining endogenous regressors. It can be used as a diagnostic for whether a particular endogenous regressor is "weakly identified". SW chi-squared is a test of underidentification of individual endogenous regressors. It is distributed as chi2 (4-4+1) under the null that the particular endogenous regressor in question is underidentified.

Stock-Yogo weak ID F test critical values for single endogenous regressor:

5% maximal IV relative bias	16.85
10% maximal IV relative bias	10.27
20% maximal IV relative bias	6.71
30% maximal IV relative bias	5.34
10% maximal IV size	24.58
15% maximal IV size	13.96
20% maximal IV size	10.26
30% maximal IV size	8.31

Underidentification test

Kleibergen-Paap rk LM statistic:	Chi-sq (1) = 78.16	P-val= 0.0000

*Note: This statistics is a generalization of Anderson LM and Cragg-Donald Wald statistics to the case of non-i.i.d. errors.

Weak instrument robust inference

Anderson-Rubin Wald test:	F (4,473372) = 114.43	P-val = 0.0000
Anderson-Rubin Wald test:	Chi-sq (4) = 457.71	p-val = 0.0000
Stock-Wright LM S statistic:	Chi-sq (4) = 459.96	p-val = 0.0000

*Note: This test statistic is cluster robust. This is to test the significance of the endogenous regressors in the structural equation being estimated. The null hyåothesis is that the coefficients of the endogenous regressors in the structural equation are jointly equal to zero. Both tests are robust to the presence of weak instruments. The tests are equivalent to estimating the reduced form of the equation (with the full set of instruments as regressors) and testing that the coefficients of the excluded instruments are jointly equal to zero. Both statistics are distrubuted as chi-squared with L1 degress of freedom, where L1 = number of excluded instruments (in this case, it is 4).