The Causal Effect of Household Risk-free Rates on Portfolio Choice

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Abstract

Lack of participation in the stock market remains an ongoing discussion in finance. Brown, Veld & Veld-Merkoulova (2018) find that Perceived Equity Risk Premium (PERP), defined as the difference between the individual's expected stock market return and her personal opportunity cost of capital, can explain limited stock market participation, but were unable to provide causal evidence on that. We examine the causal impact of PERP on portfolio choice by estimating changes in portfolio choice at the time of mortgage runoffs. We merge administrative register-based panel data from Statistics Denmark with individual mortgage transaction data from the Association of Danish Mortgage Banks. Using a Regression Discontinuity in Time (RDiT) framework, we find the probability of equity market participation increases discontinuously at mortgage runoff, and conditional on equity market participation, the share of liquid wealth held in risky assets decreases discontinuously. Our result confirms Becker and Shabani (2010) theoretical prediction, and is consistent with Brown, Veld & Veld-Merkoulova (2018) and the life-cycle model prediction of Davis, Kubler and Willen (2006). PERP is an important determinant for portfolio choice.

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1 Introduction

CAPM is a cornerstone in modern portfolio theory. It suggests that the market risk-free rate and the expected market return are two important benchmark rate one should be looking at when making portfolio choice. But when households make their portfolio choice decision, they rarely use these benchmarks. Vissing-Jørgensen (2003), Hurd, van Rooij & Winter (2011), and Kaplanski et al. (2016) have shown that households use their own subjective stock market expectations in assessing the economic benefits of investing in stock market rather than using expected market returns. Recently, Brown, Veld & Veld-Merkoulova (2018) find that not only stock market return expectations are highly heterogeneous, the risk-free rate each household faces are also heterogeneous. They show that households use their personal opportunity cost of capital as the risk-free rate, instead of the market risk-free rate. This is consistent with the life-cycle model prediction of Davis, Kubler and Willen (2006) who show that when households cannot borrow at the risk-free rate they invest nothing in bonds, therefore the risk-free rate each household faces should be their cost of borrowing. More specifically, Becker and Shabani (2010) show that the cost of borrowing on mortgage debt should be the household risk-free rate.

Brown, Veld & Veld-Merkoulova (2018)'s finding that households use their personal opportunity cost of capital as household risk-free rate is an intriguing new idea, as policy can effectively affect this rate. And it is in the central interest of policymakers to understand how their policy affects household demands for risky assets, i.e. their decision to participate in the stock market and the amount of risky assets to invest. But so far, most of these discussions have been theoretical. The very limited empirical evidence can only claim correlation but not causality on the impact of household risk-free rate on their stock market participation.

It is indeed very difficult to provide causal evidence on that. First of all, it's hard to find a good natural experiment that creates random variation on risk-free rate household faces without simultaneously affecting household portfolio choice. For example, a monetary policy that changes policy rate can change the risk-free rate households face. But at the same time, this policy will almost certainly also change their stock market return expectations and directly affect household portfolio choice. Another example, there is discussion about removing tax rebate on mortgage interest. This policy can change household risk-free rates. But it will also reduce household wealth. When wealth and interest rate change at the same time, we cannot distinguish between the two channels. So we cannot infer causality. Moreover, it is also difficult to use typical non-experiment designs like instrumental variables, as it requires the instrument to isolate treatment variation that is "as good as randomized". So in this paper, we're going to propose a research design that allows us to provide FIRST causal evidence on the impact of household risk-free rate on their portfolio choice.

Our research design is to estimate changes in portfolio choice at the time of mortgage runoffs using a Regression Discontinuity design. When having a mortgage, a household faces the choices of investing in safe asset, risky asset and repaying a fixed amount of monthly mortgage debt. If he decides to pay an amount in excess of the required payment, this can be seen as purchasing a bond with face value equals to the excess payment and a yield to maturity equals to the mortgage interest rate. This means that when having a mortgage, the household has an alternative risk-free rate available to them that is the mortgage interest rate. After paying off the mortgage, this alternative risk-free rate is no longer available, household risk-free rate becomes the market risk-free rate, or return on government bonds. So at the time of the mortgage runoff, household risk-free rate changes from mortgage interest rate to market risk-free rate. And the mortgage runoff itself is unlikely to change household expectations on stock market returns. And at the mortgage runoff, household's opportunity set stays unchanged. Based on the permanent income hypothesis, households' wealth does not change. So we rely on time to generate variation in household risk-free rate and use that for identification.

So how should we expect portfolio choice to change at the runoff point? Our theoretical foundation is the debt retirement channel put forth by Becker and Shabani (2010). Becker and Shabani (2010) argue that retirement of mortgage debt offers a household an immediate risk-free return equal to the mortgage interest rate, which is generally higher than the market risk-free rate. This means that before paying off its mortgage, the household has an implied risk-free rate that is equal to the mortgage interest rate instead of the market risk-free rate. Having a mortgage thus reduces the expected excess return on risky assets, leading to a lower benefit of equity market participation. Upon paying off its mortgage, the household's implied risk-free rate falls from the mortgage interest rate to the market risk-free rate; consequently, the benefit of equity market participation increases. Thus, at the time of mortgage runoffs, we expect to see a jump in the probability of equity market participation, and the increased likelihood of stock ownership can be attributed to the retirement of mortgage debt.

Becker and Shabani (2010) also suggest that conditional on equity market participation, having a mortgage increases the share of liquid wealth held in risky assets. The incentive of households to hold safe assets is lower because they can be better off by paying down their mortgages than investing in the safe asset, given that the mortgage rate is higher than the risk-free rate. At the mortgage runoff, the option of paying down mortgage, which yields a higher return than the safe asset, no longer exists. Households then choose to allocate their liquid wealth between the risky asset and the safe asset, and the conditional risky asset share of liquid wealth is expected to fall.

Denmark as a country with the highest household indebtedness in OECD countries is naturally of great interest to this research. The quality of Danish register data in studying

household economics is well documented; see discussions in Andersen, Campbell, Nielsen, and Ramadorai (2018). The mortgage loan-level data we obtained from Finans Danmark ranges from 2009 to 2015. It contains 97% of mortgage borrowers in Denmark. The demographics, education attainment, income, and wealth information are obtained from two administrative registers made available by Statistics Denmark, ranging from 1998 to 2015 and covering the entire universe of the Danish population. This dataset allows us to control for individual's background risks to the largest extent, gives us a large enough sample, and makes it possible to avoid sample selection bias likely present in survey data.

We use the RDiT framework presented in Hausman and Rapson (2018) to estimate the causal effect of household risk-free rate on household demand for risky assets. Mortgage runoffs are defined as when borrowers complete their schedule of payments and bring their mortgage balances to zero without prepayment. Research has shown that a) RD designs require seemingly mild assumptions compared to those needed for other non-experimental approaches; and (b) RD design is not 'just another' evaluation strategy, and that causal inferences from RD designs are potentially more credible than those from typical 'natural experiment' strategies. David S. Lee (2008) formally shows that one need not assume the RD design isolates treatment variation that is "as good as randomized"; instead, such randomized variation is a consequence of agents' inability to precisely control the assignment variable near the known cutoff. In our context, The assignment variable is "relative year to mortgage runoff". The treatment assignment D is determined based on whether an individual is before or after the runoff. D = 1 for when the individual is treated, when he is after the runoff. D = 0, for when individual is untreated. He is before the mortgage runoff. When we use time as the assignment variable, this is a special application of the traditional RD, called Regression Discontinuity in Time framework discussed in Hausman & Rapson (2018). This framework is in many ways similar to event study which is widely applied in finance. Research have shown that RDiT framework can use data from a long time horizon, instead of only focusing on a short window around the event & RDiT can include high-order polynomial controls in time.

Since RDiT is a special application of cross-sectional RD, there are some differences between the 2 frameworks I would like to address. Notice that, we observe portfolio choice for the same individual who are treated in some period and untreated in others. Rather than observing portfolio choice for some individuals who are treated and others who are not, as in the cross-sectional RD. Another difference between RD and RDiT is the need to include control variables. Because when time is the assignment variable, there can be unobservables that are correlated with time which cause discontinuous impacts on portfolio choice. It is very common for papers that use RDiT framework to include discontinuous controls. The is also part of the reason why we see papers using RDiT use a larger window around the cutoff compared to studies using cross-sectional RD. That's

what we will do as well. Finally, the assumption need for inferences is also different in RdiT. Errors in our study is likely to exhibit persistence. For example, individuals' portfolio choice is likely to be correlated through time. So we will report cluster robust SEs, clustering at individual level.

Following Becker and Shabani's model assumption and having the RD design in mind, we construct our sample following the following criteria. First and foremost, we focus on 20 or 30 year FRM contracts on owner occupied housing. Actually nearly all mortgages that have run-off in recent years were standard, 20- or 30-year fixed rate mortgages. Although more flexible mortgages have been available in Denmark in recent years, such mortgages are a decade or more from run-off. One reason for having this criteria is that Becker and Shabani's model only analyze individuals who have fixed rate mortgages. The other reason is that RD framework rely on the assumption that individuals are unable to precisely manipulate their position around the runoff. So that we can effectively replicate a randomized experiment in which individuals would be randomly assigned to the treatment. If the timing of this run-off is determined 20 or 30 years before when the mortgage is originated, then the actual date of their final payment can be considered quasi-exogenous to their financial condition in the years surrounding the run-off. Some of our sample have multiple runoffs from different year, in this case, we choose the latest runoff. Because as long as the person still have mortgage debt, the debt retirement channel still exist, and the person's opportunity cost should still be the mortgage interest rate he pays. And his PERP is first changed once all his mortgage loans are paid off. Finally, we require individuals to be employed at least 3 years after the runoff. This is because we are not interested in portfolio choice for constrained individuals. Steffen's paper shows that constrained individuals tend to use some of the resources freed up by the mortgage run-off to increase leisure (working less) or consumption. Because before the mortgage runoff, they were forced to work more. They are borrowing constrained, so they cannot borrow elsewhere. Those individuals tend to have very low demand for risky assets. We choose to focus on unconstrained individuals who have adequate liquid wealth to invest and to whom portfolio choice is an important decision on their balance sheet. Our purpose is not to generalize our result to the rest of the population. Since we don't have data on employment status for individuals who have runoffs after 2012, the actual mortgage runoff year ranges from 2009 to 2012. These restrictions leave us with 61,712 observations from 1998 to 2015, corresponds to 3,435 distinct individuals.

In parametric analysis, we use a second-degree fractional polynomial panel data fixed effects model. Our setting has both cross-sectional variation and variation in time (T) dimension, but the RDiT is primarily identified using variation in T. One challenge for identification in relation to this set-up is that confounders correlated with the relative year may have discontinuous impacts on the portfolio outcomes. As a result, it is necessary

to include control variables to prevent bias, rather than simply to improve precision as in the traditional RD. Naturally, the errors are very likely to exhibit persistence. We assume the same individual's behavior to be correlated through time, and report cluster robust standard errors, clustering at individual level. Since the mortgage runoff year is different for different person (cross-sectional variation), we also control for year fixed effects.

The overall equity market participation rate is 32.44% before the mortgage runoff. We find that on average the probability of equity market participation increases discontinuously by 2.57 percentage points at the mortgage runoff, which is statistically significant. Conditional on equity market participation, the share of liquid wealth held in risky assets decreases discontinuously by 6.43 percentage points at the mortgage runoff which, viewed in the light of a conditional risky asset of 29.41% before the runoff, is an economically sizable effect, besides being statistically significant. These results are robust to bandwidth selections. The placebo test result also shows that the discontinuity in risky asset demands at a mortgage runoff is unlikely to be driven by other confounders. Thus, our empirical findings confirm the key predictions of the model in Becker and Shabani (2010). They highlight the role of debt interest rates as an important mechanism behind asset allocation and stock market participation decisions.

Our paper is related to a growing literature on the effect of housing on household portfolio choice. From a theoretical perspective, Grossman and Laroque (1990) and Flavin and Yamashita (2002) predict that housing reduces household demand for risky assets because it increases their exposure to risk and illiquidity. Cocco (2005) uses a structural life-cycle model and shows that house price risk and equity market participation costs reduce household risky asset participation. Previous studies have also suggested different channels through which housing affects the conditional risky asset share after a house purchase. Fratantoni (2001) and Hu (2005) point out that homeowners with a mortgage face expenditure risk due to the committed mortgage payments. The risky asset share of liquid wealth will fall after a house purchase because of liquidity concern. Yao and Zhang (2005) use a structural model to study optimal household portfolio choice. They show that when owning a house, investors reduce the stock share in their total wealth (i.e., the sum of bonds, equity, and home equity), reflecting the substitution effect of home equity for risky stocks, but the investors hold a higher risky asset share in their liquid wealth portfolios (i.e., bonds and stocks), reflecting the diversification effect due to the low correlation between stocks and housing returns. Becker and Shabani (2010) argue that the conditional risky asset share will increase due to the debt retirement channel mentioned above.

While these studies construct theoretical models to understand the relationship between housing/mortgage and household portfolios, others turn to empirical analyses using various datasets. Fratantoni (1998) finds that the elasticity of the risky asset share with

respect to mortgage debt is negative. Yamashita (2003) finds that households with a high house-to-net-worth ratio hold a lower proportion in stocks. Heaton and Lucas (2000a) and Cocco (2005) show that in cross-sectional OLS regressions in which property value is included as a covariate, the risky asset share is positively associated with mortgage debt. Most of these studies use cross-sectional data and fail to separate the effects of mortgage debt and home equity wealth. Recently, Chetty, Sándor, and Szeidl (2017) address the potential bias in previous studies and isolate plausibly exogenous variations in home equity and mortgage debt. They find that for homeowners an increase in mortgage debt reduces the share of liquid wealth held in stocks, while an increase in home equity raises the risky share with CRRA preference. These empirical studies focus on households with a mortgage and it remains challenging to distinguish the impacts of various channels through which housing/mortgage affects household portfolios. By studying the exogenous mortgage runoff events, we are able to distinguish the debt retirement channel from others and test the predictions from this particular channel.

Our paper is also related to the literature that studies the effect of debt termination on consumption, labor supply, and asset accumulation decisions. Coulibaly and Li (2006), Scholnick (2013) and Andersen, d'Astous, Martínez-Correa, and Shore (2018) use mortgage termination as a clearly defined income change to test the permanent income hypothesis. Similarly, Stephens Jr (2008) uses auto loan termination to test households' consumption response and find that a loan termination increases non-durable consumption. For us, the mortgage termination is not simply an income change. The mortgage interest rate also plays an important role, since mortgage interest rate is usually higher than the market risk-free rate. The mortgage runoff signifies the discontinuity of a higher return investment vehicle. Unlike studies cited above where individuals are likely to anticipate the income changes and adjust their consumption and labor supply accordingly ahead of time, the loss of an investment vehicle (i.e., paying back mortgages) at mortgage runoffs defines a cleaner discontinuity. As long as the loan is not paid off, the alternative interest rate (i.e., mortgage rate) exists and offers a better investment opportunity than holding the safe asset, which yields the market risk-free rate. Anticipation does not change the interest rate gap between a mortgage and the safe asset ahead of mortgage runoffs. After a mortgage runoff, the debt retirement channel disappears. Hence, instead of a joint test of rationality and anticipation, our research design allows for a pure rationality test of what people do when there are no longer mortgage payments.

The rest of the paper is organized as follows. Section 2 reviews theoretical analyses in the literature to understand how mortgage debt is incorporated into household financial decision making process. Section 3 presents the Danish institutional context, where Danish households' asset and debt holdings will be discussed. A detailed description of the data and our sample will be presented. Section 4 describes our identification strategies.

Section 5 discusses the empirical results. Finally, section 6 concludes the paper.

2 Theoretical Consideration

A large literature has studied portfolio choice along the extensive participation margin (i.e., the decision to hold a certain type of financial asset) and the intensive allocation margin (i.e., 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 choices are found to be affected by a variety of factors, including risk preferences (Merton, 1969; Samuelson, 1969), financial characteristics (Guiso, Jappelli, and Terlizzese, 1996; Brunnermeier and Nagel, 2008), demographic features (Barber and Odean, 2001; Cocco, Gomes, and Maenhout, 2005; Christiansen, Joensen, and Rangvid, 2008; Love, 2010), background risks (Heaton and Lucas, 2000b; Rosen and Wu, 2004; Edwards, 2008; Cardak and Wilkins, 2009), and information and participation costs (Basak and Cuoco, 1998; Vissing-Jorgensen, 2002; Haliassos and Michaelides, 2003; Gomes and Michaelides, 2005; Alan, 2006). In this paper, we are particularly interested in the theoretical prediction of portfolio choice outcome at the time of mortgage runoffs.

Becker and Shabani (2010) develop a model that describes portfolio choice for households with and without a mortgage. They consider households with FRMs, who face the decision of how to allocate their wealth between risky assets (stocks), safe assets, and repayment of mortgage debt. Households' decision to pay an amount λ in excess of the required mortgage payment can be seen as purchasing a bond with face value λ and a yield-to-maturity equal to the mortgage interest rate r. The equivalence of mortgage debt retirement to bond investment has implications for equity market participation and optimal portfolio allocation. For households with power utility and constant relative risk aversion γ , the optimal share of wealth invested in the risky asset can be summarized as

$$\alpha = \begin{cases} \frac{E[\widetilde{R}]-r_f}{\gamma\sigma^2} & \text{if } r < r_f \\ \frac{E[\widetilde{R}]-r}{\gamma\sigma^2} & \text{if } r_f \leq r \leq E[\widetilde{R}] \\ 0 & \text{if } E[\widetilde{R}] < r \end{cases} \tag{1}$$

where α denotes the optimal risky asset share, r_f is the risk-free rate for safe assets, and $E[\widetilde{R}]$ is the expected return on risky assets, where $log(1+\widetilde{R}) \sim N(\mu, \sigma^2)$.

Equation 1 shows that when mortgage interest rate is lower than the market risk-free rate ($r < r_f$), households have no incentive to retire their mortgage debt ahead of schedule. Their portfolio choice is the same as households without a mortgage in a standard portfolio choice model, in that households will choose an equity share equal to the ratio of the expected excess return to the price and quantity of risk. When mortgage interest rate is between the market risk-free rate and the expected return on risky asset

$(r_f \leq r \leq E[\widetilde{R}])$, households with a mortgage should invest a smaller share of their wealth in risky asset because of the diminished expected excess return or a smaller PERP. Finally, when mortgage interest rate is greater than the expected return on risky asset $(E[\widetilde{R}] < r)$, households should use all their available wealth to pay down mortgage and not invest in risky asset at all.

In reality, we are generally in the middle scenario, that is, the mortgage rate is higher than the risk-free rate, but lower than the expected return on the risky asset. Predictions about the effect of mortgage debt on risky asset holdings along the extensive and the intensive margin are presented in Propositions 1 and 3 in Becker and Shabani (2010):

> *Proposition 1*
>
> *The effect of mortgage debt on stock market participation is: having a mortgage should decrease the probability of equity market participation.*

Compared to households without a mortgage, the benefit of stock ownership is lower for households with a mortgage and sufficiently high mortgage interest rate, because they have less wealth invested in the risky asset and earn less on each dollar invested in the risky asset $(E[\widetilde{R}] - r < E[\widetilde{R}] - r_f)$. Therefore, these households will be less likely to own stocks.[1] The opposite is true at mortgage runoffs. Thus, we expect equity market participation to increase at mortgage runoffs.

> *Proposition 3*
>
> *The effect of mortgage debt on the optimal portfolio share of liquid wealth is: conditional on equity participation, having a mortgage should increase the equity share of liquid wealth.*

When households have a mortgage and also participate in the stock market, their incentive to hold safe assets is lower. This is because households are better off by paying down their mortgages than investing in safe assets, given that the mortgage interest rate is higher than the risk-free rate. In a world without frictions (i.e., no liquidity concern, taxes or other factors that affect household portfolio choice), the model predicts that the optimal equity share of liquid wealth should be equal to 1.[2] At mortgage runoffs, the debt retirement channel disappears. Households then choose to allocate their wealth between risky and safe assets based on their risk tolerance. Thus, the conditional risky asset share of liquid wealth is expected to fall at mortgage runoffs.

[1] This effect should be larger for households with a higher mortgage rate.

[2] Note that the optimal equity shares used for the participation decision are shares of total wealth, whereas equity shares used for the risky shares decision are shares of liquid wealth.

3 Data

3.1 Institutional Background

Denmark is a small, open economy that is hightly integrated with the rest of the world. The Danish institutional context provides an ideal testing ground for how debt affects household demand for risky assets. First of all, as the country that tops the household indebtedness measure, Denmark has attracted considerable attention for the effect of household debt on macroeconomic stability (Andre, 2016). Mortgage is the most common form of debt and the largest liability in Danish households' balance sheets. It is of natural interest to study the effect of mortgage debt on risky asset demand in a country where homeowners rely heavily on mortgages and also have a relatively high stock market participation rate. Second, the Danish mortgage system imposes minimal refinancing and prepayment costs. Individuals' behavior is less likely to be affected by market frictions. Third, the macroeconomic environment and financial conditions in Denmark are relatively stable compared to those in the United States following the crisis.[3] These conditions make it more plausible to identify exogenous mortgage runoffs. Finally, Statistics Denmark and Finans Danmark provide micro level register-based panel data on demographics, extensive history of labor income, asset holdings, and detailed mortgage loan characteristics. The high quality administrative data is essential in estimating causal effect of mortgage debt on household portfolio choice.

Danish Mortgage Market

Supply Side. The Danish mortgage market operates under a "balance principle", which requires a matching of cash flows on the loan and funding side. It limits the amount of risks (interest rate risk, volatility risk, foreign exchange risk, and liquidity risk) a mortgage credit institution (MCI) can undertake. In addition, MCIs are supervised by the Danish Financial Supervisory Authority (FSA, in Danish Finanstilsynet). The capital base of MCIs must be a minimum of 8% of risk weighted assets. It was established as a cooperative system. For a long time in the past, competition was severely restrained by regulations. Borrowers were only offered a limited number of products. However, since the 1990s, deregulation and financial innovations have given rise to a wide range of

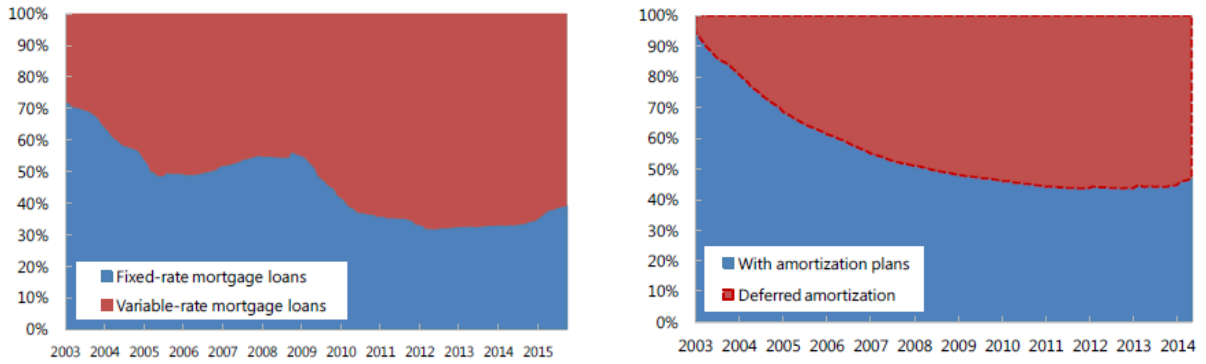
[3]Stock market volatility is lower in Denmark compared to that in the US during and after the 2008 financial crisis. Even though there were large losses in the banking sector and many banks faced challenges in obtaining liquidity, there were no traditional "bank runs" in Denmark due to the unlimited government guarantee made to all depositors and other unsecured creditors under Bank Package I. Despite falling house prices during the crisis period, the mortgage credit institutions have not experienced material losses on loans. Mortgage loan delinquencies and defaults have traditionally been low in Denmark, even in the global financial crisis period. This is partly due to the fact that mortgage loans are full recourse in Denmark and borrowers remain personally liable for any shortfall between the sale value of a property and the outsatnding amount of the loan.

mortgage products for borrowers to choose from. Now the Danish mortgage market is one of the largest in the world. The outstanding mortgage loans to GDP ratio in Denmark exceeds 100%, compared to 81% in the United States(Frankel, Gyntelberg, Kjeldsen, and Persson, 2004) .

For residential properties, mortgages have a maximum loan to value (LTV) ratio of 80%.[4] MCIs issue covered bonds (realkreditobligationer) to fund the loans. After a significant revision of the law in 2007, non-specialist banks are now also allowed to issue covered bonds. The bonds have gone through many economic and political changes, including the falling of house prices following the 2008 financial crisis, and have very high credit ratings.

During 2009 to 2015, there were mainly five MCIs: Nykredit/Totalkredit, Realkredit Danmark, Nordea Kredit, BRFkredit, and DLR Kredit that lend to private households. Market concentration is high. Nykredit/Totalkredit and Realkredit Danmark account for almost 70% of all DKK covered bond issues. Interest rates on mortgage bonds are entirely determined by the market, and do not dependent on borrowers' credit scores.[5] Fixed-rate (up to 30 years) mortgages (FRMs) used to dominate the market. However, adjustable-rate mortgages (ARMs) and interest-only loans have become more and more popular in the course of the 2000s, see Figure 1. Covered bond investors do not bear credit risk. In case of borrower defaults, MCIs hold personal recourse against the delinquent household. They possess a senior claim on the proceeds from the property sale.

Figure 1: Fixed vs. Adjustable Rate Mortgages



Demand Side. The Danish mortgage system offers borrowers flexibility in refinancing[6]

[4]The remaining 20% can be borrowed from a bank with a rate that is typically higher than the mortgage rate and lower than the consumer loan rate. During most of our sample period, there is no legal minimum down payment requirement, although most households make down payments when buying a house. Since November 1, 2015, every household has been required to have at least a 5% down payment when buying a house.

[5]Denmark has a zero/one credit score system, see Andersen, Campbell, Nielsen, and Ramadorai (2018) for details.

[6]Refinancing is to repay a loan by taking out another loan. Borrowers can refinance their mortgages to lower their interest rate, extend loan maturity or cash out equity in their homes.

and prepayment[7]. Without cashing out, borrowers can refinance even when they have negative home equity. In addition, it does not require any new assessment of credit score neither. Borrowers have flexible terms in prepaying their mortgages without penalty. When interest rates increase, they can buy back the corresponding bonds at the market price and deliver them to the mortgage banks. When interest rates fall, borrowers can prepay their mortgage by purchasing the bond at face value.

Defaults and foreclosures on mortgage loans are rare in Denmark. In the pre-crisis period, the average number of owner-occupied flats defaults are 20 per month.[8] During the crisis in 2008, the number of forced sale of owner-occupied housing is only 381. One important reason for the low number of foreclosures is that there is full recourse in Denmark and borrowers remain personally liable for any shortfall between the sale value of a property and the outstanding amount of the loan. Other reasons include the strict credit screening process at origination, which makes sure that borrowers have the ability to repay, and convenient and low-cost mortgage refinancing policy.

is that strategic default is not possible. A Danish mortgage borrower will remain liable for the full mortgage debt.

3.2 Sample

Our dataset is merged from two sources, Statistics Denmark and Finans Danmark. The micro-level mortgage term structure data from Finans Danmark ranges from 2009 to 2015. It contains the universe of mortgage borrowers from all MCIs that lend to private households. Similar data has been used to study Danish households' mortgage refinancing decision (Andersen, Campbell, Nielsen, and Ramadorai, 2018) and the effect debt runoffs on consumption, labor supply and asset accumulation decisions (Andersen, et al., 2019). This dataset contains comprehensive information on mortgage debt, including but not limited to, whether the loan is interest-only loan, loan value at origination, issue date, LTV at origination, LTV at current year, principal covered bond value, principal cash value, maturity, remaining maturity, remaining principal, mortgage interest rate, interest rate binding period, and whether the loan has an interest rate cap.

This individual-level mortgage data is merged with individual background characteristics from Statistics Denmark. The background characteristics include demographics, education attainment from the Danish Civil Registration System (CPR register), and income, and wealth information from the Danish tax authority (SKAT). It covers the entire Danish population and is available from 1998 to 2015. Income and wealth information

[7]Prepayment is a way where borrowers make extra payments to reduce their loan balance and the amount of interest paid on the loan.

[8]Source: Statistics Denmark: https://www.dst.dk/da/Statistik/emner/priser-og-forbrug/ejendomme/tvangsauktioner

includes labor income, bank loans[9], net wealth[10], bank deposit, market value of bonds, market value of risky assets, etc. Demographics include age, marital status, number of children, and education attainment.

Following Becker and Shabani (2010)'s model prediction and having the RD design in mind, we construct our sample following these criteria:

1. *The outstanding balance naturally becomes zero at the end of mortgage contract for 30 year FRMs on owner occupied housing (we exclude holiday housing, agriculture housing, and other types of housing).*

First and foremost, we focus on 20 or 30 year FRM contracts on owner occupied housing. Actually nearly all mortgages that have run-off in recent years were standard, 20- or 30-year fixed rate mortgages. Although more flexible type of mortgages are available in Denmark in recent years, such mortgages are a decade or more from run-off. One reason for having this criteria is that Becker and Shabani (2010)'s model only analyze individuals who have fixed rate mortgages. The other reason is that RD framework rely on the assumption that individuals are unable to precisely manipulate their position around the runoff. So that we can effectively replicate a randomized experiment in which individuals would be randomly assigned to the treatment. If the timing of this run-off is determined 20 or 30 years before when the mortgage is originated, then the actual date of their final payment can be considered quasi-exogenous to their portfolio choice decision in the years surrounding the run-off. Compare the two graphs in Figure 2, we can see that individuals are more likely to precisely manipulate the ARM contract runoff time to coincide with retirement. Reduction of labor supply happens at a much smaller scale after FRM runoffs. The first restriction leaves us with 22,273 runoffs observations from 2009 to 2015.

One could argue that individuals can choose initial mortgage terms to time the mortgage runoff with retirement. But there are many unknowns that makes it complex to do that. For example, there is always uncertainty about retirement age. The retirement policy can changed over the course of 30 years depending on the political party in power and the economic condition. Moreover, standard mortgages contract is termed exactly 20 or 30 years, so even borrowers know when he's going to retire, he is typically unable to time his mortgage run-off dates with his retirement.

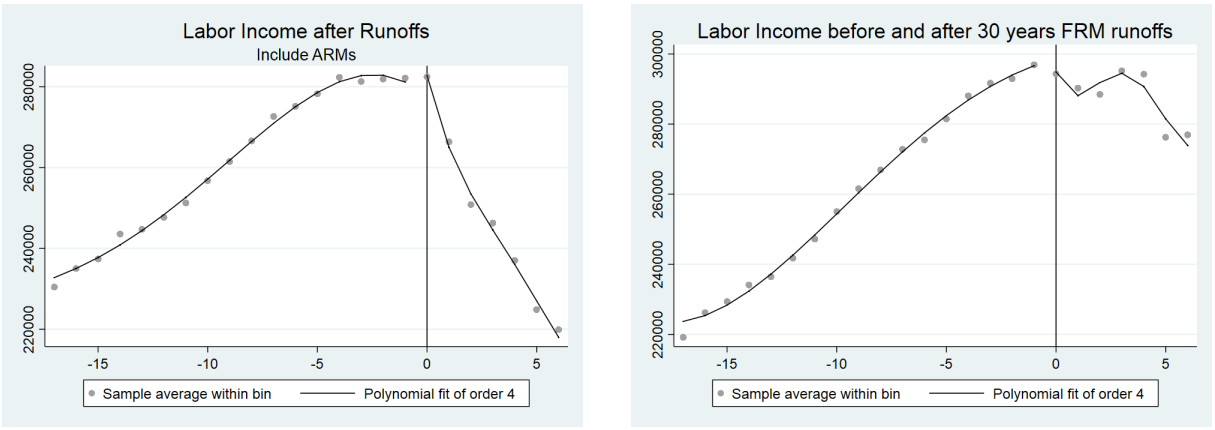
Another concern is about refinance. What if people refinance to precisely control the runoff date? We use data from 3 years before to 3 years after the mortgage runoff year in

[9]Bank loans include consumer loans and the proportion of a loan for a house that is not covered by mortgage.

[10]Net wealth includes property value, bank deposits, stocks, bonds, and debt in different financial institutions including mortgage and consumer debt. This measure does not include individuals' holdings of unbanked cash, the value of their cars, their private debt (i.e., debt to private individuals), accumulated pension savings, private businesses, or other informal wealth holdings.

the RD analysis. The question is do people really have the incentive to refinance so close to the maturity? Agarwal, Driscoll, and Laibson (2013) have shown that in presence of fixed costs, it is never optimal to refinance when the mortgage is close to maturity, as when the remaining principal is small, the fixed costs are likely to be higher than the potential interest savings. Individuals is likely to be better off borrowing non-mortgage debt or they could always draw from their savings.[11] Whether to refinance or not really depends on the interest rate environment and the fees financial institutions charges. These are market uncertainties outside the control of individuals. We run our analysis both including the individuals who refinance 3 years before and excluding them. Our results is robust to these different specifications.

Figure 2: Labor Income Before and After FRM Mortgage Runoffs including ARMs



2. *In cases of multiple runoffs per person, we choose the latest runoff.*

Some of our sample have multiple runoffs from different years. In this case, we choose the latest runoff. Because as long as the person still have mortgage debt, the debt retirement channel still exist, and the person's opportunity cost of capital should still be the mortgage interest rate he pays. His alternative risk-free rate is first changed to the market risk-free rate once all his mortgage loans are paid off. We then collapse the data to 1 observation per person per year for those who have multiple runoffs in the same year to make sure that their portfolio choice and background information are not measured repeatedly.

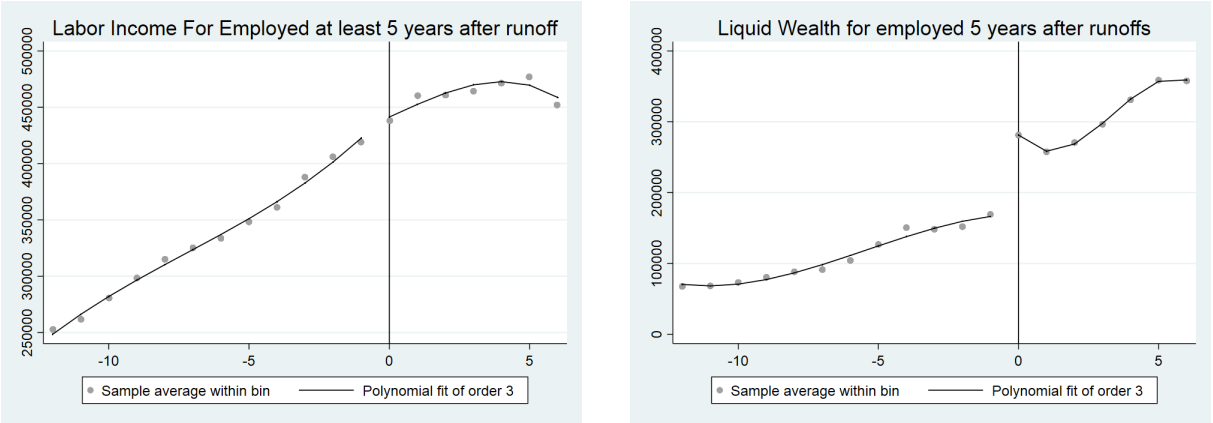
3. *Employed at least 3 years after runoff.*

Finally, we require individuals to be employed at least 3 years after the runoff. This is because we are not interested in portfolio choice for constrained individuals. Andersen,

[11] Agarwal, Driscoll, and Laibson (2013) specify in their model that costs associated with refinancing depends on both a fixed cost and an option value of waiting for further interest rate declines. In the presence of fixed costs, the probability of refinancing is lower when the mortgage is closer to maturity or when the principal left on the mortgage is small, as in these cases the fixed costs are likely to be higher than the potential interest savings.

et al. (2019) show that constrained individuals tend to use some of the resources freed up by the mortgage run-off to increase leisure or consumption. Because before the mortgage runoff, they were forced to work more. And they are borrowing constrained, so they cannot borrow elsewhere. Those individuals tend to have very low demand for risky assets. We choose to focus on unconstrained individuals who have adequate liquid wealth to invest and to whom portfolio choice is an important decision on their balance sheet. Our purpose is not to generalize our result to the rest of the population. Since we don't have data on employment status for individuals who have runoffs after 2012, the actual mortgage runoff year ranges from 2009 to 2012.[12]

Figure 3: Labor Income and Liquid Wealth Before and After Runoffs for Main Sample



These restrictions leave us with 3,435 distinct individuals/distinct mortgage runoffs, which corresponds to 61,712 observations from 1998 to 2015. Some summary statistics of this main sample is shown in Table 1. Figure 3 shows the temporal pattern of labor income and liquid wealth before and after mortgage runoffs for the main sample.

[12]Deposit rate ranges from 3% in the beginning of 2009 to 0.3% in the end of 2012. After 2012, the deposit rate started to be negative in Denmark. Mortgage interest rate in this paper is referred to the effective mortgage interest each individual pays on its mortgage, which is interest rate on the covered bond plus the administrative margins.

Table 1: Descriptive Statistics for Main Sample

Variable	(1) Main Sample	(2) 1 year before runoff	(3) Runoff Year	(4) 1 year after runoff
Age Quartiles Categories (0-3)	1.17	1.09	1.19	1.29
	(0.9491208)	(0.8398524)	(0.851638)	(0.8570312)
Marrital Status (1-6)	1.33	1.28	1.27	1.30
	(0.6496575)	(0.6251601)	(0.6284762)	(0.6761513)
Education Level (10-70)	38.45	38.93	39.03	39.14
	(15.29743)	(15.28173)	(15.19501)	(15.1795)
Number of Children	1.21	1.29	1.24	1.17
	(1.054616)	(1.072982)	(1.083863)	(1.075112)
Labor Income before tax and deduc	381,018.80	419,136.10	438,141.20	460,264.30
	(252212.6)	(253097)	(271560.9)	(360775)
Bank Debt	162,636.80	149,738.80	413,150.00	242,528.30
	(360875.3)	(295931)	(554860.5)	(321702)
Net Wealth	367,713.00	590,154.30	-240,042.90	505,012.00
	(953331.2)	(976794.1)	(1262186)	(1124500)
Liquid Wealth	180861.50	169,177.60	281,334.30	257,708.40
	(499435.2)	(448398.9)	(639309.5)	(705828.6)
Equity Market Participation	31.94%	32.44%	34.01%	34.14%
	(0.4662513)	(0.468314)	(0.4738852)	(0.4743232)
Unconditional Risky Asset Shares	10.71%	9.71%	8.32%	8.65%
	(0.2268439)	(0.2129444)	(0.1881536)	(0.1910359)
Observations	27,577	1,535	1,535	1,535
Conditional Risky Asset Shares	32.75%	29.41%	24.40%	25.11%
	(0.2918385)	(0.2818451)	(0.2543451)	(0.2543625)
Observations	61,712	3,435	3,435	3,435

*Note: This Table reports mean and standard deviation of control variables and portfolio outcomes, standard deviation in parentheses. Where applys, numbers are in Danish Krone. During 2009 to 2015, 1 DKK = approx. 0.16 USD. Column 1 reports relevant statistics for the entire main sample. Column 2 reports relevant statistics at 1 year before ecogenous mortgage runoffs. Column 3 reports statistics at exogenous mortgage runoff year. Finally, Column 4 reports statistics at 1 year after mortgage runoff.

Representative sample

In order to check if this is selective sample, we compare our main sample with a control sample. The control sample contains individuals who:

1. *have fixed rate mortgages on owner occupied housing*
2. *do not have any FRM loan runoff on owner occupied housing during 2009 to 2012*
3. *randomly assign each individual a runoff year between 2009 to 2012*
4. *individuals have to be employed at least 3 years after the artificially assigned runoff year*
5. *collapse the data to 1 observation per person per year* (See Restriction 2 in main sample selection criteria)

These restrictions give us 161,099 distinct individuals, which corresponds to 2,887,130 observations from 1998 to 2015. The only difference between the control sample and our main sample is that they will have their mortgage runoff at different point in time. A comparison between the main sample and the control sample is shown in Figure 4. Individuals in the main sample is slightly older compared to those in control sample, which is expected. Mortgage runoffs typically happens at a later stage in people's life. In terms of education, marital status, number of children. The two groups are quiet comparable. An interesting pattern shows up in bank debt and net wealth. Individuals run up their non-mortgage debt in anticipation of the runoff and pay it off right after. We also observe wealth deccumulation leading up to the mortgage runoff and the deccumulation stops right after the runoff. This is because rational, unconstrained individuals smooth their consumption around the runoff. Based on the Permanent income hypothesis, rational, unconstrained borrowers should not change their consumption after the runoff.

Figure 4: Compare Main and Control Sample

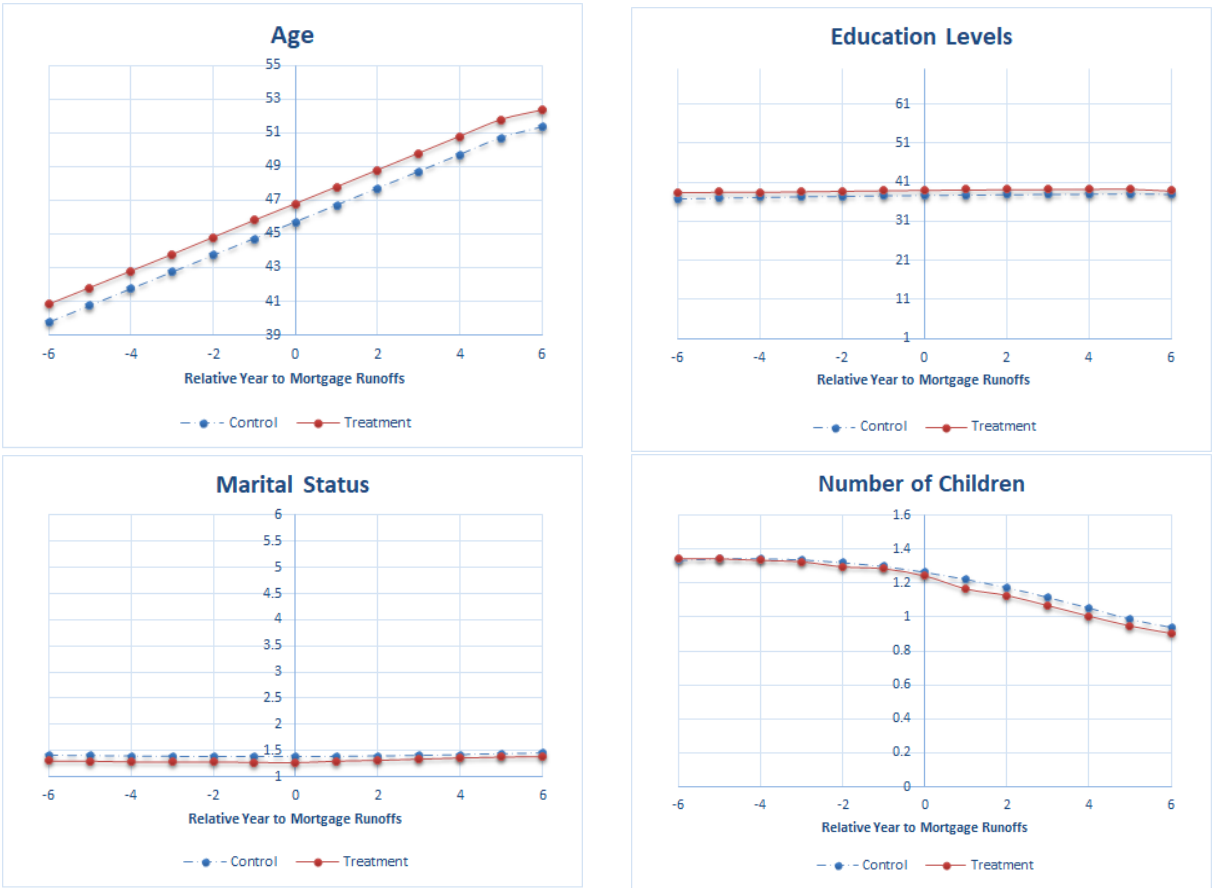
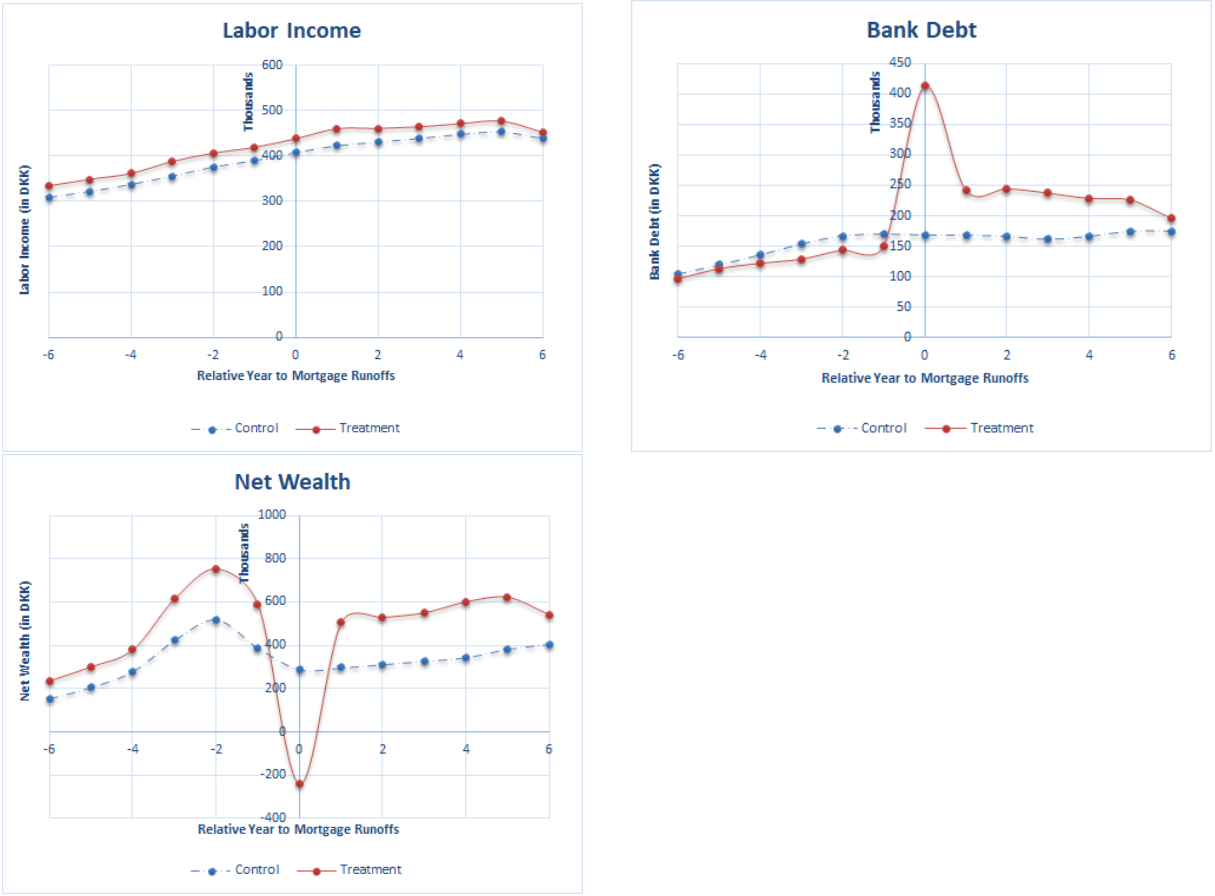


Figure 4: Compare Main and Control Sample (Continued)



4 Empirical Strategy

4.1 Regression Discontinuity in Time (RDiT) Framework

We use the RDiT framework presented in Hausman and Rapson (2018) to estimate the changes in portfolio choice at the time of mortgage runoffs. In this section, we discuss how our set-up fits into the RDiT design, and which methodology we choose for the parametric analysis.

As in a typical RDiT framework, we know the timing of the treatment, i.e., mortgage runoff year. The variable "relative year", *relyr*, ranges from -10 to 6, meaning portfolio outcomes and controls are available from 10 years before to 6 years after runoffs. We assume that for all years where $relyr \geq 0$, this person is treated, and for all years $relyr < 0$, this person is not treated. The "treatment" means that there is a discontinuity in the implied risk-free rate at mortgage runoff. It falls from the mortgage interest rate to the market risk-free rate.

We use time-series data from 1998 to 2015. The running variable is "relative year to mortgage runoff". When time is the running variable, it is not possible to test for sorting

and anticipation effects with the traditional density test used in cross-sectional RD, since the density of the running variable would be uniform. It turns out anticipation is not an issue in our setting as anticipation is independent of the model predictions. Prior to a mortgage runoff, individuals choose to allocate their wealth between safe asset, risky asset, and repayment of mortgage debt, where retirement of mortgage debt offers a return equal to the mortgage interest rate, which is normally higher than the return on safe asset. They may or may not anticipate the debt retirement channel to disappear, but as long as the mortgage is not fully paid off, individuals will not adjust their behavior. After the runoff, however, they can only choose between two types of assets, safe asset and risky asset. As a result, their portfolio choice may change. Therefore, mortgage runoff defines a clean discontinuity, and we can conduct a pure rationality test of what people would do when they no longer have the opportunity to retire their mortgage debt.

Rather than observing portfolio outcomes for individuals who have a runoff and others who do not (as in the traditional RDD), we observe individuals who are treated in some periods and untreated in others. Instead of the "local randomization" interpretation used in the traditional RD, our setting features a real discontinuity at a threshold. Under this interpretation, it is particularly relevant to make sure that there is no sorting behavior at the threshold. We impose several sample selection criteria in Section 3.2, which exclude two major effects, refinancing and retirement. In the parametric analysis, we will use a panel data fixed effects model and other time-series econometric methods to further deal with this issue.

Our RDiT setting has both cross-sectional variation and variation in T dimension, but the RDiT is primarily identified using variation in T. Cross-sectional variation reflects in treatment dates. Given that the mortgage runoff year is different across individuals, we structure the data using relative year to mortgage runoff, instead of calendar year. One challenge for identification arises in relation to this set-up. Confounders correlated with the relative year may have discontinuous impacts on the portfolio outcomes. As a result, it is necessary to include control variables to prevent bias, rather than simply to improve precision as in the traditional RD. Naturally, the errors are very likely to exhibit persistence. We thus apply cluster-robust standard errors in the parametric analysis to account for this. Simple RD plots on portfolio outcomes are shown in the Section 5.

4.2 Parametric Estimation

The parametric analysis is carried out using a second-degree fractional polynomial panel data fixed effects model. Our main estimation equation is specified as follows:

$$Y_{it} = \alpha_i + \beta_1 D_{it} + \beta_2 relyr_{it}^{(p1)} + \beta_3 relyr_{it}^{(p2)} + \beta_4 X_{it} + u_{it} \tag{2}$$

where dependent variable Y_{it} is portfolio choice outcome for household i in year t. The outcomes we focus on in this paper are the equity market participation rate and and the share of risky assets in liquid wealth. The dummy variable $D_{it} = 1$ when $relyr_{it} \geq 0$, and 0 otherwise. β_1 is our parameter of interest. It describes the size of discontinuity in portfolio outcomes at the time of mortgage runoffs. X_{it} denotes a list of control variables, including age categories[13], marital status[14], education level[15], labor income, bank debt, and net wealth. $p1$ and $p2$ are exponents selected from $\{-2, -1, -0.5, 0, 0.5, 1, 2, 3\}$. The convention is that X^0 equals $ln(X)$. This regression fits 8 FP1 models and 36 FP2 models and selects the model that fits the data the best from the 44 models by selecting the one with the maximum R^2 value. It lets you specify a standard linear regression (by selecting only 'x'), a polynomial regression (by selecting only x, x^2), or a fractional polynomial by selecting two terms. α_i denotes individual fixed effects, as we allow for unobserved individual heterogeneity through time. Additionally, we assume individual's behavior to be correlated through time, and report cluster robust standard errors, clustering at individual level. Since the mortgage runoff year exhibit cross-sectional variations, we control for year fixed effects.

5 Results

We present our results in this section. Using the RDiT framework, we find that on average the probability of equity market participation increases discontinuously by 2.57 percentage points at the mortgage runoff; conditional on equity participation, the share of liquid wealth held in risky assets decreases discontinuously by 6.43 percentage points at the mortgage runoff. This result is robust to bandwidth selections. The placebo test result shows that the discontinuity in risky asset demands at a mortgage runoff is unlikely to be driven by other confounders. Thus, our empirical findings confirm Predictions 1 and 3 of the model in Becker and Shabani (2010).

[13]There are 4 age categories, ranging from 0 to 3.

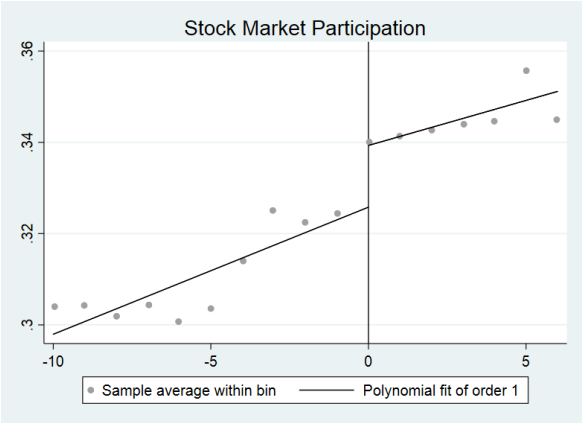
[14]There are 6 types of marital status, ranging from 1 to 6. "Married" includes married and registered partnership. The other 5 categories include Single, Unmarried, Divorced, 2 partners, and Dissolved registered partnership. Others are marked as missing.

[15]Education Level describes the main education groups, ranging from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, and PhD.

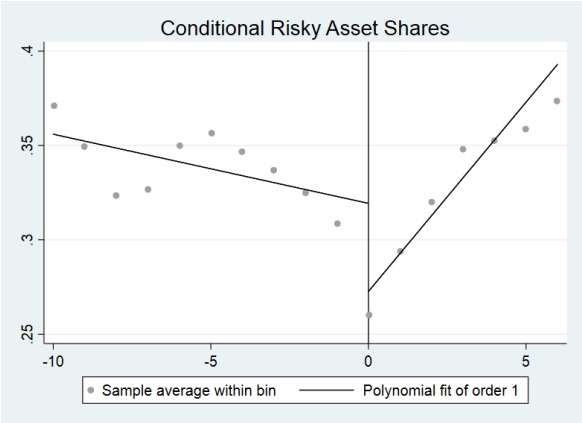
5.1 Raw Plots

Figure 5: Portfolio Choice Before and After Mortgage Runoffs: Main Sample

Panel A. Equity Market Participation



Panel B. Shares of Liquid Wealth Held in Risky Assets

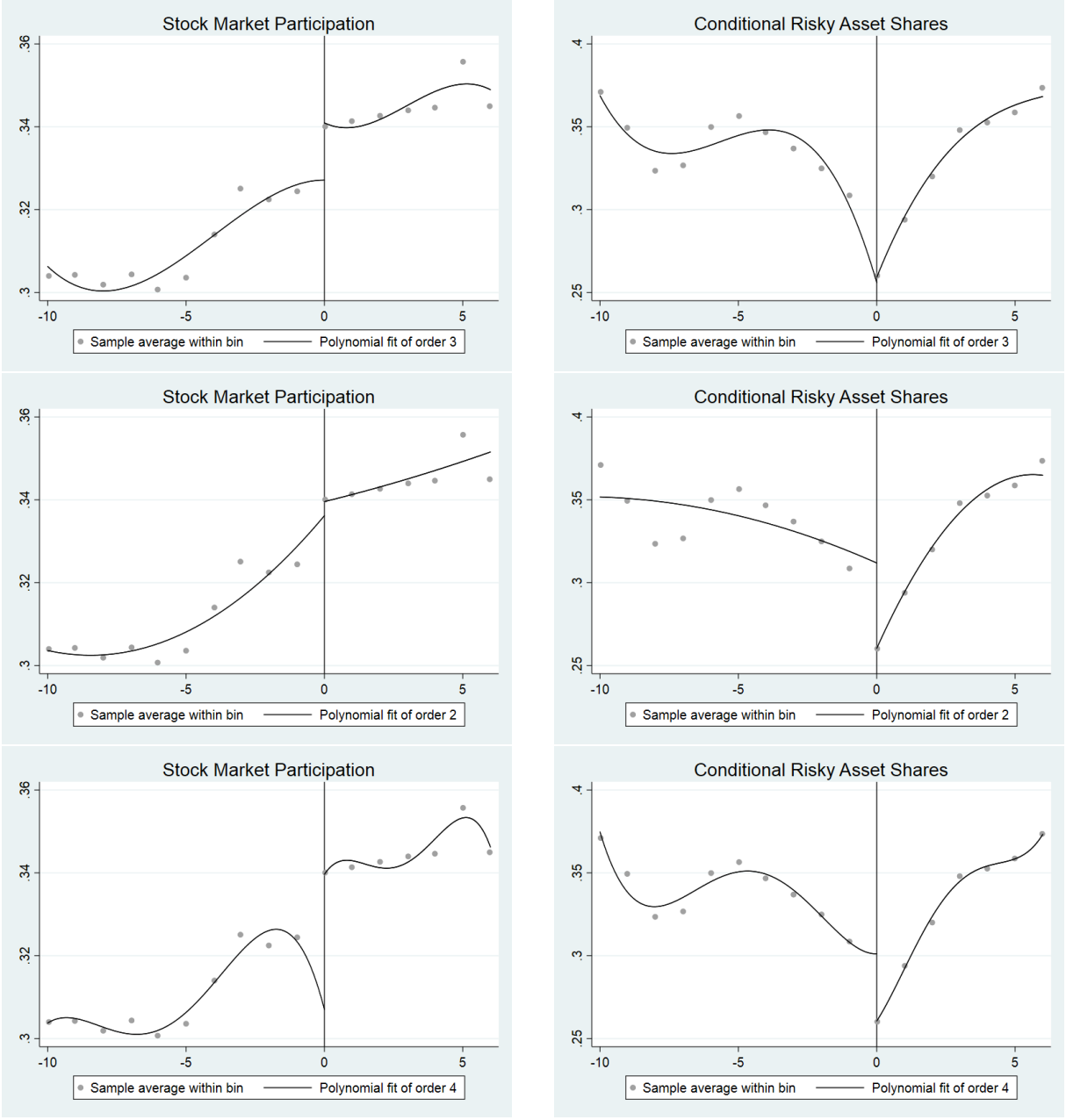


First, we show some simple RD plots on portfolio outcomes along the extensive and the intensive margin. These plots show the relationship between the assignment variable and the portfolio choice outcome without adding any controls or any fixed effects. Panel A of Figure 5 plots the average equity market participation rate across all individuals in the main sample from 15 years before to 6 years after the mortgage runoff. The solid vertical line in the figure indicates the year of mortgage runoff. Participation rate averages around 32.4% in the 3 years leading up to the runoff and then jump discontinuously to 34% at the mortgage runoff year. As explained in Section 2, the opportunity to retire mortgage debt, which offers a higher return than safe asset, disappears at runoff. As a result, the expected excess return on the risky asset increases at the runoff year, leading to higher risky asset participation.

Panel B of Figure 5 plots the average shares of liquid wealth held in risky assets across all individuals in the main sample from 15 years before to 6 years after the mortgage runoff. Conditional on participation, the risky asset share averages around 33% in the 3 years leading up to the runoff and then jump down discontinuously to 24.4% at the mortgage runoff year. The reason for the decline mainly attributes to the discontinuity of the mortgage retirement channel.

Different Polynomial Order

Figure 6: Different Polynomial Orders



Fitting polynomials to time series data can sometimes be misleading.[16] There might be latent structure in the time series that reflects level shifts, outliers, multiple time trends or non-constant error term. When fitting a higher order polynomial to the data, these challenges can be particularly significant. So we explore the discontinuity in portfolio choice at mortgage runoff years using different polynomial order.

[16] Hausman and Rapson (2018) suggests that overfitting of the global polynomial may arise with high order polynomial powers. The degree to which these dynamics will matter in practice depends on how large the true autoregressive coefficient is, and on the choices of bandwidth and specification.

Figure 6 plots the estimated treatment effects for the second order and first order polynomials. The discontinuity in equity market participation and risky asset shares in liquid wealth seems to be persistent at the mortgage runoff year across different polynomial orders. The directions of the jumps are also in line with theoretical predictions.

5.2 Parametric Analysis Results

Estimating Equation 2 with the extensive and the intensive margin as outcome, we present our baseline results in this section. Columns 1 to 3 of Table 2 report regression estimates for the treatment effect of mortgage runoffs on equity market participation. Column 1 presents a basic specification without control variables and year fixed effect. The average participation rate increases by 1.38 percentage points at the runoff. Column 2 includes the year fixed effect but no control variables. The inclusion of the year fixed effect makes sure that any impact from the national level, for example, interest rate, mortgage regulation, and GDP growth rate, that may affect portfolio choice and the timing of mortgage runoff does not bias the estimate. The average participation rate increases by 1.51 percentage points under this specification. Finally, Column 3 is our preferred specification for participation decision, where both the year fixed effect and control variables are included in the regression. The list of control variables are chosen from the standard portfolio choice literature. By adding controls, these observed portfolio choice determinants will be held constant when we interpret the coefficient on D. The average participation rate increases by 2.57 percentage points at the runoff. Under all three specifications, we assume the same individual's behavior to be correlated through time, and report cluster robust standard errors. The coefficients are significantly positive in all three columns.

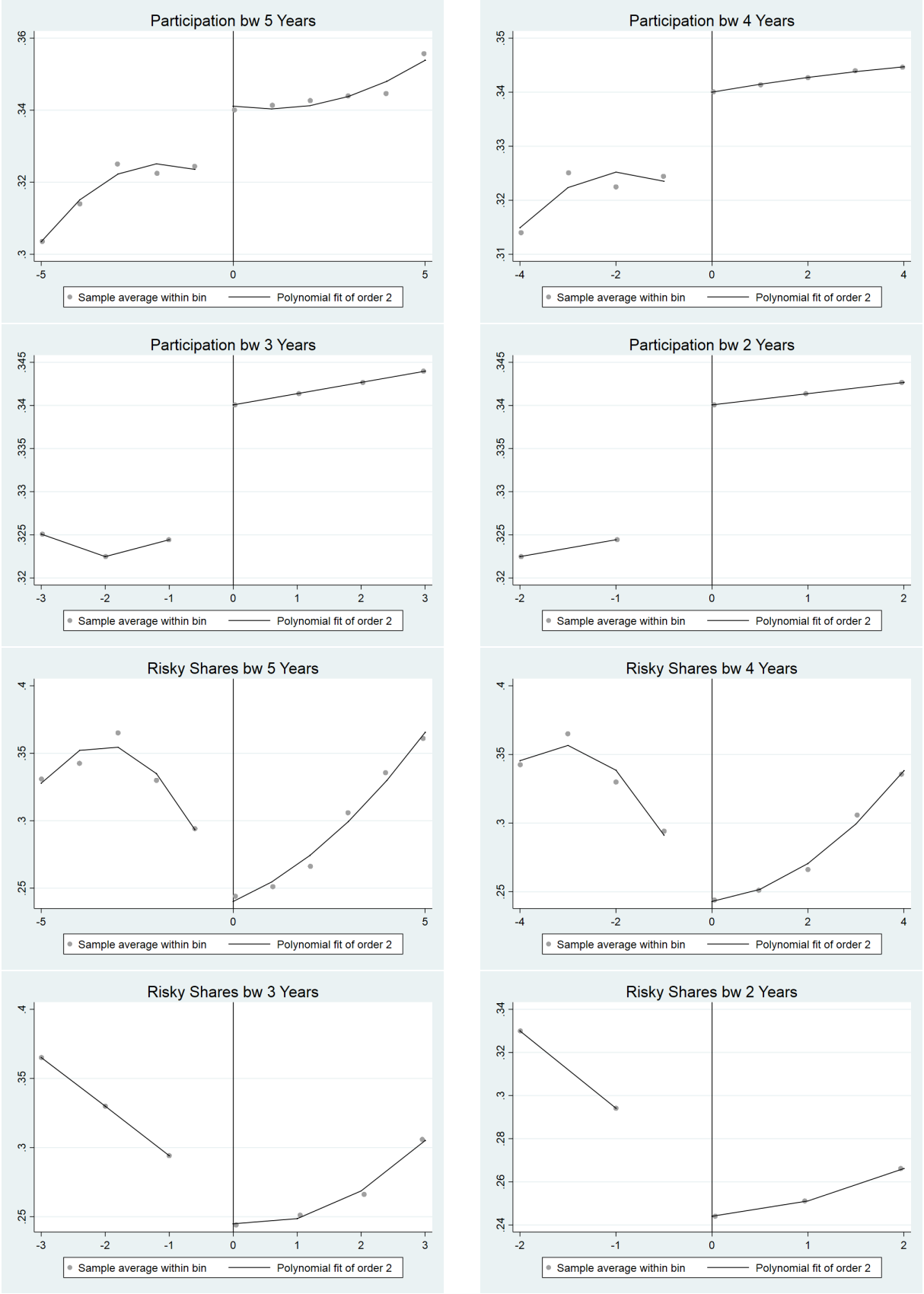
Columns 4 to 6 of Table 2 report regression estimates for the treatment effect of mortgage runoffs on the share of liquid wealth held in risky assets. Analogue to Columns 1 to 3, we present three different specifications: without controls and year fixed effects, without controls but with the year fixed effects, and finally with both controls and the year fixed effects. Column 6 is our preferred specification for risky asset shares. The average risky asset share in liquid wealth falls by 6.43 percentage points at the runoff. The coefficients are significantly negative in all three specifications.

Table 2: Main Results

	Participation			Risky Shares		
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	L3 R3	L3 R3	L3 R3	L3 R3	L3 R3	L3 R3
D	0.0138**	0.0151**	**0.0257*** **	-0.0306***	-0.0771***	**-0.0643*** **
	(0.00541)	(0.00632)	**(0.00748)**	(0.0116)	(0.0143)	**(0.0158)**
Constant	0.326***	0.375***	0.380***	0.280***	0.390***	0.398**
	(0.00317)	(0.0419)	(0.0699)	(0.00855)	(0.0476)	(0.179)
Observations	24,045	24,045	23,934	8,039	8,039	8,013
R-squared	0.014	0.014	0.035	0.079	0.093	0.125
Number of individuals	3,435	3,435	3,430	1,354	1,354	1,352
Controls	NO	NO	YES	NO	NO	YES
Year FE	NO	YES	YES	NO	YES	YES

Note: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table reports the second-degree fractional polynomial panel data fixed effects model estimates on the effect of mortgage runoffs on portfolio choice, with a window width of 3 years around the runoff. All specifications report cluster robust standard errors, clustering at individual level. Column 1-3 report the effect of mortgage runoffs on equity market participation decision. Some specification includes control variables and calendar year fixed effects. Column 4-6 report the effect of mortgage runoff on risky asset shares in liquid wealth. Some specification includes control variables and calendar year fixed effects. Control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth.

Figure 7: Different Bandwidth Graphs



5.3 Robustness Check

We perform a series of robustness check in this section.

Sensitivity Check

Figure 7 plots the estimated treatment effects across different sizes of bandwidth. The size of the jump at the mortgage runoff year does not seem to differ significantly with bandwidth selections. Table 3 and Table 4 present the regressions analogs of Figure 7. With controls and year fixed effects, columns 2, 4, 6, 8, 10 of Table 3 report the estimates of equity market participation using bandwidth of 5, 4, 3, 2, 1 year(s) around the runoff year, respectively. On average, equity market participation jumps up discontinuously by about 2.7 percentage points across bandwidths. The jump is significant and relatively stable across all specifications. In terms of the risky asset share, Columns 2, 4, 6, 8, 10 of Table 4 report the estimates with controls and year fixed effects using bandwidth of 5, 4, 3, 2, 1 year(s) around the runoff year, respectively. On average, conditional on participation, the risky asset share jumps down discontinuously by 6.4 percentage points across bandwidth. All coefficients are significant and the magnitude of the coefficients are also stable across different specifications.

We also estimate Equation 2 by imposing different restrictions on labor supply after mortgage runoff. Table 10 shows that by requiring individuals to be employed at least 3 years after runoff, instead of 5 years, the equity market participation still increases by similar amount compared to our main results. Conditional on participation, Table 11 shows that the risky asset share still falls by similar amounts.

Table 3: Participation decision under different bandwidths: main sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	L5 R5	L5 R5	L4 R4	L4 R4	L3 R3	L3 R3	L2 R2	L2 R2	L1 R1	L1 R1
D	0.0115**	**0.0294*** **	0.0150***	**0.0286*** **	0.0138**	**0.0257*** **	0.0142***	**0.0267*** **	0.0152***	**0.0281*** **
	(0.00363)	**(0.00421)**	(0.00339)	**(0.00412)**	(0.00541)	**(0.00748)**	(0.00494)	**(0.00824)**	(0.00448)	**(0.00719)**
Constant	0.327***	0.403***	0.326***	0.267***	0.326***	0.380***	0.326***	0.282***	0.325***	0.324***
	(0.00316)	(0.123)	(0.00282)	(0.0652)	(0.00317)	(0.0699)	(0.00357)	(0.0640)	(0.00275)	(0.0264)
Observations	37,785	37,616	30,915	30,778	24,045	23,934	17,175	17,092	10,305	10,263
R-squared	0.017	0.039	0.014	0.037	0.014	0.035	0.015	0.035	0.016	0.037
Number of individuals	3,435	3,431	3,435	3,430	3,435	3,430	3,435	3,430	3,435	3,421
Controls	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Year FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regressions on equity market participation at mortgage runoffs. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 10 report results for different bandwidth selections, from Column 1 and 2 reporting the largest window from 5 years before to 5 years after the runoff, to Column 9 and 10 reporting the narrowest window from 1 year before to 1 year after the runoff.

Table 4: Conditional risky asset shares under different bandwidths: main sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	L5 R5	L5 R5	L4 R4	L4 R4	L3 R3	L3 R3	L2 R2	L2 R2	L1 R1	L1 R1
D	-0.0710***	**-0.0653*** **	-0.0528***	**-0.0665*** **	-0.0306***	**-0.0643*** **	-0.0455***	**-0.0702*** **	-0.0516***	**-0.0619*** **
	(0.0116)	**(0.0158)**	(0.0120)	**(0.0156)**	(0.0116)	**(0.0158)**	(0.0115)	**(0.0189)**	(0.0109)	**(0.0134)**
Constant	0.321***	0.549***	0.302***	0.508**	0.280***	0.398**	0.291***	0.851***	0.295***	1.208
	(0.00834)	(0.201)	(0.00882)	(0.204)	(0.00855)	(0.179)	(0.00784)	(0.321)	(0.00655)	(0.856)
Observations	12,567	12,531	10,302	10,275	8,039	8,013	5,741	5,722	3,456	3,446
R-squared	0.063	0.102	0.070	0.110	0.079	0.125	0.064	0.130	0.053	0.098
Number of individuals	1,506	1,500	1,408	1,406	1,354	1,352	1,287	1,285	1,226	1,222
Controls	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Year FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regressions on shares of risky assets held in liquid wealth at mortgage runoffs. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 10 report results for different bandwidth selections, from Column 1 and 2 reporting the largest window from 5 years before to 5 years after the runoff, to Column 9 and 10 reporting the narrowest window from 1 year before to 1 year after the runoff.

Placebo Test Results

This is to test whether the treatment effect is zero when it should be. The concern is that the relation may be fundamentally discontinuous and jump at the cutoff is contaminated by other factors. We change the runoff year for treated individuals and see if there is a jump somewhere else. In one specification, we use 1 year before the actual runoff year, i.e. $relyr_{it} = -1$, as the alternative cutoff, and find no statistically significant change in portfolio choice at this hypothetical runoff time. In another specification, we randomly assigned runoff year to the treated individuals. Again, we find no statistically significant change in portfolio choice at this hypothetical cutoff point.

Table 5: Placebo Test

	1 year before as runoff year		Randomly assigned runoff	
	Participation	Risky shares	Participation	Risky shares
VARIABLES				
D	-0.0020	0.0210	-0.0091	-0.0195
	(0.0060274)	(0.0147365)	(0.0065825)	(0.0119395)
Constant	0.3608***	0.3350	0.3496***	0.7358***
	(0.180)	(0.2891386)	(0.0756253)	(0.0980197)
Observations	23,934	8,013	24,045	8,039
R-squared	0.004	0.022	0.0236	0.0059
Number of ids	3,430	1352	3,435	1,354
Controls	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
bandwidth: 3 years before to 3 years after the hypothetical runoff.

RD Plots for Control Variables

As we mentioned earlier, control variables are important in the RDiT framework. They are included to obtain an unbiased estimate, while in many cross-sectional RDs, adding covariates is meant to improve precision. These control variables are correlated with the running variable, and may have discontinuous effect on the outcome as well. Figure 8 plots a parallel RD estimated on control variables. Age, education, marital status, number of children, and labor income show a smooth pattern around the runoff. However, bank debt shows a discontinuity at mortgage runoff. The same pattern of bank debt accumulation before and after mortgage runoff can be found in Andersen, d'Astous, Martínez-Correa, and Shore (2018). They understood it as an attempt to circumvent the saving forced by the mortgage payment schedule in the final years of the mortgage to smooth consumption or other saving. It is unlikely that the treatment effect at the runoffs is driven by other confounders.

5.4 Heterogeneous Effect

Up until now, we estimated the local average treatment effect of mortgage runoff on portfolio choice. In this section, we explore treatment effect heterogeneity across individuals.

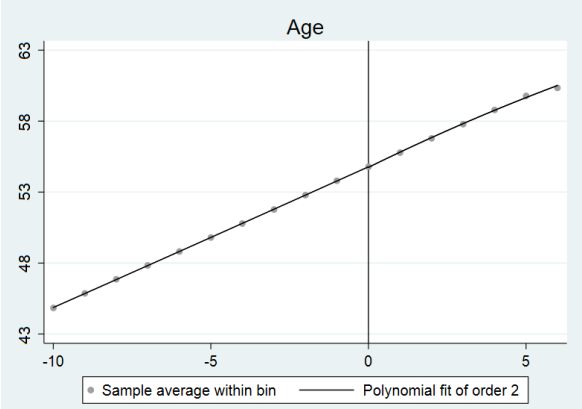
We re-estimate Equation 2 by education levels, age, income, and wealth groups[17], and attempt to understand what drives the average treatment effect.

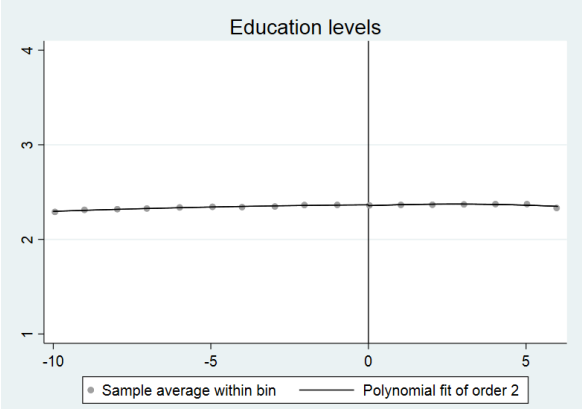
Education

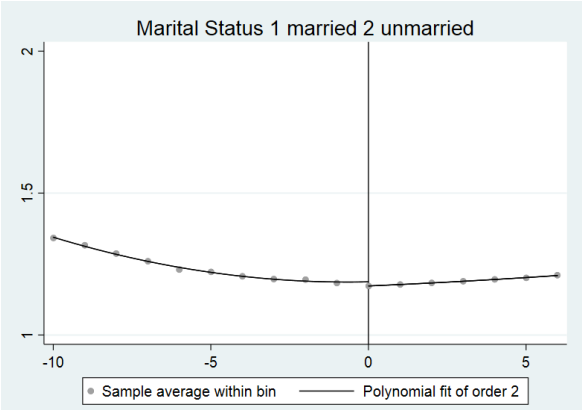
Table 6 presents how the discontinuities in equity market participation and risky asset share at the mortgage runoff point vary with different education levels. For individuals with primary school education, on average, the participation increases by 3.47 percentage points at the mortgage runoff using a bandwidth of 3 years. Conditional on participation, the risky share decreases by 15.3 percentage points at the runoff. For individuals with high school, apprenticeship, or short-time higher education, on average the participation rate either increases a very small amount or the increase is not statistically significant, depending on bandwidths. The risky asset share falls significantly if we use a bandwidth of 3 or 2 years. However, if we use a broader bandwidth, the decrease becomes insignificant. For individuals with college education, on average, the participation increases by 3.74 percentage points at the mortgage runoff when using a bandwidth of 3 years. Conditional on participation, the risky shares decrease by 6.03 percentage points at the runoff. Finally, for individuals with a Master or PhD education, the discontinuity in risky asset demand is not statistically significant. But the signs of the coefficients for both participation and risky asset share are in line with theoretical predictions.

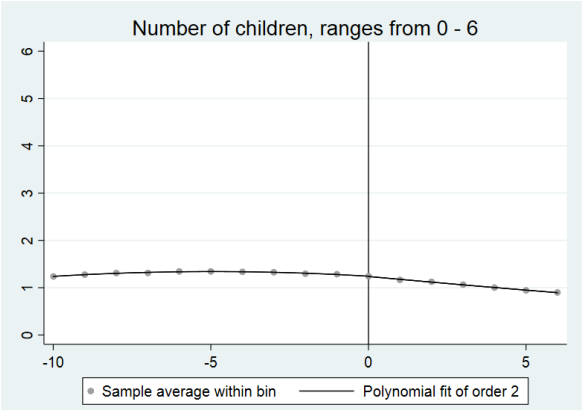
[17]Individuals are categorized into different education, age, income, and wealth groups based on their information at the mortgage runoff year. This analysis contains only individuals in the main sample.

Figure 8: RD Plots for Control Variables









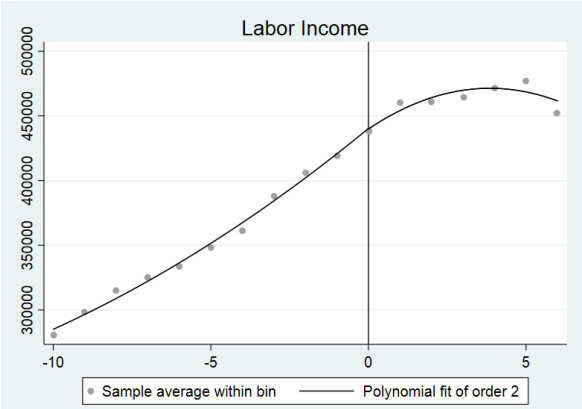


Table 6: Treatment Effect by Education Levels

Panel A. Primary School

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0434*	0.0467**	0.0347**	0.0202	-0.143***	-0.149***	-0.153***	-0.132***
	(0.0226)	(0.0226)	(0.0165)	(0.0194)	(0.0404)	(0.0391)	(0.0393)	(0.0418)
Constant	-0.108	0.397**	0.476**	0.390***	0.824*	-0.564	0.495***	0.389**
	(0.472)	(0.180)	(0.186)	(0.0792)	(0.429)	(0.707)	(0.169)	(0.194)
Observations	1,980	1,620	1,260	900	705	579	452	326
R-squared	0.038	0.037	0.025	0.017	0.073	0.089	0.125	0.142
Number of ids	180	180	180	180	82	77	73	71
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals with primary school education. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Panel B. High School, Apprenticeship, short-time higher education

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0187*	0.0166*	0.0136	0.0106	-0.0327	-0.0338	-0.0478**	-0.0665**
	(0.0101)	(0.00937)	(0.00909)	(0.0111)	(0.0218)	(0.0223)	(0.0213)	(0.0262)
Constant	0.246***	0.323*	0.332**	0.289***	0.368***	0.323***	0.188	0.524***
	(0.0496)	(0.167)	(0.144)	(0.0656)	(0.119)	(0.115)	(0.332)	(0.113)
Observations	8,730	7,145	5,555	3,965	2,751	2,249	1,747	1,239
R-squared	0.009	0.007	0.008	0.008	0.079	0.092	0.099	0.088
Number of ids	795	795	795	795	330	309	296	281
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals with high school, apprenticeship, or short-time higher education. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Table 6: Treatment Effect by Education Levels

Panel C. College Education

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0616***	0.0560***	0.0374*	0.0631***	-0.0567*	-0.0682**	-0.0603**	-0.0745**
	(0.0210)	(0.0204)	(0.0200)	(0.0226)	(0.0305)	(0.0313)	(0.0288)	(0.0357)
Constant	0.0229	0.0358	0.422***	-0.0549	0.437	0.505***	0.400	0.585***
	(0.120)	(0.109)	(0.0933)	(0.104)	(0.282)	(0.184)	(0.303)	(0.152)
Observations	4,251	3,477	2,705	1,933	1,418	1,166	918	661
R-squared	0.031	0.025	0.022	0.031	0.100	0.102	0.124	0.140
Number of ids	387	387	387	387	176	163	157	148
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals with college education. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Panel D. Masters and PhDs

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0315	0.0215	0.00687	-0.00864	-0.0450	-0.0478	-0.0621	-0.0464
	(0.0276)	(0.0237)	(0.0255)	(0.0268)	(0.0418)	(0.0433)	(0.0485)	(0.0521)
Constant	-0.0750	0.311	0.367***	0.564***	5.949**	4.999**	0.244	0.315
	(0.181)	(0.214)	(0.127)	(0.147)	(2.353)	(2.360)	(0.182)	(0.294)
Observations	1,890	1,547	1,202	858	726	598	466	333
R-squared	0.027	0.020	0.020	0.031	0.107	0.112	0.130	0.108
Number of ids	173	173	173	173	84	80	79	75
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals with Masters or PhD education. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Table 7: Treatment Effect by Age Groups

Panel A. Bottom Age Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0429*	0.0414*	0.0282	0.0632**	-0.0447	-0.0637*	-0.0702**	-0.106**
	(0.0223)	(0.0221)	(0.0217)	(0.0304)	(0.0365)	(0.0351)	(0.0318)	(0.0439)
Constant	0.0578	0.0924	0.102	-0.0840	4.760***	0.803***	0.711***	-1.156
	(0.159)	(0.113)	(0.109)	(0.126)	(1.808)	(0.217)	(0.251)	(1.728)
Observations	3,872	3,168	2,464	1,759	977	805	635	458
R-squared	0.035	0.035	0.030	0.028	0.109	0.121	0.137	0.128
Number of ids	354	353	353	353	129	117	112	107
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the bottom age quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Panel B. 2nd Age Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0599***	0.0544***	0.0554***	0.0527**	0.0289	0.0186	-0.00233	-0.0470
	(0.0206)	(0.0198)	(0.0190)	(0.0211)	(0.0396)	(0.0367)	(0.0349)	(0.0420)
Constant	0.782**	0.429***	0.432***	0.308***	-2.238	0.435*	0.710***	0.577**
	(0.305)	(0.130)	(0.120)	(0.109)	(2.285)	(0.252)	(0.215)	(0.255)
Observations	4,111	3,365	2,617	1,869	1,119	923	719	509
R-squared	0.012	0.016	0.015	0.015	0.106	0.112	0.099	0.067
Number of ids	375	375	375	375	137	130	127	116
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the second age quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Table 7: Treatment Effect by Age Groups

Panel C. 3rd Age Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0215	0.0234	0.0253*	0.0307**	-0.0783**	-0.0606**	-0.0399	-0.0509
	(0.0179)	(0.0154)	(0.0145)	(0.0151)	(0.0318)	(0.0298)	(0.0290)	(0.0313)
Constant	0.371***	0.248***	0.227***	0.142*	0.488***	0.386**	-0.886*	1.219***
	(0.129)	(0.0791)	(0.0731)	(0.0837)	(0.130)	(0.186)	(0.449)	(0.126)
Observations	4,026	3,295	2,562	1,830	1,439	1,171	908	645
R-squared	0.018	0.009	0.010	0.013	0.070	0.075	0.088	0.129
Number of ids	367	367	367	367	170	155	149	140
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the third age quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Panel D. Top Age Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0229*	0.0217*	0.0116	0.00288	-0.101***	-0.106***	-0.113***	-0.103***
	(0.0139)	(0.0122)	(0.0110)	(0.0118)	(0.0270)	(0.0263)	(0.0263)	(0.0291)
Constant	0.870**	0.735***	0.366***	0.480***	0.164	-0.0591	-0.420***	0.424***
	(0.396)	(0.264)	(0.0798)	(0.0809)	(0.622)	(0.439)	(0.119)	(0.130)
Observations	4,755	3,890	3,026	2,162	2,045	1,678	1,309	939
R-squared	0.026	0.020	0.017	0.016	0.098	0.116	0.144	0.146
Number of ids	433	433	433	433	231	223	213	209
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the top age quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Age

Table 7 presents how the discontinuities in equity market participation and risky asset shares at the mortgage runoff differ across age profiles. On average, participation increases by around 4 percentage points at the runoff year across bandwidth for individuals who belong to the bottom age quartile. Conditional on participation, their risky shares decrease by around 7 percentage points at the runoff. For individuals who belong to the

second age quartile, on average, participation increases by 5.5 percentage points at the runoff year. The discontinuity in conditional risky shares, however, is not statistically significant for this group. For individuals who belong to the third age quartile, participation increases by 2.5 to 3 percentage points when we use a smaller bandwidth, and the discontinuity is not statistically significant if a bandwidth of 4 or 5 years is used. On the other hand, conditional risky shares fall by 6 - 7.8 percentage points at runoff when we use a larger bandwidth, and the discontinuity is not statistically significant if a narrower bandwidth (2 or 3 years) is used. For the individuals who belong to the top age quartile, the participation increases by around 2 percentage points when a bandwidth of 4 or 5 years is used. While the conditional risky shares fall by a significant 10 percentage points.

Income

Table 8 reports how the discontinuities in equity market participation and risky shares at the mortgage runoff vary across income quartiles. Individuals who are in the bottom income quartile on average respond stronger compared to the population on equity market participation at mortgage runoff year. Individuals who earn more (top 50% income percentile), on average tend to decrease their risky shares more compared to those who earn less (bottom 50% income percentile) at the mortgage runoff year.

Wealth

Table 9 reports the results by wealth quartile. Again, the equity market participation increases and the conditional risky asset share falls at the mortggae runoff across wealth quartiles. Individuals who are less wealthy (bottom 50% wealth percentile), on average, decrease their risky asset shares in liquid wealth more at the mortgage runoff year compared to the those who are in the top 50% wealth percentile (10 - 12 percentage points versus 4 - 7 percentage points).

Table 8: Treatment Effect by Income Quartiles

Panel A. Bottom Income Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0478***	0.0486***	0.0454**	0.0424*	-0.00764	-0.0166	-0.0192	-0.0723
	(0.0173)	(0.0165)	(0.0177)	(0.0217)	(0.0446)	(0.0335)	(0.0366)	(0.0584)
Constant	0.162**	0.141*	0.135*	0.126*	0.231	0.390***	0.419*	3.193
	(0.0727)	(0.0852)	(0.0727)	(0.0642)	(0.271)	(0.144)	(0.222)	(3.597)
Observations	4,153	3,398	2,643	1,888	890	729	571	407
R-squared	0.020	0.015	0.009	0.010	0.134	0.127	0.087	0.096
Number of ids	380	379	379	379	119	106	100	92
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the bottom income quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Panel B. 2nd Income Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.00485	0.00476	0.0121	0.0173	-0.0366	-0.0270	-0.0290	-0.0233
	(0.0132)	(0.0116)	(0.0114)	(0.0136)	(0.0347)	(0.0331)	(0.0315)	(0.0304)
Constant	0.288*	0.401***	0.720*	0.284***	0.525***	0.660***	0.569***	0.470***
	(0.151)	(0.0965)	(0.406)	(0.0587)	(0.168)	(0.172)	(0.161)	(0.133)
Observations	4,216	3,450	2,684	1,918	1,289	1,043	810	575
R-squared	0.006	0.003	0.005	0.005	0.075	0.091	0.124	0.120
Number of ids	384	384	384	384	154	140	134	128
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the second income quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Table 8: Treatment Effect by Income Quartiles

Panel C. 3rd Income Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0416**	0.0482**	0.0306*	0.0206	-0.0505	-0.0512*	-0.0679**	-0.0919**
	(0.0185)	(0.0212)	(0.0173)	(0.0186)	(0.0310)	(0.0302)	(0.0322)	(0.0370)
Constant	0.569***	0.618***	0.590***	0.579***	0.456	0.202	0.406	0.869***
	(0.181)	(0.186)	(0.171)	(0.148)	(0.374)	(0.368)	(0.348)	(0.237)
Observations	4,210	3,446	2,680	1,914	1,585	1,313	1,027	734
R-squared	0.029	0.026	0.018	0.012	0.110	0.136	0.166	0.160
Number of ids	383	383	383	383	182	179	173	166
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the third income quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Panel D. Top Income Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0339*	0.0331*	0.0355**	0.0340*	-0.111***	-0.106***	-0.102***	-0.0873**
	(0.0190)	(0.0198)	(0.0180)	(0.0180)	(0.0302)	(0.0302)	(0.0308)	(0.0363)
Constant	0.253	0.121	0.0873	-0.122	3.913**	1.321**	1.527*	8.279***
	(0.494)	(0.287)	(0.299)	(0.326)	(1.952)	(0.665)	(0.856)	(0.326)
Observations	4,200	3,435	2,669	1,904	1,825	1,498	1,166	836
R-squared	0.039	0.034	0.041	0.048	0.079	0.082	0.096	0.136
Number of ids	384	384	384	384	214	202	196	187
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the top income quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Table 9: Treatment Effect by Wealth Quartiles

Panel A. Bottom Wealth Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0152	0.0230*	0.0252**	0.0219	-0.103**	-0.112**	-0.121**	-0.0995**
	(0.0176)	(0.0127)	(0.0127)	(0.0142)	(0.0480)	(0.0468)	(0.0468)	(0.0458)
Constant	0.218**	0.166*	0.156*	0.176**	0.0638	0.799***	1.014***	1.091***
	(0.107)	(0.0958)	(0.0806)	(0.0803)	(0.421)	(0.273)	(0.272)	(0.361)
Observations	4,193	3,430	2,667	1,904	966	802	622	444
R-squared	0.015	0.013	0.014	0.015	0.081	0.096	0.123	0.126
Number of ids	382	382	382	382	124	118	110	102
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the bottom wealth quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Panel B. 2nd Wealth Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0156	0.0172	0.0190	0.0128	-0.1000**	-0.101**	-0.106***	-0.102
	(0.0151)	(0.0122)	(0.0123)	(0.0124)	(0.0407)	(0.0393)	(0.0380)	(0.0680)
Constant	0.397*	0.313*	0.430**	0.243*	3.459***	2.010***	3.492***	3.947***
	(0.205)	(0.170)	(0.180)	(0.142)	(0.686)	(0.381)	(0.224)	(0.565)
Observations	4,181	3,422	2,662	1,902	936	769	608	434
R-squared	0.015	0.016	0.013	0.016	0.115	0.129	0.135	0.137
Number of ids	382	381	381	381	120	108	107	100
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the second wealth quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Table 9: Treatment Effect by Wealth Quatiles

Panel C. 3rd Wealth Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0413**	0.0403**	0.0414**	0.0389**	-0.0660*	-0.0510	-0.0508*	-0.0672**
	(0.0173)	(0.0184)	(0.0173)	(0.0165)	(0.0357)	(0.0315)	(0.0305)	(0.0324)
Constant	0.212	0.380**	0.352***	0.268***	0.358	0.112	0.374	0.968**
	(0.132)	(0.179)	(0.124)	(0.0824)	(0.320)	(0.372)	(0.284)	(0.433)
Observations	4,210	3,446	2,679	1,912	1,376	1,129	877	625
R-squared	0.009	0.007	0.009	0.010	0.077	0.074	0.076	0.080
Number of ids	384	384	384	384	165	158	151	144
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the third wealth quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

Panel D. Top Wealth Quartile

	Participation				Risky Shares			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	L5 R5	L4 R4	L3 R3	L2 R2	L5 R5	L4 R4	L3 R3	L2 R2
D	0.0183	0.0148	0.0114	0.0104	-0.0460**	-0.0394**	-0.0339*	-0.0345
	(0.0142)	(0.0122)	(0.0118)	(0.0127)	(0.0183)	(0.0189)	(0.0196)	(0.0218)
Constant	2.114*	-0.0810	0.169	0.513***	0.353**	0.310*	0.230**	0.318***
	(1.241)	(0.453)	(0.247)	(0.0801)	(0.169)	(0.163)	(0.106)	(0.102)
Observations	4,195	3,431	2,668	1,906	2,311	1,883	1,467	1,049
R-squared	0.037	0.027	0.030	0.029	0.115	0.126	0.144	0.142
Number of ids	383	383	383	383	260	243	235	227
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regression estimates on jumps of participation and risky shares at mortgage runoffs, for individuals belong to the top wealth quartile. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 4 report participation results for different bandwidth selections, whereas Column 5 to 8 report risky shares results for different bandwidth selections.

6 Conclusion

In this paper, we incorporate mortgage debt into households' financial decision making process and study the effect of mortgage runoffs on household portfolio choice. Before paying off their mortgages, households face the decision to allocate their wealth between safe assets, risky assets, and the payment of mortgage debt (i.e., the mortgage debt retirement). They have an implied risk-free rate (the mortgage interest rate) that is generally higher than the market risk-free rate. At the time of mortgage runoffs, the

opportunity to retire mortgage debt, which offers a higher return than the safe asset, disappears. After paying off the mortgage debt, individuals can only choose between two investment vehicles, safe assets and risky assets, and the implied risk-free rate drops from the mortgage interest rate to the market risk-free rate. Hence, the expected excess return of holding risky assets is lower before a mortgage runoff than after a mortgage runoff. Becker and Shabani (2010)'s model predicts that *having a mortgage should decrease the probability of equity market participation; conditional on equity participation, having a mortgage should increase the equity share of liquid wealth.* We expect the opposites are true at mortgage runoffs.

Merging the administrative register-based panel data from Statistics Denmark with micro level mortgage term structure data from the Association of Danish Mortgage Banks, we observe individual's portfolio choice and background information from 15 years before to 6 years after their mortgage runoffs. We identify individuals with exogenous mortgage runoffs as our main sample so that it is possible for us to isolate the effect of mortgage runoffs from other confounders on portfolio choice.

Applying the RDiT framework presented in Hausman and Rapson (2018), we estimate the causal effect of mortgage runoffs on the demand for risky assets. Our empirical findings confirm predictions from Becker and Shabani (2010)'s model. On average, the probability of equity market participation increases at the year of mortgage runoff. Conditional on equity participation, the shares of liquid wealth held in risky assets decrease significantly at the mortgage runoff.

Our results highlight the role of debt interest rate as a key mechanism behind asset allocation and equity market participation decisions. Our paper also has important policy implications. For example, in an environment with historically low mortgage interest rates, the expected excess return of risky asset is higher than in the case with higher mortgage rates. This leads to an increase in risky asset demand as paying back mortgage ahead of schedule is less attractive. Our results also shed light on the discussion about what if the government removes the tax rebates on mortgage interests. In this case, the effective mortgage rate increases. Individuals then have stronger incentive to pay back their mortgage quicker. As a result, households will be less likely to hold risky assets.

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Appendix 1

Table 10: Participation Decision for individuals employed at least 3 years after runoffs

VARIABLES	(1) L5 R5	(2) L5 R5	(3) L4 R4	(4) L4 R4	(5) L3 R3	(6) L3 R3	(7) L2 R2	(8) L2 R2	(9) L1 R1	(10) L1 R1
D	0.00837**	**0.0218*** **	0.00896***	**0.0227*** **	0.0103***	**0.0245*** **	0.00546	**0.0261*** **	0.00965***	**0.0156*** **
	(0.00363)	**(0.00421)**	(0.00339)	**(0.00412)**	(0.00337)	**(0.00434)**	(0.00494)	**(0.00495)**	(0.00293)	**(0.00460)**
Constant	0.331***	0.285***	0.331***	0.254***	0.329***	0.285***	0.334***	0.268***	0.330***	0.318***
	(0.00193)	(0.0416)	(0.00184)	(0.0490)	(0.00245)	(0.0402)	(0.00338)	(0.0435)	(0.00180)	(0.0192)
Observations	36,889	36,572	31,610	31,346	25,074	24,872	17,910	17,763	10,746	10,664
R-squared	0.005	0.014	0.004	0.013	0.003	0.011	0.003	0.009	0.003	0.007
Number of individuals	3,582	3,565	3,582	3,563	3,582	3,563	3,582	3,562	3,582	3,561
Controls	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Year FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regressions on equity market participation at mortgage runoffs. Different from the main sample, here we only require individuals to be employed at least 3 years after runoff. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 10 report results for different bandwidth selections, from Column 1 and 2 reporting the largest window from 5 years before to 5 years after the runoff, to Column 9 and 10 reporting the narrowest window from 1 year before to 1 year after the runoff.

Table 11: Risky Asset Shares for individuals employed at least 3 years after runoffs

VARIABLES	(1) L5 R5	(2) L5 R5	(3) L4 R4	(4) L4 R4	(5) L3 R3	(6) L3 R3	(7) L2 R2	(8) L2 R2	(9) L1 R1	(10) L1 R1
D	-0.0564***	**-0.0385*** **	-0.0554***	**-0.0459*** **	-0.0556***	**-0.0527*** **	-0.106***	**-0.0549*** **	-0.0591***	**-0.0376*** **
	(0.00672)	**(0.00833)**	(0.00657)	**(0.00809)**	(0.00666)	**(0.00923)**	(0.0103)	**(0.0115)**	(0.00662)	**(0.00861)**
Constant	0.333***	0.504***	0.330***	0.417***	0.326***	0.426***	0.368***	0.614***	0.320***	0.590***
	(0.00432)	(0.0929)	(0.00444)	(0.0935)	(0.00469)	(0.0891)	(0.00711)	(0.105)	(0.00394)	(0.114)
Observations	12,407	12,333	10,661	10,602	8,458	8,408	6,026	5,990	3,621	3,600
R-squared	0.027	0.067	0.025	0.071	0.026	0.077	0.026	0.079	0.030	0.070
Number of individuals	1,582	1,573	1,517	1,510	1,452	1,445	1,365	1,359	1,294	1,287
Controls	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Year FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. This Table presents results from quadratic polynomial panel data fixed effects regressions on shares of risky assets held in liquid wealth at mortgage runoffs. Different from the main sample, here we only require individuals to be employed at least 3 years after runoff. All specifications report cluster robust standard errors, clustering at individual level. Where it applies, control variables include: age categories (There are 4 age categories, ranges from 0 to 3.), marital status (There are 6 types of marital status, ranges from 1 to 6. "Married" includes married and registered partnership. The other 5 categories includes Single, Unmarried, Divorced, 2 partners, Dissolved registered partnership. Others are marked as missing.), education level (Education Level describes the main education groups, ranges from 10 to 70 and contains 9 education levels. The 9 levels are Primary School, General education, Vocational education, Apprenticeship, Short higher education, medium long higher education, Bachelor, Long higher education, PhD.), labor income, bank debt, and net wealth. Column 1 to 10 report results for different bandwidth selections, from Column 1 and 2 reporting the largest window from 5 years before to 5 years after the runoff, to Column 9 and 10 reporting the narrowest window from 1 year before to 1 year after the runoff.