Responses to Saving Commitments: Evidence from Mortgage Run-offs

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Abstract

We study consumers' responses to removing a saving constraint. Mortgage run-offs predictably relax a saving constraint for borrowers whose mortgage committed them to save by paying down principal. Using the entire Danish population, we identify mortgages on track to run off between 1995 and 2014. We measure the effect of run-offs on earnings and the household balance sheet. We find that borrowers use 39 percent of previous mortgage payments to decrease labor income, and use 53 percent to pay down other debts. Borrowers run up non-mortgage debt prior to the run-off and this run-up stops once the mortgage is repaid.

JEL classification: D14, D15, G21

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1. Introduction

Compulsory saving schemes potentially force some households to save more, and spend less, than they would otherwise prefer. Employer and government pension programs are an example of such compulsory savings constraint. Although saving commitments are sometimes used to force one's future self to increase savings, mortgages also impose a saving commitment for which the goal is home ownership. Mortgage borrowers effectively save in housing equity by making principal payments to reduce their mortgage debt and, to obtain favorable rates, borrowers typically choose mortgage contracts which commit them to a predetermined schedule of payments.

Mortgage run-offs provide an ideal natural experiment to identify the consequences of relaxing a self-imposed saving commitment. Mortgages run off when borrowers complete their schedule of payments and bring their mortgages balance to zero without prepayment. After a run-off, borrowers are no longer forced to save by paying down their mortgages; they can allocate freed-up resources to saving elsewhere, spending more, or increasing leisure by working less. Because unconstrained borrowers can offset saving commitments by borrowing or saving less elsewhere prior to the run-off, savings commitments should only affect those for whom the mortgage contract constrains saving and consumption decisions.

Measuring the consumption and investment response to a mortgage run-off can be seen as a test of a variant of the Permanent Income Hypothesis, PIH henceforth (Modigliani and Brumberg, 1954; Friedman, 1957). The PIH implies that unconstrained, rational, forward-looking, risk-averse individuals should not change their consumption in response to a predictable change in income. Individuals who anticipate that their income will increase in the future should draw down savings to increase consumption today, so that consumption will not increase when income does. A mortgage run-off has the same consumption-smoothing prediction: rational, unconstrained borrowers should not change consumption after the run-off. This smoothing is achieved by borrowing or drawing down savings to make mortgage payments prior to the run-off. The theoretical prediction is that non-mortgage net wealth should fall leading up to the run-off as unconstrained borrowers offset mortgage principal payments and this wealth decumulation should stop after the run-off. As a result, net non-mortgage savings increases after the run-off.

The empirical validity of the PIH has been tested in many different settings[2] and the failure of the PIH is often attributed to a liquidity constraint which prevents individuals from borrowing to smooth consumption (Deaton, 1991; Carroll, 1997). The effect of a mortgage run-off on consumption, asset accumulation and other debt repayment should also vary with the financial position of the borrower. On one hand, the mortgage repayment schedule does not impose a constraint on the saving rate or consumption of individuals that choose to save elsewhere while paying down their mortgage, or can borrow using non-mortgage debt. These unconstrained individuals could save less or borrow elsewhere to offset the saving commitment imposed by the mortgage and they could always liquidate some of their savings to finance consumption if they wanted to increase it. On the other hand, individuals who do not wish to save as much as the mortgage contract requires must choose to either consume less or borrow elsewhere at higher rates. Individuals who chose to consume less in response to the mortgage's saving commitment would be expected to spend some of the resources freed up by the run-off, either on leisure (working less) or consumption. We present a theoretical framework formalizing these predictions in Section 2: reduced labor income post-run-off, particularly among those expected to be more constrained and increased saving and reduced non-mortgage debt post-run-off, particularly among those expected to be less constrained.

We investigate these predictions empirically by examining the evolution of earning and of the main components of households' balance sheet in the years before and after mortgage run-offs. The data used in our analysis include year-end administrative information on the universe of the Danish population for nearly all assets and liabilities – including those in bank accounts, investments, credit cards, and homes – as well as employment status, pension contributions and payouts, and labor income. This allows us to directly examine all possible margins of adjustments in response to relaxing a saving constraint – with the exception of consumption, which, given the breadth of data we use, is the residual.

We find that the final mortgage payments lead to two observable adjustments. First, we show that just after run-offs borrowers reduce their labor supply: our point estimates suggest

[2] Agarwal, Liu, and Souleles (2007), Agarwal and Qian (2014), Souleles (1999), Johnson, Parker, and Souleles (2006), and Hsieh (2003) are examples of papers that look at the consumption response to changes to income or cash on hand. Jappelli and Pistaferri (2010) survey theoretical results on the consumption response to income shocks, and Attanasio and Weber (2010) and Fuchs-Schuendeln and Hassan (2015) survey empirical results.

that individuals reduce labor income by 39 percent of the amount previously devoted to mortgage payments. As suggestive evidence for the mechanism through which this decrease in earnings is happening, we show that an increasing proportion of individuals switch to part-time work after the run-off. Furthermore, although individuals tend to run off their mortgages at later stages of their life, we show that the decrease in earnings is not limited to individuals who retire following their final mortgage payment: this effect is found both for younger individuals and for individuals who do not retire during the time frame we analyze.

Second, we find a faster repayment of other debts after the run-off: individuals devote 53 percent of their previous mortgage payment to reducing other debt. However, probably because most Danes save less in taxable or investments accounts relative to other countries, we find no statistically significant evidence of asset accumulation in bank deposits, stocks, or bonds. Danes are already subjected to compulsory savings scheme which place most of them at a "corner solution" in terms of savings. Chetty et al. (2014) estimate that a $1 tax subsidy to pension savings only raises $0.01 of additional pension savings by the Danish population - using virtually the same sample period – and that overall savings rates are driven by compulsory set savings levels, indicating that Danes are already at the pension saving limit.

Our results differ somewhat across sub-samples of potentially constrained and unconstrained individuals, providing suggestive evidence consistent with our theoretical intuition. However, the differences between these groups are not strongly significant, which makes evidence of these differences more suggestive than definitive. For borrowers without pre-run-off assets or other debt – for whom we would expect the savings constraint imposed by the mortgage to bind – labor income falls by 47 percent of freed up liquidity after the run-off. Borrowers had presumably been constrained to consume less leisure than they would have preferred prior to the run-off (and presumably lower consumption, though we cannot measure this directly). For these borrowers, we find no statistically significant change in other debts or assets. For borrowers without pre-run-off assets but with pre-run-off other debt, there is no statistically significant evidence of a reduction in labor income and we cannot reject the hypothesis that they cease borrowing to finance mortgage payments nearly one-for-one.

While the institutional setting of mortgage run-off on fixed rate mortgages will be familiar to U.S. readers, the data available on each household are much richer. We use administrative registry data from the Danish tax authorities covering the universe of Danish mortgages. We observe the value of the mortgage backed security attributable to an individual's mortgage, although we do not observe the mortgage terms explicitly. Therefore, we identify a mortgage run-off as a mortgage with a balance that falls steadily to zero on schedule.[3] The main analysis uses the *anticipated* date of final payment — predicted three years before its realization — as the event relaxing the saving commitment. This is an *intention-to-treat* approach (e.g. Imbens and Rudin, 2015) where the analysis focuses on mortgages on the glide path to run off, whether they actually run off or not. This approach, which we explain in more detail in the methodology section, allows us to control for potential selection problems coming from prepayments and rebalancing incentives just before the runoff.[4]

Nearly all mortgages that have run off in recent years were standard, 20- or 30-year fixed rate mortgages with 240 or 360 monthly payments of equal size. These mortgages differ from their counterparts in the U.S.A. in that they typically come with a prepayment penalty and are not discharged in foreclosure; these features imply that it is almost never optimal for borrowers to default or prepay in the years leading up to mortgage run-off when the mortgage balance is relatively low. Although more flexible mortgages have been available in Denmark in recent years, such mortgages are a decade or more from run-off.[5]

This is not the first paper to consider run-offs. Coulibaly and Li (2006) use the Consumer Expenditure Survey (CEX) to measure the consumption and saving responses for 286 mortgage run-off events. The nature of the CEX allows them to analyze different categories of expenditures such as non-durables, home furnishing, entertainment, and vehicles. They find that for every US$ 1 freed up from mortgage payments, consumers increase expenditures on house furnishing and entertainment by 20 cents and 4 cents, respectively, and increase savings by 32 cents. Stephens (2008) uses CEX data to measure the consumption response

[3] Given penalties for prepayment, this will not reflect an individual consistently making larger-than-required payments each month. Although we do not observe the mortgage balance, the value of the mortgage backed security represents the mortgage balance, adjusted for the gap between the interest rate on the mortgage and the current market interest rate for mortgages with that maturity. We have data on mortgage-backed security prices to infer the mortgage balances from these data. These calculations can be made more precise using data on the annual mortgage interest paid.

[4] We run robustness checks for different lengths of time of the glide path to runoff, including perfect compliance to mortgage payoff until runoff, and we find that our results are the same.

[5] For a detailed discussion of the institutional setup of the Danish mortgage market please see Andersen, Campbell, Nielsen and Ramadorai (2017).

for approximately 200 car loan run-off events[6]. He finds that a 10% increase in after-tax income due to the run-off increases nondurable consumption by 2.8%. Scholnick (2013) uses administrative data from a Canadian financial institution to measure the credit card spending response for 147 mortgage run-off events. He finds support for the magnitude hypothesis, which predicts that the magnitude of an anticipated income change affects consumption smoothing. d'Astous (2019) uses administrative data from a North American Bank to identify the credit card consumption and term loan uptake responses for 291,777 term loan run-off events. He finds that people increase credit consumption and term loans by 9 cents and 15 cents on the dollar, respectively.

Table 1 summarizes the major features and results of these papers and compares them with our study, with an attempt to standardize the way results are expressed so that magnitudes are comparable. Our data include a large number of run-off events (as in d'Astous), high-quality administrative data (as in Scholnick and d'Astous) spanning all financial institutions (unlike Scholnick and d'Astous who have data from one bank each), and a full range of earnings and household balance sheet outcomes not available in other data used to study mortgage run-offs. While our data have a number of advantages in data quality, size, and breadth, we complement the expenditure outcomes that are well-covered by credit card spending (Scholnick and d'Astous) and survey responses in the CEX (Stephens and Coulibaly and Li). Our data allows the first analysis of the effect of run-off on earnings and the complete household balance sheet as measured by administrative data.

Our study on run-off events is also related to the literature that studies major life pre-planned events such as retirement, for which PIH would predict no change in behavior around the event given its *predictable* nature. For example, Aguiar and Hurst (2005) find evidence of the PIH documenting that there is no change in consumption of food – as distinct from expenditure on food – around retirement (a highly predictable event) but do find that households with *unexpected* shocks such as unemployed show a deterioration in food consumption after the unanticipated event. However, Bernheim et al. (2001) find a discontinuous drop in general consumption around retirement and a negative correlation between the size of the drop and retirement savings or income replacement rates. They find that these patterns cannot be explained by standard classical arguments of variation in risk

[6] About 4% of an original sample of 5,000 according to Table 1 presented in the paper.

taking, discount rates, uncertainty and consumption/leisure preferences. However Bernheim et al. (2001) argue that this patterns can be explained by behavioral theories that allow for i) the pre-planned retirement event to have an "unexpected" component if people evaluate adequateness of savings just before retirement date and turn out to be insufficient, ii) "mental accounting" and self-control problems and iii) decision models over time that allow for dynamically inconsistent preferences. Therefore, the results in Aguiar and Hurst (2005) and Bernheim et al. (2001) suggest that even within the category of "predictable" events, there are domains in which consumption responds to such events as if they were "unpredictable".[7]

Additionally, studies such as Ganong and Noel (2019) have used predictable changes in income such as the exhaustion of the unemployment insurance (UI) benefits to test three theories of consumption: the PIH, the buffer stock model, and the hand-to-mouth model. Ganong and Noel (2019) find that among these three, the buffer stock model explains the data best; however it cannot explain the sharp drop in consumption at exhaustion. Ganong and Noel (2019) offer a few potential explanations for this empirical puzzle related to individuals' ability to anticipate the predictable change in income. First, a of lack of effort to find a job and over-optimism about finding it before exhaustion can explain the sharp unexplained drop in consumption. In this context, benefit exhaustion may cause the individual to realize that finding a job is not as easy as they had thought, and therefore to reduce consumption sharply. Second, a combination of pessimistic beliefs during the periods receiving UI periods and overoptimistic beliefs about job finding can explain the consumption path before and after exhaustion of benefits. Finally, inattention about exhaustion timing could also explain the empirical puzzle. Inattentive individuals only realize that UI benefits come to an end the day the stop receiving the benefits and therefore adjust their finances sharply after exhaustion.

Jørring (2018) used a detailed database of both account and card transactions from U.S. consumers to measure financial mistakes and use predictable increases in debt payments to study if these mistakes are related to consumption smoothing. His main finding is that people

[7] In the case of Bernheim et al. (2001) it seems sensible that people overreact in consumption to the retirement, if they have procrastinated and delay the task of looking into their finances well in advance to retirement. In this case, people might react to the "news" of retirement if they find out just prior to retirement that they don't have sufficient savings and compensate by reducing consumption substantially. In the case Aguiar and Hurst (2005) people react according to the PIH in the food consumption domain by allocating more time to food shopping and preparation after retirement.

that commit financial mistakes, such as unnecessary card fees, also lack consumption smoothing behavior. Finally, Baugh, et al (2018) use administrative transactional household data of bank accounts and credit cards in the U.S. to study how households' consumption reacts to predictable positive or negative cash flows. The main result is an asymmetric response of consumption: Consumers increase consumption spending when receiving tax refunds, but they fail to reduce their spending when they make expected tax payments. Our study focus on run-off events, which are arguably a highly predictable event and an important milestone for many households. Mortgages can be seen as saving commitments that tie a portion of households' disposable income to saving in the form of mortgage principal payments. If we think of mortgages as negative bonds – bonds that homeowners sell to investors – then paying down mortgage principal reduces the holding of such negative bonds. Mortgage repayment schedules therefore impose on borrowers a predictable saving commitment schedule. Even rational, expected utility maximizers may wish to commit to such a saving schedule not because they value the commitment per se, but rather because it gives them access to a mortgage with a more desirable interest rate.

Although savings commitments can be used by present-biased agents to force their future selves into saving more (Laibson, 2018), we use this setting to make predictions about how rational, forward-looking, risk-averse individuals would respond to a saving commitment being relaxed in a *predictable* manner. These predictions are derived using elements of the literature on the Permanent Income Hypothesis, PIH henceforth (Modigliani and Brumberg, 1954; Friedman, 1957), and of the literature on liquidity constraints (e.g, Zeldes, 1984; Carroll, 2001; Deaton, 1991).

2. Theoretical Framework

Our framework borrows from Stephens (2008), which applies this class of models to study an auto loan debt run-off; his results in the context of auto loans apply equally to mortgage run-offs. Although more sophisticated models can be analyzed (e.g. Carroll, 1997), this stylized framework is sufficient to generate the relevant theoretical predictions that guide our empirical analysis.

His model has three periods; in the first period consumers borrow to finance a car loan, in the second period they repay the loan and in the third period they consume what is left. We can think of the end of the second period as the run-off date and people can borrow or use savings in this period before the run-off. We lay out a model with consumption and labor supply decisions, which illustrates the effects of mortgage run-offs on consumption, savings, borrowing, leisure and earnings, for constrained and unconstrained consumers. Our model, explained in more detail in Appendix A, extends Stephens (2008) in two ways, but is otherwise identical to it in structure and notation: first, Stephens (2008) assumes that consumers cannot borrow in the second period, and second he does not include the labor supply decision. We extend Stephens (2008) in these two dimensions.

How does the model predict labor income, non-mortgage borrowing, and saving to change between the pre- and post-run-off periods, and how should these changes be different for those with larger and smaller mortgage payments? Larger mortgages imply lower discretionary income in the second period, as more must be repaid.

How does the consumer adjust consumption and labor income in response to this reduction in discretionary income? The answer depends on whether the consumer is constrained or unconstrained, that is, whether they have the ability to use savings or take on more debt to consume more prior to the mortgage runoff.

For unconstrained consumers, who save or borrow in period 2 before the run-off, larger mortgages will be associated with increased borrowing or reduced savings prior to a mortgage run-off but without a relative change in consumption, leisure or earnings between periods 2 and 3.[8] Reduced discretionary income in the second period caused by a larger mortgage is shared between reduced consumption and reduced leisure in periods 2 and 3; there are no changes in relative consumption or leisure between periods 2 and 3. This is achieved through increased borrowing or reduced savings in period 2, leading to lower consumption in period 3 as the larger non-mortgage loan or smaller saving from period 2 leaves fewer resources available in period 3 when the loan must be repaid or the savings drawn down.

[8] This setting abstracts from the run-offs we explore empirically by considering only one pre-run-off period (period 2) and only one post-run-off period (period 3). A more realistic model would include multiple pre- and post-run-off periods to show dynamics of debt and savings accumulation before and after the run-off. In a more realistic setting, the proportion of any consumption effects allocated pre- and post-run-off would be based on the number of periods pre- and post-run-off. This would affect the amount of borrowing needed to smooth consumption pre- and post-run-off for a given change in lifetime consumption.

For constrained consumers, who neither save nor borrow in period 2 prior to the run-off, larger mortgages will be associated with larger relative increases in consumption or leisure – and associated decreases in earnings – between periods 2 and 3, without adjustments in savings or borrowing. For this type of consumer, the brunt of reduced discretionary income in the second period caused by a marginally larger mortgages is borne entirely in period 2. Both consumption and leisure in period 2 (since both are assumed to be normal goods) fall, without any adjustment to saving, borrowing, or period 3 consumption and leisure.

As Stephens (2008) notes, the borrowers' financial position at the time of run-off indicates whether the Euler Equation holds, and consequentially the nature of the expected consumption and saving response to the run-off. The Euler Equation holds when borrowers have the ability to take out more debt or run down their savings leading up to the run-off. The presence of savings or debt at the time of run-off provides suggestive evidence that these borrowers are unconstrained.[9] In our empirical approach, we use the financial position at the time of the run-off to identify individuals that are constrained or unconstrained.

To summarize, consumers who were constrained by the saving rate imposed by their mortgage can choose to borrow to fund consumption or not. For individuals who chose not to increase consumption early, we would predict that relaxing a saving constraint would lead to an increase in consumption (or an increase in leisure).[10] For unconstrained consumers who had chosen to finance consumption through other debt prior to the mortgage run-off, we would predict that they would use the freed-up liquidity from mortgage payments to pay down their other accumulated debts.

[9] The Euler Equation might not hold for a borrower with assets at the time of run-off if those assets were held in a trust that the consumer could not access. Similarly, it might not hold for a borrowers with debt at the time of run-off who had maxed out their ability to borrow at that rate. Such borrowers might be mis-identified as unconstrained by their asset position.

[10] Since the income expansion path can be of any monotonically increasing shape, it is theoretically plausible to get increases of consumption or leisure. Only in specific cases, such as perfect complements, one can make unambiguous predictions about the ratio of consumption to leisure.

3. Data

a. Data sources

Our dataset includes demographic and financial information on the universe of adult Danes between 1995 and 2014. We derive data from two different administrative registers made available through Statistics Denmark: demographic information from the Danish Civil Registration System (CPR Registeret), and income and financial information from the Danish Tax Authority (SKAT).

Demographic information from the Danish Civil Registration System contains the entire Danish population. It includes the individuals' personal identification number as well as their gender, date of birth, and marital history. The personal identification number is unique for each individual in the population, and is used across all administrative datasets. The administrative records also contain a unique household identification number, as well as those of each individual's spouse and children in the household. We use these data to obtain basic demographical information about each individual and household.

Income and financial information from the Danish Tax Authority contains both the total and disaggregated income and wealth information for the entire Danish population. The Danish Tax Authority receives this information directly from the relevant third-party sources: employers supply statements of wages paid to their employees, and all financial institutions supply information on their customers' deposits, interests paid and received, security investments in stocks and bonds, and dividends. Our main labor income variable is aggregated at the annual-level, and an additional variable indicates whether the individual works part- or full-time. Because taxation in Denmark mainly occurs at the source level, this income and wealth information is highly reliable. Though this information is extensive, not all components of wealth are recorded by the Danish Tax Authority: we do not have information about 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. We observe the total interest payments paid on the mortgage within the year, although not the specific terms of the mortgage contract, as well as the value of the mortgage backed security attributable to an individual's mortgage, a proxy for the actual mortgage balance.

b. Methodology

Because the mortgage could be refinanced (or prepaid, although at a cost), unobservable variables could correlate with the decision to refinance the mortgage and with other outcomes studied in the analysis. To overcome the fact that prepayment could create a selection problem, we look at mortgages whose balances appear on track to run off in a given year based on changes in balances in six to three years beforehand. The main analysis therefore uses the *anticipated* date of final payment — predicted three years before its realization — as the event relaxing the saving commitment. In this intention-to-treat (ITT) approach (e.g. Imbens and Rudin, 2015), random assignment into the treatment is assumed to hold for the predicted final payment date, not its actual realization.

This intent-to-treat approach looks at mortgages on the glide path to run off, whether they actually run off or not. This allows us to observe individuals who take out a new mortgage just when their old mortgage is running out so that their total mortgage balance never falls to zero. This also mitigates concerns about unobservable variables correlating with the final payment and subsequent behavior, while still capturing a discontinuous change in annual required mortgage payments.

Mortgage run-offs remove a savings constraint; a borrowers' cash available jumps discontinuously when the mortgage runs off at a pre-specified time (Coulibaly and Li, 2006; Scholnick, 2013). Such run-off analyses rely on the assumption that individuals are unable to precisely manipulate their position around the discontinuity and effectively replicate a randomized experiment in which individuals would be randomly assigned to the treatment. The timing of this discontinuity (run-off) is determined 20 or 30 years before when the mortgage is originated. In our case, because borrowers have committed to their mortgage repayment schedule many years ago, the actual date of their final payment can be considered quasi-exogenous to their financial condition in the years surrounding the run-off. One could argue that individuals can choose initial mortgage terms to time the end of the mortgage with retirement decisions. However, there are many unknowns that makes it complex to do so. For example, there is always uncertainty about retirement age, which can be changed over the course of 30 years depending on the political swings as well as on the economic conditions in the country. Furthermore, mortgages typically have terms that are exactly 20 or 30 years, so even borrowers who know their future retirement date exactly will typically be unable to choose standard mortgages with run-off dates that align exactly with their retirement plans.

c. *Sample Construction*

Since we do not have the exact terms of the mortgage contracts, we use the balance at the end of each calendar year (as proxied by the value of the mortgage backed security attributable to that mortgage) to identify expected run-off year and the estimated annual payment. The reason for this methodological choice is that we are doing the analysis a few years around the mortgage run-off date. This implies changes in the market value of the mortgage due to market risks do not create big swings in this value from year to year.[11] This allows us to identify mortgages that are on the path to run-off within some range to control for swings in the market.

We identify a mortgage as on track to run off in exactly three years if the following criteria are met: (i) The cumulative decline in the mortgage balance over the past three years (between six and three years before the expected run-off) must be similar to – between 80% and 120% of – the mortgage balance (three years before the expected run-off); and, (ii) The annual declines in the mortgage balance over the past three years (between six and five years, five and four years, and four and three years before the expected run-off) must be similar to – between 75% and 133% of – one another.[12] We ignore the interest payment component of the balance change in this process, as they are small compared to principal repayment in the years right before the final payment. Moreover, since our objective is to analyze the impact of relaxation of saving commitments on economic choices, our sample is designed to focus on individuals that clearly display adherence to the saving commitment implicit in the mortgage payment schedule. Finally, we focus on the individuals for whom the saving commitment is an important item of the household balance sheet. Our purpose is not to generalize our result to the rest of the Danish population.

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[11] For example, the underlying bond used to calculate the market value of the mortgage is subject to interest rate risk like any bond. However, since we are focusing on the last few years of the mortgage before the run-off, the sensitivity of the market value of the remaining bond to interest rates changes (duration) is small. One would need to have big swings in interest rates to create big variations from year to year in the market value of the mortgage. This has not been the case in Denmark. Another important risk that can affect the market value of the mortgage bond is default risk. Denmark has full recourse and very strict rules to deal with default that translates into very low levels of default in Denmark.

[12] That is, $0.75 \leq \frac{Bal_6 - Bal_5}{Bal_5 - Bal_4} \leq 1.33$ and $0.75 \leq \frac{Bal_5 - Bal_4}{Bal_4 - Bal_3} \leq 1.33$.

Taking into account the considerations above, we identify 77,790 individuals[13] in the sample that have a mortgage on track to run off between 1995 and 2014 (that is, they have an expected run-off year between 2001 and 2011). Since we examine behavior in the three years before and after an expected run-off, the analysis includes data from 1998 (three years before the first expected run-off in the sample) to 2014 (three years after the last expected run-off in the sample). We define the estimated annual mortgage payment as one third of the balance three years prior to the expected run-off. We additionally impose three restrictions on the sample, where either identification of outcome variables are diffuse due to limits in the register data, or where identification of the treatment leads to very small run-offs since we want to focus on individuals for which the mortgage payment is a significant expenditure constraint.[14]

After imposing these restrictions, our final sample consists of 15,895 individuals.[15] These individuals show mortgage balances that fall mechanically between six and three years prior to the expected run-off year (Figure 1). The median mortgage balance falls to zero in the expected run-off year (Figure 1.a) and the share of mortgages with zero balance jumps discontinuously from less than 20 percent in the year prior to the expected run-off to more than 50 percent in the year of the expected run-off (Figure 1.b). The bulk of individuals dropped for our main analysis have mortgage payments so small that they should not affect their other economic decisions. Additional robustness checks in Section 5 exploit these small mortgages to perform a placebo test.

A possible challenge of our identification strategy is the possibility that individuals time the maturity of their mortgage contract with other life-cycle events. Although we do not

[13] Our main analysis is done at the individual level. However, in the robustness section we do the analysis at the household level and find that the baseline results at the individual level are not changed.

[14] We impose three main restrictions on the sample. Here we state the number of individuals affected by each of these restrictions, although some individuals are affected by more than one of these. (i) 17,111 individuals receive income from privately owned companies. We exclude these self-employed individuals because they can use their companies as a saving mechanism in the sense that they can decide to take out or not earnings from the companies for tax reasons. This is in effect an important saving mechanism that could be affected by mortgage run-offs and that we cannot observe in the Danish registers. (ii) We then exclude 393 individuals with either large (>1 million DKK) year-to-year changes in net financial wealth or extremely large (>10 million DKK) housing wealth. (iii) Finally we exclude 44,391 individuals with small mortgage payments relative to their income (estimated annual mortgage payments less than 10 percent of average of annual labor income between five and three years before the expected run-off). We exclude these small mortgages from our baseline analysis to focus on mortgages that are economically significant to borrowers.

[15] When our regressions have the individual's working status as the outcome we further drop 8,968 individuals for whom the working status is missing.

observe the historical mortgage contract terms in our main dataset, we use current mortgage loan contract data, which includes mortgage contract terms for the universe of active mortgages in Denmark in the period 2009-2014, and match these to the active mortgages in our main data in year 2009.[16] Figure 2 shows the distribution of mortgage maturities at origination for these mortgages. 74.5% of the mortgage maturities falls exactly into 5-year bins finishing either in 0 or 5. Mortgages are issued quarterly and 17.5% of the maturities fall one year short from 0 or 5 year bins (i.e. they finish with either 1, 2, 6, or 9) due to issuing calendar rounding's. Only 8% of the mortgage maturities finish with either 2, 3, 7, or 8. This suggests that the vast majority of the mortgages maturities are chosen as standard lengths, or within one year of that, ruling out maturities strategically chosen with respect to the run-off year. While 8% of the mortgage maturities may seem non-standard and potentially strategically selected, a 30 year mortgage refinanced after 18 years could also give rise to a 12-year maturity non-strategically chosen mortgage contract.[17]

[INSERT FIGURE 1 ABOUT HERE]

Table 2 presents descriptive statistics for the sample used in the analysis. All variables are recorded at the end of the calendar year and are measured three years prior to the year in which the mortgage is paid off. All monetary amounts are expressed in Danish kroner (DKK).[18] Panel A. shows that our sample consists of individuals who are on average 57 years old, approximately 61% of which are male, with about 2 adults in the household and out of which 73% are married, 7% are divorced and 41.5% are retired. Panel B. shows that the average annual labor income is about 222,000 Danish kroner (DKK). Pension income (payouts from pension retirement funds) is on average 49,000 DKK a year, (although people that have not retired have zero pension payouts). The total contributions to pensions are on average about 21,000 DKK a year. Panel C. shows the financial assets and liabilities (beyond mortgages). Individuals in our sample keep on average 91,000 DKK in liquid bank deposits,

[16] 3,688 mortgages from our main sample are still active in 2009.

[17] Mortgages is issued in series each quarter, in large pools. Historically, asking for a mortgage with non-standard maturity (coupon rate or other contract term) results in a small amount of bonds with these characteristics. This causes the bond itself to become illiquid in the market. As a mortgage owner you want your mortgage to be as liquid in the market as possible, because it gives you the largest possibility to gains better terms when refinancing your mortgage.

[18] The exchange rate between DKK and U.S. dollar was 14.94% at the beginning of our sample in 1998, averaged 16.27% over the sample and was 17.81% at the end of our sample in 2014. We use nominal values since mortgage payments and balances, and hence our run-off calculations, are based on nominal values. We control for inflation in our regressions with calendar year fixed effects.

35,000 DKK in stocks, 52,000 DKK in bonds and 32,000 DKK in loans. *Panel D* shows that housing assets are on average 1,007,000DKK, with a mortgage value of about 134,000DKK and mortgage payments of about 34,000DKK a year. These payments represent on average about 22% of the individual's labor income.

[INSERT TABLE 2 ABOUT HERE]

d. Identification of behavioral change

We analyze individual responses using a simple event-study methodology to predict values for individual *i*, at run-off time *t* with the following estimating equation:

$$Y_{i,t} = \beta_1 After_{i,t} + \beta_2 After_{i,t} \times Payment_i + CalendarYear\ F.E. + f(t) + \alpha_i + \varepsilon_{i,t} \quad (1)$$

where $Y_{i,t}$ is either annual labor income in year *t* or the annual change in a financial balance between years *t-1* and *t*. $Payment_i$ is the estimated annual mortgage payment (in thousands of DKK) calculated as the value of the mortgage three years prior to the anticipated final payment divided by three. The dummy variable *After* is equal to 1 if the year is one, two, or three years after the anticipated final payment and 0 if it is one, two, or three years before. We omit the year in which the payment is anticipated to end to circumvent the fact that different mortgages run out at different times in the year and therefore individuals benefit from different levels of increased liquidity within that year. An individual-level dummy variable (α_i) which absorbs all time-invariant effects at the individual level and calendar-year dummies (λ_t) that absorb year effects are included in all specifications unless otherwise specified. Finally, $f(t)$ consists of the linear run-off year and its interaction with the size of annual mortgage payment, to control for potential linear trends in event-study time. Standard errors are clustered at the individual level.

This specification could technically allow two different identification strategies – both intended to reveal the causal effect of the run-off on the outcomes of interest – to be shown and compared in the same regression. A simple identification strategy is a before- versus after-run-off comparison: when presenting the results, we normalize the $After_{i,t}$ variable by multiplying it with the average mortgage payments ($\overline{Payment}$) so that its coefficient (β_1) can be interpreted as the before- versus after-run-off change in the outcome of interest as a proportion of an average-sized mortgage payment. However, for this before- versus after-run-off to accurately measure the causal effect of a run-off, the location of the discontinuity must be uncorrelated with the errors. In our case, a comparison of pre- and post-run-off behavior will only reveal the true effect of relaxing the saving constraint if the exact timing of the run-off is exogenous and borrower behavior is otherwise smooth around the time of the run-off.

Our preferred identification strategy instead allows a weaker assumption about the endogenous timing of run-offs by comparing the before- and after-run-off patterns in the outcome of interest for those with small and large mortgages. We examine how economic outcomes change post-run-off as mortgage payment size – and with it, the amount of wealth freed up by the run-off – gets bigger. The coefficient on the $After_{i,t} \times Payment_i$ interaction (β_2) captures how the before- versus after-run-off difference in the outcome of interest change as the size of the mortgage payment increases. The coefficient β_2 has the appealing interpretation of showing how an additional kroner of mortgage payment is allocated after the run-off, comparing smaller mortgages to larger ones. This identification strategy will be unbiased as long as there are no differences between large and small mortgages in the degree to which run-off timing is endogenous.

4. Results

We present our baseline results in Table 3, estimating equation (1) with labor income and changes in bank account, stock, bond, and bank loan balances. We find that on average individuals adjust only two of the margins we study: labor income and other bank loans. We find no statistically significant evidence of differences in stock, bond, or bank account balance accumulation before versus after the run-off. In what follows, we concentrate our analysis on the results on labor income and non-mortgage debt.

The estimated coefficient on $After_{i,t} \times Payment_i$ ($\beta_2 = -0.39$, 95% C.I. -0.67 to -0.10) provides an estimate of the share of the wealth freed up by a run-off that is offset by a subsequent reduction in labor income. For an average 34,000 DKK mortgage payment, this estimate indicates that labor income drops by approximately 13,000 DKK (6 percent of average annual income) following the run-off. This estimate suggests that 39 percent of the money freed up by the run-off is “spent” on increased leisure (e.g., working fewer hours or earning less per hour - probably in a job with less intensity).

Bank loans are typically large and infrequent, which increases the estimation error on our estimated effect of run-offs on changes in bank loan balances. Comparing smaller and larger mortgages before and after the run-off indicates that 53 percent of the additional wealth freed up by larger mortgage payments after the run-off goes to reduced debt accumulation (coefficient on $After_{i,t} \times Payment_i$ $\beta_2 = -0.53$, 95% C.I. -1.00 to -0.050).

[INSERT TABLE 3 ABOUT HERE]

Our identification strategy controls for time-invariant individual characteristics through the individual fixed-effects and the interaction with mortgage payment size allows us to compare similar individuals for a given mortgage payment. By comparing individuals three years after the final mortgage payment with themselves three years prior, we minimize the risk that a change in individual preferences is driving our results. It is important to emphasize that individuals in our main sample are 57 years of age on average and plausibly more likely to reduce their labor supply given that they are near to retirement. This would create a confound between a reduction in the labor supply due to the runoff and the natural increase in desire to reduce labor supply as one approaches retirement.

Because the timing of mortgage run-offs could coincide with the timing of retirement, we investigate the robustness of our earnings results in the sub-samples of individuals that do and do not retire during the event-study, and across young (under 55 years old three years before their final mortgage payment) and older individuals (55 years and older). Table 4 shows the results of estimating equation (1) for these groups of individuals. The results show that the decrease in earnings is present even for individuals that do not retire (coefficient on $After_{i,t} \times Payment_i, \beta_2 = -0.50,$), and for younger individuals (coefficient on $After_{i,t} \times Payment_i,\ \beta_2 = -0.56,$). However, the smaller samples of non-retired and younger individuals reduce our statistical power and increases the standard errors of our estimates in these sub-samples.

[INSERT TABLE 4 ABOUT HERE]

Figure 3 provides further evidence for the mechanism driving the earnings adjustment. Using a variable identifying whether individuals are part-time workers, we show that the fraction of individuals with a larger-than-average mortgage payment are increasingly working part-time after the run-off. The share of borrowers with smaller-than-average mortgage payments working part-time does not change.

Because theory suggests individuals with different assets and debt should respond differently to a relaxation of the saving constraint, we divide our sample into four groups depending on people's financial position three years prior to the run-off (when we predict the expected run-off year) and re-estimate our baseline equation for each group. Table 5 presents the results. Panel A. consists in the subsample of individuals with no financial assets (i.e., no stock nor bond holdings) and no bank loan debt; Panel B. consists in individuals that had at least some stocks and bonds or accumulated debt; and Panels B1 through B3 refine the groups of individuals with at least some stocks and bonds or accumulated debt into three further groups (i.e., Panel B1. for individuals with no financial assets but with bank loan debt; Panel B2. for individuals with financial assets (i.e., some stock or some bond holdings) and no bank loan debt; and Panel B3. for individuals with financial assets and bank loan debt).[19]

[INSERT TABLE 5 ABOUT HERE]

The reduction in labor supply found in the average results is driven by individuals who had no assets and no other debt at the moment of the run-off. Our comparison exploiting differences in mortgage payment size suggests that as mortgage payments – and with them, the amount of money freed up by the run-off) increase, the before- versus after-run-off difference in labor income is reduced by 47 percent of that amount (coefficient on $After_{i,t} \times Payment_i$ $\beta_2 = -0.47,$ 95% C.I. -0.74 to -0.19). Because these individuals have neither substantial assets not debts in the years prior to the run-off, they may be "hand to mouth" consumers who consume all disposable income. They are the most likely to be constrained by the savings constraints imposed by the mortgage, or to act as if they are constrained. For this group, we show evidence that a non-trivial share of the money freed up by the run-off goes to increased leisure, as proxied by reduced labor income. The labor supply responses for those with assets or debts prior to the run-off are generally small and statistically

[19] Specifically, individuals are identified as holding stocks and bonds if the value of their end-of-year stocks and bonds holdings combined is higher than 50,000DKK on average six to three years before the predicted final payment. Similarly, they are identified as having bank loan debt if their end-of-year debt is higher than 50,000DKK on average six to three years before the predicted final payment.

indistinguishable from zero, consistent with a view that the consumption (of goods or leisure) is not constrained by their schedule of mortgage payments

The noisiness of bank loan data limits our ability to cleanly identify different effects of the run-off on changes in bank loans for different groups. However, examining individuals with debts but not assets prior to the run-off provides some evidence that this group merely substitutes paying off mortgage debt for paying off other debt one-for-one. Comparing the before- versus after-run-off changes in bank loan balances by mortgage payment size, larger mortgage payments are associated with larger reductions in bank loans after the run-off. While estimates are noisy, we cannot reject the hypothesis that the offset is one-for-one (coefficient on $After_{i,t} \times Payment_i \ \beta_2 = -1.31,$ 95% C.I. -2.81 to 0.20).

To better understand the dynamics of our outcomes of interest, Figure 4 plots run-off-year-specific coefficients from regressions that mirror the ones in Table 3, replacing $After_{i,t}$ dummy variables (and their interaction with mortgage payment) with dummy variables for each run-off year (and their interaction with mortgage payment).[20] Labor incomes are relatively smooth in the years prior to the run-off and the level of labor income does not jump at the run-off year (top Panel of Figure 4). Instead, the slope gets steeper (more negative) after the run-off so that labor incomes drop faster year-to year after the run-off. While this finding is inconsistent with a classic life-cycle model in which leisure could be adjusted costlessly, it could be explained by an increased rate of search for (and therefore switching to) lower-pay or lower-hours work after the run-off.

Changes in bank loans increase sharply in the three years prior to the run-off, as borrowers accumulate debt to finance required mortgage savings, and then this debt accumulation stops abruptly after the run-off (bottom Panel of Figure 4). This pattern can be understood 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.

[20] The regressions used to construct Figures 2 and 3 only include controls for the number of years since run-off (either as dummies or in linear form in columns 1) or their interaction with the annual mortgage payment (in columns 2).

5. Robustness Checks

a. Retirement and pension savings

To further quantify the extensive margin of the labor supply decision, Table A1 presents the coefficients from logit regressions on the probability of retiring and becoming unemployed. Retirement and unemployment are defined as going from unretired to retired and employed to unemployed in a given year, respectively.[21] The results show no statistically different propensity to retire once the mortgage runs off.

Furthermore, because individuals near retirement could also use their pension savings as an adjustment margin, Table A1 also presents OLS regressions on pension outflows and inflows. Our preferred specification exploiting the size of mortgage payments provides no evidence of adjustments through pension savings inflow nor outflows.

b. New mortgages

Individuals could also contract new mortgages (or prepay their current mortgage) as a way to adjust their consumption-savings plan. In such cases, we would not expect to find adjustments along other savings margin if the substitution is from a mortgage that is running off to a new mortgage. To test this hypothesis, we estimate the propensity to take out a new mortgage (defined as an increase in mortgage balance greater than 500,000 DKK in a given year, i.e. the extensive margin) and on the size of any mortgage (i.e. the intensive margin). Table A2 shows that our preferred specification exploiting the size of mortgage payments provides no evidence of adjustments through new mortgage loans.

c. Robustness to compliance schemes

Our main analysis uses the predicted date of mortgage run-off as the event relaxing the savings constraint, which can be interpreted as estimating the causal effect as an intent-to-treat. Because such compliance scheme should not affect the estimated effects we find, in this section we re-estimate our baseline equation (1) using different compliance schemes. We calculate the same models as presented in Table 3 but we impose additional further

[21] Being employed is defined as receiving labor income during the calendar year, alternatively, being unemployed is defined as any form of unemployment (including being on leave for maternity or medical reasons, being a student, being retired or being on poverty cash benefits).

restrictions of decreasing mortgage balances up to (i) two years prior to the predicted run-off year, (ii) one year prior to the predicted run-off year, and (iii) the year of the run-off event. These three alternative definitions of compliance make tighter restrictions of our baseline definition of glide path where we only require individuals to have decreasing mortgage balances in year six through three prior to run-off. Table A3 shows that our results about decreasing labor income and bank loans are robust to the different specifications of compliance.

We also test the robustness of our main findings to the econometric specification used. We re-estimate our main effects on changes in labor income and bank loans using different controls in Table A4. The results of columns (3) and (4) show that it is important to control for linear event-time and its interaction with the size of the mortgage payment to control for potentially different trends across individuals with high and low mortgage payments.

d. Analysis of Couple-Level Balance Sheets

In our main analysis, the unit of observation is an individual. In cases where both spouses within a household have their names on the mortgage contract the value of the mortgage is split across these two individuals in the data. Because there could be interactions in the labor supply decision within households, we re-estimate our main specifications by grouping individuals in three different ways. First, we sum up all studied outcomes at the household-level (whether the mortgage is held by only one of the spouse or both), second we sum up all studied outcomes at the household level only when both spouses are on the mortgage contract, and finally we look at the spouses for which the mortgage contract only appears under their partner's name ("non-run-off spouses").

The results of Table A5 show no effect of the mortgage run-off for non-run-off spouses (Panel C.). This suggests that within a household the spouses make separate financial decisions. Because the non-run-off spouses show no statistically significant effect, including them in the household-level analysis mostly adds noise (Panel A.). Looking at household-level outcomes but excluding non-run-off spouses yields qualitatively and quantitatively similar results as our main analysis (Panel B.).

e. Placebo analysis

Finally, our main analysis excludes individuals for whom the mortgage payment as a fraction of their labor income is lower than 10%. For these individuals, we do not expect the mortgage run-off to relax a quantitatively important saving constraint. If this is the case, such individuals can be used in a placebo analysis where we compare their behavior before and after the mortgage run-off to the behavior of individuals for whom the mortgage payment is substantial (i.e. higher than 10% of their labor income). To this end, we re-estimate our main specification on the entire sample of individuals for whom we identified a mortgage run-off (60,114 individuals, excluding those who receive company income or have large financial wealth changes) and we identify the individuals with payments higher than 10% of their income (which compose our main sample) using a dummy variable called High Pmts. The results, presented in Table A6, show that while individuals with small mortgages reduce their labor income by about 1,870 DKK a year, individuals with high mortgage payments reduce it more, by a total of 4,650 DKK a year. Concerning bank loans, individuals with small mortgage reduce bank loans by about 2,160 DKK a year, a quantitatively small response when compared to the results from our main sample of individuals with high mortgage payments that suggest that 50% of resources previously going to mortgage payments (about 15,000 DKK) go to reducing previously accumulated debt in.

6. Conclusions

This paper documents consumers' responses to a change in saving commitments. Because mortgages commit borrowers to a repayment schedule that pays down their mortgage balance, a mortgage run-off relaxes a saving commitment. This saving commitment does not bind for consumers who choose to save more than is required by the mortgage contract or who borrow elsewhere to undo the saving requirement of the mortgage. Theory predicts that such consumers should not adjust their consumption but should increase savings or decrease debt with mortgage payments once they cease. We find that individuals with pre-run-off debts (but without pre-run-off assets) – for whom the mortgage saving commitment should not bind – perfectly offset the end of the mortgage saving commitment by paying down other debt post-run-off one-for-one. For this subset of borrowers, they work around the saving constraint of the mortgage just as theory would suggest.

Borrowers with neither pre-run-off savings nor other debt are most likely to be constrained by the mortgage saving requirement to save more and spend less than they would like pre-run-off. We find that these borrowers reduce labor supply post-run-off, increasing their consumption of leisure once they are no longer forced to saving by paying down their mortgage balance. The savings constraint imposed by the mortgage binds for these borrowers.

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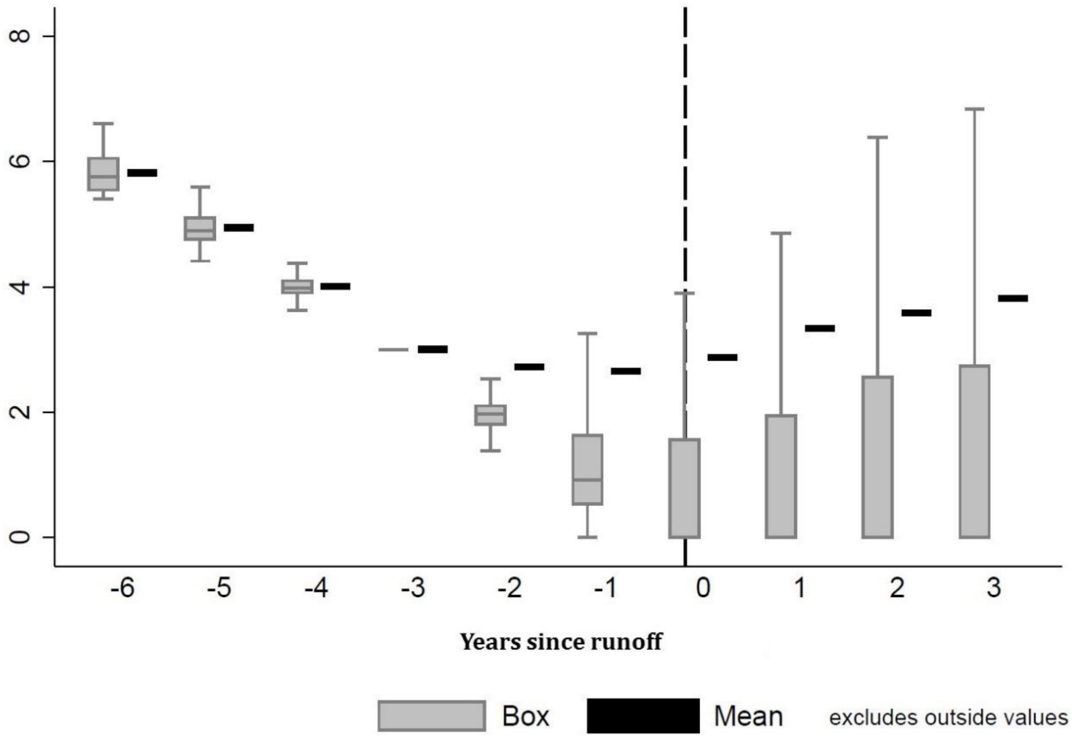
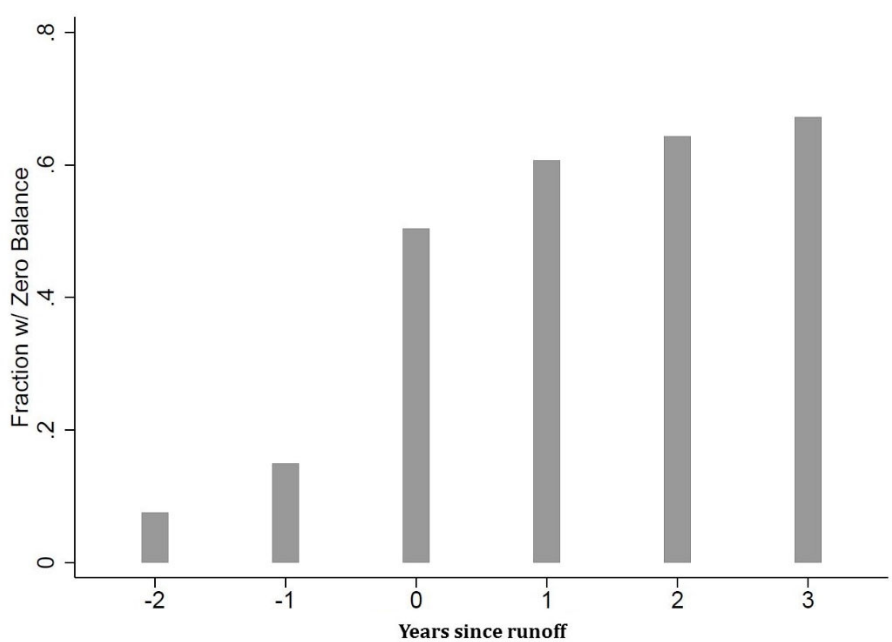
Figure 1. Mortgage Run-offs Identification

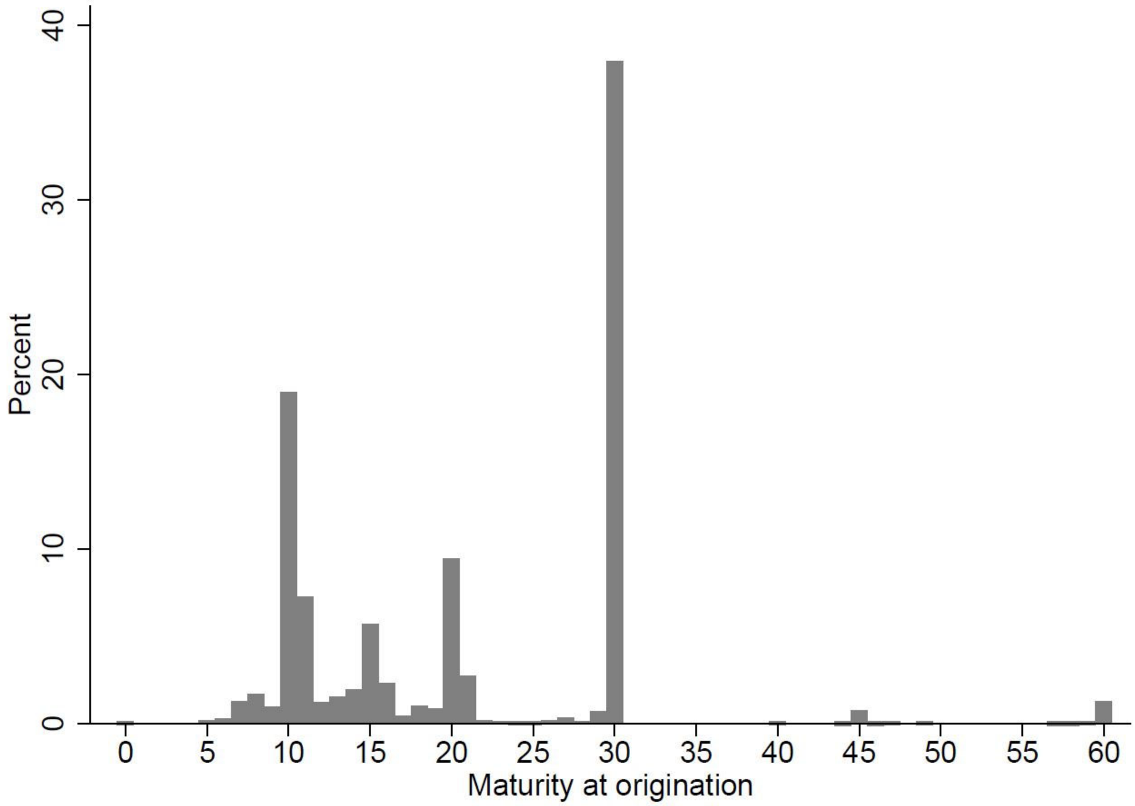


a) Mortgage value as a proportion of its value three years prior to the final payment



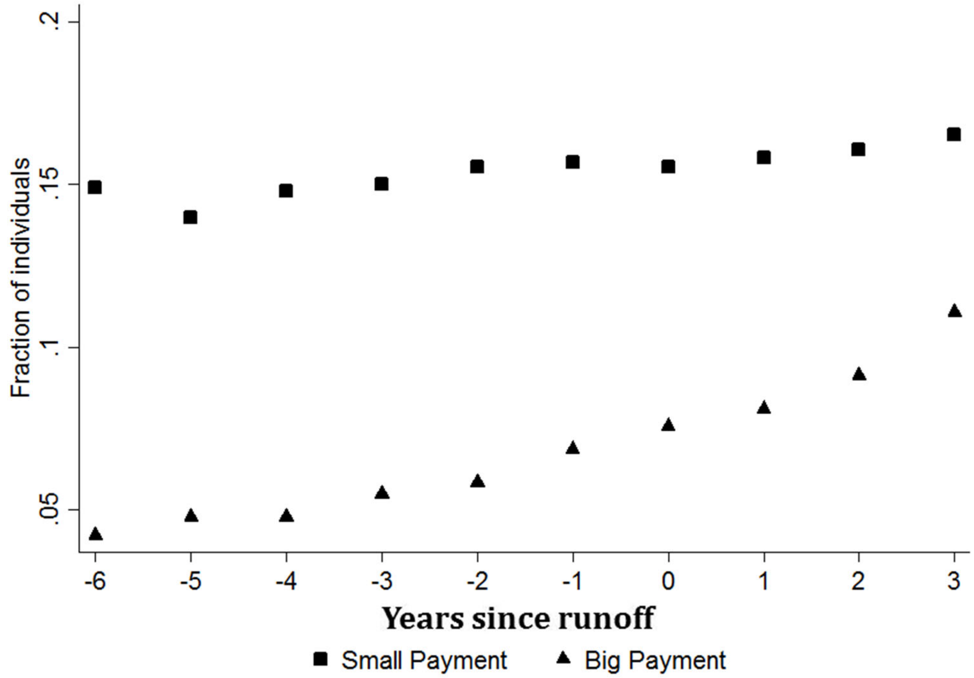
b) Proportion of individuals with a zero mortgage value

Figure 2. Mortgage Maturities at Origination



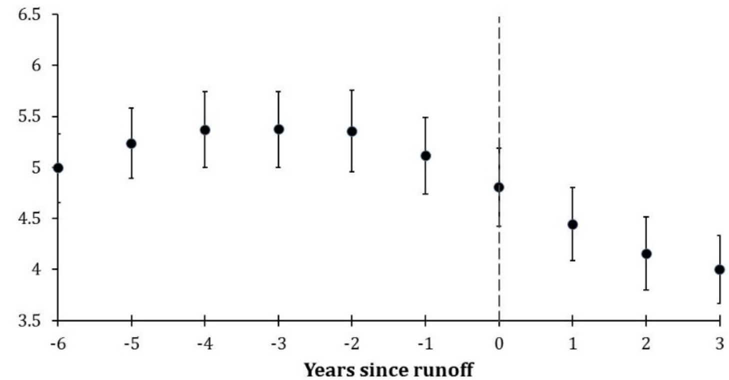
This Figure plots the distribution of mortgage maturities at origination for the subsample of active mortgages in 2009 using data mortgage contract-level data.

Figure 3. Share of Individuals working Part-Time

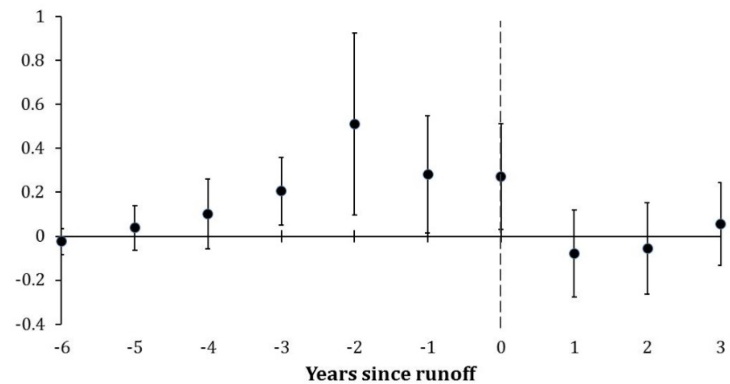


This Figure plots the share of individuals that are part-time workers for individuals with small mortgage payments (i.e. under the average value of 34,000 DKK) and big mortgage payments (i.e. above the average value of 34,000 DKK).

Figure 4. Labor Income and Bank Loans Response



i) Labor Income



ii) ΔBank Loans

This figure plots the results of OLS regressions on labor income and changes in bank loans and presents the results of regressions including years since run-off dummies, the mortgage payment, and their interaction. The black dots present the coefficients of years since run-off dummies multiplied by the mortgage payment plus the baseline coefficient on the mortgage payment (along with 95% confidence intervals).

Table 1: Run-offs Literature Comparison

	Andersen et al. (2017)	d'Astous (2017)	Scholnik (2013)	Stephens (2008)	Coulibaly and Li (2006)
Run-off Type	Mortgage	Term Loans	Mortgage	Car Loans	Mortgage
Data Source	Danish registries	North American bank	Canadian bank	CEX	CEX
Data Type	Administrative data	Administrative data	Administrative data	Survey	Survey
# Run-offs	14,581	291,777	147	Approx. 200	286
Sample Period	1995-2014	Dec/2009 – May/2013	Dec/2004 - June/2006	1984-2000	1988-2001
Identification	Glide path with imperfect and perfect compliance	Glide path with imperfect and perfect compliance	Glide path with perfect compliance	Changes in payments	Glide path with imperfect compliance
Constrained / Unconstrained Subsamples	Yes (Pre-existing debt / assets before run-off)	Yes (Fraction of card balance paid)	Yes (Interest payments on card balances)	Yes (Age, % of liquid wealth, loan maturity)	No
Share of freed up resources that go to each source after the run-off (Average Effects)[i]					
Leisure/Labor	Earnings decline (39%)	-	-	-	-
Consumption	-	Card expenditures (9%), New term loans (18%)[ii]	Card expenditures (17%)[iii]	Nondurables (12%), Other (NS)[iv]	Nondurables (NS), Home furnishing (19%), Entertainment (4%), Vehicles (NS)
Savings/Assets	Stocks (NS), Bonds (NS), Bank deposits (NS)	-	-	-	Savings (32%)
Debt reduction	Non-mortgage loan reduction (31%)	-	-	-	-

i. The table shows the share of freed up resources from each run-off that go to each source after the run-off based on the coefficients provided by these authors. Results are transformed when necessary to make results comparable across studies. We report estimates with at least a 10% significance level. "NS" indicates a non-statistically significant result.
ii. Card expenditure result from column 1 of Table 4. New term loan result calculated by multiplying the increase in the probability of getting a new loan after the run-off (0.0084, from column 2 of Table 3) times the average new loan size ($2,198 from column 1 of Table 2), divided by average pre-run-off payment ($102, from Table 2).
iii. Marginal effect calculated as an average of monthly effects 0 to 6 months post-run-off for a run-off of average size ($751, Table 1), using quadratic estimates (last column of Table 2). For example, the marginal effect for month 0 is 0.671 + 2*(-0.000466)*751. Result included although significance of this average effect is unknown.
iv. The nondurables coefficient (0.281 from model 1 from Table 2 of Stephens) shows the effect of a payment change as a share of income on the percent (literally log) change in non-durables expenditure. To make this result comparable to others, we multiple it by the share of income devoted to non-durables in a CEX sample (0.4165 = $917/($26,420/12), where $917 is the average monthly non-durables consumption from Table 1 in Coulibaly and Li and $26,420 is the average annual income from Table 7 in Coulibaly and Li). "Other" refers to consumption of food, strictly nondurables, and other consumption.

Table 2. Descriptive Statistics

	Mean		Std. Dev.
A. Demographics			
Age	56.9		10.3
Male	61.2	%	-
# Adults in household	1.9		0.6
Married	72.7	%	-
Divorced	7.2	%	-
Retired	41.5	%	-
B. Income and Pensions ('000s DKK)			
Labor Income	222.0	DKK	112.7
Total Pension Outflows	48.7	DKK	70.3
Total Pension Inflows	20.7	DKK	49.1
C. Wealth ('000s DKK)			
Bank Deposits	91.3	DKK	157.2
Stocks	35.1	DKK	152.5
Bonds	51.5	DKK	346.3
Bank Loans	31.7	DKK	85.2
D. Housing ('000s DKK)			
Housing Assets	1,006.8	DKK	683.8
Mortgage Value	134.1	DKK	73.2
Mortgage Payments	33.7	DKK	18.6
Mortgage Payments/Income	22.2	%	1.7

This table provides descriptive statistics for the main variables used in the analysis. The sample used is based on the mortgage run-off as predicted three years before the mortgage is paid off. There are 15,895 run-off events. All variables are recorded at the end of the calendar year and are measured three years prior to the year in which the mortgage is paid off. Labor income and mortgage payments are annual. All monetary amounts are expressed in Danish kroner (DKK). The exchange rate between DKK and U.S. dollar was 14.94% at the beginning of our sample in 1995, averaged 16.27% over the sample and was 17.81% at the end of our sample in 2014.

Table 3. Average Results

	Labor Income	ΔBank Deposits	ΔStocks	ΔBonds	ΔBank Loans
After x $\overline{\text{Payment}}$	-0.14***	-0.17**	-0.03	-0.04	-0.09
	(0.03)	(0.09)	(0.05)	(0.07)	(0.07)
After x Payment_i	-0.39***	-0.12	0.07	-0.15	-0.53**
	(0.14)	(0.34)	(0.12)	(0.18)	(0.24)
R^2	0.061	0.001	0.015	0.002	0.004

This table shows the results of OLS regressions which control for year fixed effects, individual fixed effects, and linear run-off year and its interaction with the size of annual mortgage payment. The sample used is based on the mortgage run-off as predicted three years before the mortgage is paid off. There are 15,895 run-off events. Dependent variables are labor income, measured as total income in thousands of Danish kroner (DKK) received during the calendar year, and bank deposits, stocks, bonds and bank loans, measured as changes in thousands of DKK from their value at the end of the previous calendar year. After is a variable equal to zero in the three years before the mortgage is paid off and one in the three years after the mortgage is paid off. Payment_i is the individual-level average annual mortgage payment in thousands of DKK three to six years before the mortgage is paid off, as reported in Table 2. $\overline{\text{Payment}}$ is the average value in thousands of DKK of the payment in the regression sample. Standard errors clustered at the individual level are presented in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent levels respectively.

Table 4. Retirement and Age Effects

	Retirement?		Age	
	No	Yes	< 55	≥55
After x $\overline{\text{Payment}}$	0.05	-0.27***	0.16	-0.33***
	(0.06)	(0.05)	(0.05)	(0.04)
After x Payment_i	-0.50*	-0.44***	-0.56*	-0.39***
	(0.30)	(0.12)	(0.33)	(0.10)
No. of run-offs	6,590	9,305	6,556	9,339
R^2	0.049	0.299	0.022	0.237

This table shows the results of OLS regressions which control for year fixed effects, individual fixed effects, and linear run-off year and its interaction with the size of annual mortgage payment. The sample used is based on the mortgage run-off as predicted three years before the mortgage is paid off. The dependent variables is labor income, measured as total income in thousands of Danish kroner (DKK) received during the calendar year. After is a variable equal to zero in the three years before the mortgage is paid off and one in the three years after the mortgage is paid off. Payment_i is the individual-level average annual mortgage payment in thousands of DKK three to six years before the mortgage is paid off, as reported in Table 2. $\overline{\text{Payment}}$ is the average value in thousands of DKK of the payment in the regression sample. An individual is identified as having retired if she transitions into retirement during the analysis period (6 years before to 3 years after the predicted final payment). Similarly, an individual is identified as being younger or older than 55 years old based on her age 3 years prior to the predicted final payment. Standard errors clustered at the individual level are presented in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent levels respectively.

Table 5. Wealth Effects

	Labor Income	ΔBank Deposits	ΔStocks	ΔBonds	ΔBank Loans
A. No Stocks+Bonds, No Debt (No. of run-offs = 10,058)					
After x $\overline{\text{Payment}}$	-0.16***	-0.14	-0.06*	-0.07	-0.17**
	(0.04)	(0.10)	(0.03)	(0.07)	(0.09)
After x Payment_i	-0.47***	-0.19	-0.20*	0.15	-0.41
	(0.14)	(0.40)	(0.11)	(0.19)	(0.26)
R^2	0.058	0.002	0.012	0.001	0.002
B. Some Stocks+Bonds or Debt (No. of run-offs = 5,837)					
After x $\overline{\text{Payment}}$	-0.12**	-0.22	-0.01	-0.00	0.02
	(0.05)	(0.15)	(0.12)	(0.13)	(0.12)
After x Payment_i	-0.31	-0.02	0.26	-0.51	-0.76*
	(0.28)	(0.58)	(0.23)	(0.33)	(0.45)
R^2	0.066	0.004	0.004	0.003	0.007
B1. No Stocks+Bonds, Yes Debt (No. of run-offs = 2,467)					
After x $\overline{\text{Payment}}$	-0.13*	-0.12	-0.02	-0.13	0.13
	(0.07)	(0.16)	(0.03)	(0.11)	(0.20)
After x Payment_i	0.02	-0.59*	-0.10	-0.61	-1.31*
	(0.16)	(0.35)	(0.11)	(0.46)	(0.77)
R^2	0.072	0.002	0.016	0.004	0.011
B2. Yes Stocks+Bonds, No Debt (No. of run-offs = 2,996)					
After x $\overline{\text{Payment}}$	-0.06	-0.34	-0.02	0.05	-0.22*
	(0.06)	(0.26)	(0.24)	(0.25)	(0.13)
After x Payment_i	0.10	-0.80	0.76	-0.38	-0.89**
	(0.16)	(0.81)	(0.47)	(0.58)	(0.41)
R^2	0.05	0.003	0.11	0.023	0.004
B3. Yes Stocks+Bonds, Yes Debt (No. of run-offs = 374)					
After x $\overline{\text{Payment}}$	-0.32	0.02	0.04	0.45	0.8
	(0.22)	(0.57)	(0.51)	(0.48)	(0.56)
After x Payment_i	-2.93**	4.89**	-0.10	-0.94	0.79
	(1.47)	(2.28)	(0.83)	(0.67)	(1.61)
R^2	0.152	0.026	0.015	0.007	0.02

This table shows the results of OLS regressions which control for year fixed effects, individual fixed effects, and linear run-off year and its interaction with the size of annual mortgage payment. The sample used is based on the mortgage run-off as predicted three years before the mortgage is paid off. Dependent variables are labor income, measured as total income in thousands of Danish kroner (DKK) received during the calendar year, and bank deposits, stocks, bonds and bank loans, measured as changes in thousands of DKK from their value at the end of the previous calendar year. After is a variable equal to zero in the three years before the mortgage is paid off and one in the three years after the mortgage is paid off. Payment_i is the individual-level average annual mortgage payment in thousands of DKK three to six years before the mortgage is paid off, as reported in Table 2. $\overline{\text{Payment}}$ is the average value in thousands of DKK of the payment in the regression sample. It is equal to 31.84, 38.61, 34.51, and 46.57 for individuals in Panels A., B., C., and D., respectively. An individual is identified as having debt if her end-of-year debt is higher than 50,000 DKK on average six to three years before the predicted final payment. Similarly, an individual is identified as holding stocks and bonds if the value of her end-of-year stocks and bonds combined is higher than 50,000 DKK on average six to three years before the predicted final payment. Standard errors clustered at the individual level are presented in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent levels respectively.

Table A1. Pension, Retirement, and Unemployment

	Pension			
	Outflows	Inflows	Retirement	Unemployment
After x $\overline{\text{Payment}}$	0.028	-0.091	0.28	0.11
	(0.034)	(0.078)	(0.19)	(0.28)
After x Payment_i	0.055***	-0.047**		
	(0.014)	(0.020)		
After x Payment_i /100,000			0.31	-1.44
			(0.46)	(0.95)
R^2	0.18	0.0086	0.014	0.016
No. of Run-offs	15,895	15,895	11,058	10,324

This table shows OLS regressions on pension outflows and inflows, as well marginal effects derived from logit regressions on the probability of retiring and becoming unemployed. All regressions control for year fixed effects, and linear run-off year and its interaction with the size of annual mortgage payment. OLS regressions further include individual fixed effects. Pension outflows and inflows are the sum of employer and private pensions measured in thousands of Danish kroner (DKK) at the end of the year. Retirement and unemployment are defined as going from unretired to retired, and employed to unemployed in a given year, respectively. Being employed is defined as receiving a salary during the calendar year, alternatively, being out of the labor force is defined as any form of unemployment (including being on leave for maternity or medical reasons, being a student, being retired or being on poverty cash benefits). The sample used is based on the mortgage run-off as predicted three years before the mortgage is paid off. After is a variable equal to zero in the three years before the mortgage is paid off and one in the three years after the mortgage is paid off. Payment_i is the individual-level average annual mortgage payment in thousands of DKK three to six years before the mortgage is paid off, as reported in Table 2. $\overline{\text{Payment}}$ is the average value in thousands of DKK of the payment in the regression sample. Standard errors clustered at the individual level are presented in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent levels respectively.

Table A2. New Mortgage

	All	No Stock+Bond, No Debt	No Stock+Bond, Yes Debt	Yes Stock+Bond, No Debt	Yes Stock+Bond, Yes Debt
A. Extensive Margin					
After x $\overline{\text{Payment}}$	-2.40***	-1.85**	-3.11***	-3.38**	-0.91
	(0.53)	(0.79)	(0.93)	(1.40)	(1.87)
After x Payment_i /100,000	-0.61	-0.05	-1.20	-0.03	-0.23
	(0.44)	(0.73)	(0.79)	(1.26)	(1.32)
R^2	0.0445	0.0486	0.0339	0.0539	0.0381
B. Intensive Margin					
After x $\overline{\text{Payment}}$	-17.50**	-1.57	-46.53***	-69.98***	3.39
	(7.71)	(12.20)	(13.47)	(19.19)	(12.41)
After x Payment_i	20.07*	0.95	45.74**	289.84***	8.81
	(12.07)	(8.45)	(20.89)	(18.35)	(15.11)
R^2	0.2087	0.5304	0.6735	0.8141	0.6066
No. of Observations	934	489	262	140	43

This table shows the extensive and intensive margins of new mortgage takeout. We call an annual increase in mortgage balance greater than 500,000 DKK a new mortgage. Panel A. shows the coefficients of logit regressions on a binary variable equal to one if the individual has a new mortgage in a calendar year and zero otherwise. All regressions control for year fixed effects, and linear run-off year and its interaction with the size of annual mortgage payment. OLS regressions further include individual fixed effects. The sample used is based on the mortgage run-off as predicted three years before the mortgage is paid off. After is a variable equal to zero in the three years before the mortgage is paid off and one in the three years after the mortgage is paid off. Payment_i is the individual-level average annual mortgage payment three to six years before the mortgage is paid off (expressed in millions of DKK in Panel B). $\overline{\text{Payment}}$ is the average value of the payment in the regression sample (expressed in millions of DKK in Panel B). An individual is identified as having debt if her end-of-year debt is higher than 50,000 DKK on average six to three years before the predicted final payment. Similarly, an individual is identified as holding stocks and bonds if the value of her end-of-year stocks and bonds combined is higher than 50,000 DKK on average six to three years before the predicted final payment. Standard errors clustered at the individual level are presented in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent levels respectively.

Table A3. Compliance Analysis

	Labor Income	ΔBank Deposits	ΔStocks	ΔBonds	ΔBank Loans
A. Compliance at T0-3 (No. of run-offs = 15,895)					
After x $\overline{\text{Payment}}$	-0.14***	-0.17**	-0.03	-0.04	-0.09
	(0.03)	(0.09)	(0.05)	(0.07)	(0.07)
After x Payment_i	-0.39***	-0.12	0.07	-0.15	-0.53**
	(0.14)	(0.34)	(0.12)	(0.18)	(0.24)
R^2	0.061	0.001	0.015	0.002	0.004
B. Compliance at T0-3 and T0-2 (No. of run-offs = 14,389)					
After x $\overline{\text{Payment}}$	-0.16***	-0.20**	-0.01	0.02	-0.15**
	(0.03)	(0.09)	(0.06)	(0.07)	(0.06)
After x Payment_i	-0.42***	0.01	0.11	0.00	-0.44*
	(0.16)	(0.33)	(0.13)	(0.18)	(0.24)
R^2	0.066	0.001	0.015	0.003	0.004
C. Compliance at T0-3, T0-2, and T0-1 (No. of run-offs = 12,145)					
After x $\overline{\text{Payment}}$	-0.20***	0.08	0.03	0.10	-0.23***
	(0.03)	(0.09)	(0.06)	(0.07)	(0.06)
After x Payment_i	-0.47**	0.22	0.15	-0.02	-0.39*
	(0.18)	(0.32)	(0.14)	(0.19)	(0.21)
R^2	0.07	0.002	0.032	0.004	0.003
D. Compliance at T0-3, T0-2, T0-1, and T0 (No. of run-offs = 6,804)					
After x $\overline{\text{Payment}}$	-0.27***	-0.02	0.03	0.13	-0.38***
	(0.04)	(0.14)	(0.10)	(0.11)	(0.08)
After x Payment_i	-0.39***	0.21	0.48**	-0.30	-0.59**
	(0.11)	(0.33)	(0.23)	(0.31)	(0.27)
R^2	0.081	0.002	0.034	0.005	0.004

This table shows the results of OLS regressions which control for year fixed effects, individual fixed effects, and linear run-off year and its interaction with the size of annual mortgage payment. The samples used vary by definition of compliance with the predicted mortgage run-off. The sample used in Panel A. is based on the mortgage run-off as predicted three years before the mortgage is paid off and the results are identical to the results presented in Table 2. The sample used in Panel B. adds the restriction that the mortgage balance is decreasing two years prior to the year in which the mortgage is paid off. The sample used in Panel C. further adds the restriction that the mortgage balance is decreasing one year prior to the year in which the mortgage is paid off. Finally, the sample used in Panel D. adds the restriction that the value of the mortgage is zero in the year in which it is predicted to be paid off. Dependent variables are labor income, measured as total income in thousands of Danish kroner (DKK) received during the calendar year, and bank deposits, stocks, bonds and bank loans, measured as changes in thousands of DKK from their value at the end of the previous calendar year. After is a variable equal to zero in the three years before the mortgage is paid off and one in the three years after the mortgage is paid off. Payment_i is the individual-level average annual mortgage payment in thousands of DKK three to six years before the mortgage is paid off, as reported in Table 2. $\overline{\text{Payment}}$ is the average value in thousands of DKK of the payment in the regression sample. Standard errors clustered at the individual level are presented in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent levels respectively.

Table A4. Robustness of Specifications

	(1)	(2)	(3)	(4)
A. Labor Income				
After x $\overline{\text{Payment}}$	-0.14***	-0.14***	-0.14***	-0.14***
	(0.03)	(0.03)	(0.03)	(0.03)
After x Payment_i	-0.39***	-0.38***	-0.38***	-0.98***
	(0.14)	(0.14)	(0.14)	(0.10)
R^2	0.0613	0.0583	0.2698	0.0602
B. ΔBank Loans				
After x $\overline{\text{Payment}}$	-0.09	-0.08	-0.08	-0.09
	(0.07)	(0.07)	(0.07)	(0.07)
After x Payment_i	-0.53**	-0.57**	-0.57**	-0.26**
	(0.24)	(0.25)	(0.25)	(0.10)
R^2	0.0036	0.0009	0.0014	0.0035
Year F.E.	YES	NO	NO	YES
Person F.E.	YES	YES	NO	YES
Event-Time	YES	YES	YES	NO
Event-Time x Payment	YES	YES	YES	NO

This table shows the results of OLS regressions which control for year fixed effects, individual fixed effects, and linear run-off year and its interaction with the size of annual mortgage payment. Specification (1) reproduces the baseline results of Table 2. The sample used is based on the mortgage run-off as predicted three years before the mortgage is paid off. Dependent variables are labor income, measured as total income in thousands of DKK received during the calendar year, and bank deposits, stocks, bonds and bank loans, measured as changes in thousands of DKK with respect to their value at the end of the previous calendar year. After is a variable equal to zero in the three years before the mortgage is paid off and one in the three years after the mortgage is paid off. Payment_i is the individual-level average annual mortgage payment in thousands of DKK three to six years before the mortgage is paid off, as reported in Table 2. $\overline{\text{Payment}}$ is the average value in thousands of DKK of the payment in the regression sample. Standard errors clustered at the individual level are presented in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent levels respectively.

Table A5. Household-level analysis

	Labor Income	ΔBank Deposits	ΔStocks	ΔBonds	ΔBank Loans
A. Household-Level (Including Non-Run-off Spouses) (No. of run-offs = 12,101)					
After x $\overline{\text{Payment}}$	-0.13**	-0.25*	-0.03	-0.07	-0.24*
	(0.06)	(0.13)	(0.08)	(0.09)	(0.12)
After x Payment_i	-0.35	0.14	-0.09	-0.45	-0.29
	(0.24)	(0.43)	(0.21)	(0.28)	(0.39)
R^2	0.067	0.002	0.04	0.005	0.002
B. Household-Level (Excluding Non-Run-off Spouses) (No. of run-offs = 12,973)					
After x $\overline{\text{Payment}}$	-0.16***	-0.21**	-0.04	-0.03	-0.09
	(0.03)	(0.09)	(0.06)	(0.07)	(0.07)
After x Payment_i	-0.43***	-0.03	-0.01	-0.11	-0.43**
	(0.17)	(0.33)	(0.15)	(0.19)	(0.22)
R^2	0.074	0.001	0.033	0.004	0.004
C. Non-Run-off Spouses (No. of run-offs = 7,396)					
After x $\overline{\text{Payment}}$	0.03	-0.12	-0.04	-0.13	-0.13
	(0.08)	(0.14)	(0.07)	(0.08)	(0.15)
After x Payment_i	0.08	0.00	-0.20	-0.58*	0.08
	(0.26)	(0.59)	(0.25)	(0.31)	(0.56)
R^2	0.027	0.001	0.017	0.002	0.001

This table shows the results of OLS regressions which control for year fixed effects, individual fixed effects, and linear run-off year and its interaction with the size of annual mortgage payment. The samples used vary by definition of households. The sample used in Panel A. sums all outcomes at the level of the household, even when one of the spouse does not have a run-off recorded in the data. The sample used in Panel B. sums all outcomes at the level of the household, but omits spouses for which no run-off is recorded in the data. The sample used in Panel C. only keeps the spouses that do not have a run-off within a run-off-household. Dependent variables are labor income, measured as total income in thousands of DKK received during the calendar year, and bank deposits, stocks, bonds and bank loans, measured as changes in thousands of DKK with respect to their value at the end of the previous calendar year. After is a variable equal to zero in the three years before the mortgage is paid off and one in the three years after the mortgage is paid off. Payment_i is the individual-level average annual mortgage payment in thousands of DKK three to six years before the mortgage is paid off, as reported in Table 2. $\overline{\text{Payment}}$ is the average value in thousands of DKK of the payment in the regression sample. Standard errors clustered at the individual level are presented in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent levels respectively.

Table A6. Placebo (Small mortgage payments)

	Labor Income	ΔBank Deposits	ΔStocks	ΔBonds	ΔBank Loans
All Sample (No. of run-offs = 60,114)					
After	-1.87**	0.78	0.83	-0.08	-2.16**
	(0.77)	(1.54)	(0.89)	(1.13)	(0.99)
After x High Pmts	-2.78**	-6.72**	-2.91	-1.45	-0.96
	(1.21)	(3.25)	(2.00)	(2.47)	(2.50)
R^2	0.048	0.001	0.031	0.005	0.002

This table shows the results of OLS regressions which control for year fixed effects, individual fixed effects, and linear run-off year and its interaction with the size of annual mortgage payment as well as with a binary variable indicating whether the individual's mortgage payment is higher than 10% of her labor income. The sample used is based on the mortgage run-off as predicted three years before the mortgage is paid off, without imposing the restriction that the mortgage payment be higher than 10% of the individual's labor income. Dependent variables are labor income, measured as total income in thousands of DKK received during the calendar year, and bank deposits, stocks, bonds and bank loans, measured as changes in thousands of DKK with respect to their value at the end of the previous calendar year. After is a variable equal to zero in the three years before the mortgage is paid off and one in the three years after the mortgage is paid off. High Pmts is a variable equal to one if the mortgage payments are higher than 10% of labor income, and zero otherwise. Standard errors clustered at the individual level are presented in parentheses. ***, **, * represent statistical significance at the 1, 5, and 10 percent levels respectively.

Appendix A: Detailed Theoretical Model

A.1. Model Setup

Consider a simple model with no uncertainty in which homeowners choose non-housing consumption and labor in each of three periods. In the first period (*t=1*), consumers also choose a home and a mortgage. Consumers pay off that mortgage at the end of the second period (*t=2*), and may additionally borrow or save outside the mortgage in this period prior to the runoff; this corresponds to the pre-run-off period in our statistical analysis. In the final period (*t=3*), consumers pay off any outstanding non-mortgage debt or consume the proceeds from previous saving; this corresponds to the post-run-off periods in our statistical analysis.

In period 1, consumers buy a house of value H. They can finance a fraction $0 \leq \phi \leq 1$ of the house through a mortgage loan at rate r^b, with $\phi H(1 + r^b)$ to be repaid in the second period. In the first two periods consumers can save at a rate r^l, where $r^l < r^b$, while in the final period all resources are consumed. If income in the second periods does not meet consumption needs, the consumers can also choose to borrow at a rate r^c, where $r^b < r^c$.[22]

In all periods consumers choose how much to consume (C_t) and how much to work (L_t). They derive utility from consumption and leisure (Z_t), and both are assumed to be normal goods. We normalize the maximum possible labor supply to 1, such that $L_t + Z_t = 1$. In each period, felicity $u(C_t, Z_t)$ is a function of consumption and leisure.[23] Consumers maximize the sum of utility from housing $V(H)$ and utility in each period, $u(C_t, Z_t)$, discounted at a rate β. Wages are set to w_t in period t; individuals earn $y_t = L_t w_t$ in period t. Stephens (2008) assumes no labor supply decision, which corresponds to setting $L_t = 1$ in our model.

[22] We assume that total borrowing can never exceed the value of the house, so consumers cannot borrow outside the mortgage in period 1 when $\phi = 1$. In periods 1 and 2, consumers will either save, borrow, or neither; they will never choose to both borrow and save simultaneously since $r^l < r^b$ (relevant for period 1) and $r^l < r^c$ (relevant for period 2). Stephens (2008) assumes that consumers cannot borrow in the second period, which gives the same result as setting $r^c = \infty$ in our model.

[23] We make standard concavity assumptions, namely $u_C > 0, u_{CC} < 0$, and $u_L < 0, u_{LL} > 0$. We make no assumptions about u_{CL}, which governs separability between consumption and leisure, other than requiring that they are both normal goods. We follow Stephens (2008) in assuming separability in the utility derived from the durable asset (housing in our case).

A.2. Consumer's Optimization Problem

Consumers maximize lifetime utility, *U*, by choosing consumption (C_t) and leisure (Z_t) in each period *t*, as well as house value (H), and the share of that value financed by a mortgage (ϕ) in the first period. They solve the following problem:

$$\max_{\{C_1,C_2,C_3,L_1,L_2,L_3,H,\varphi\}} U = u(C_1,Z_1) + \beta u(C_2,Z_2) + \beta^2 u(C_3,Z_3) + V(H),$$

subject to the constraint that total borrowing cannot exceed H in any period, and that all borrowing must be repaid in period 3. Consumers face the following laws of motion for borrowing and saving. In period 1, consumers' net borrowing (B_1) is defined as;

$$B_1 = C_1 + H - L_1 w_1 \leq H.$$

Any borrowing in the first period will be mortgage borrowing ($\phi = B_1/H$ for $B_1 > 0$), as non-mortgage borrowing is assumed to have a higher interest rate than mortgage borrowing ($r^b < r^c$); saving in the first period ($B_1 < 0$) is permitted by the model, but these cases are of less interest to us because they do not involve mortgages. In period 2, net borrowing (B_2) is defined as;

$$B_2 = C_2 - L_2 w_2 + (B_1(1+r^l)|B_1 < 0) + (B_1(1+r^b)|B_1 > 0).$$

B_2 depends on consumption (C_2), labor income ($L_2 w_2$), as well as proceeds from saving ($B_1(1+r^l)|B_1 < 0$) or mortgage repayment ($B_1(1+r^b)|B_1 > 0$) from the first period. B_2 may be positive (B_2>0, the level of non-mortgage debt), negative ($-B_2 > 0$, the level invested wealth), or zero. In period 3, individuals consume remaining resources,

$$C_3 = L_3 w_3 - (B_2(1+r^l)|\, B_2 < 0) - (B_2(1+r^c)|B_2 > 0).$$

A.3. Labor-Leisure vs. Consumption Decision

We assume an interior solution for leisure, so $0 < Z_t^* < 1$. Consumers always have the option to work slightly more and to consume the resulting income in the same period; at an optimum, such marginal adjustments do not increase or decrease utility. This implies the following first order condition for each period t,

$$u_{Z_t}(C_t^*, Z_t^*) = w_t u_{C_t}(C_t^*, Z_t^*).$$

A.4. Saving-Borrowing vs. Consumption Decision

At an optimum, in periods 1 and 2 consumers may choose to borrow, save, or neither. This yields nine possible types of equilibria, (3 options in the first period multiplied by 3 options in the second period). Since this paper explores mortgage run-offs, we only consider cases where mortgage borrowing is positive in the first period; there would be no mortgage run-offs to consider absent mortgage borrowing. As a result, we consider the three cases in which borrowers take out a mortgage in the first period; either borrowing, saving or neither in the second period. We consider each of the three possible equilibria in turn.

A.5. Interior Solutions for "Unconstrained" Savers and Borrowers

Consumers who choose to save or borrow in period 2 ($B_2^* < 0$ or $B_2^* > 0$, respectively) could have chosen an alternative option to consume slightly more in period 2, save less or borrow more in period 2, respectively, and consume less in period 3. Similarly, they have the option to consume slightly less in period 2, save more or borrow less in period 2, respectively, and consume more in period 3. At an optimum, such marginal adjustments do not increase or decrease utility. This implies the following first order conditions for individuals saving or borrowing in period 2, respectively:

$$\beta u_{CC_3}(C_3^*, Z_3^*)(1 + r^l) = u_{C_2}(C_2^*, Z_2^*)$$

$$\beta u_{C_3}(C_3^*, Z_3^*)(1 + r^c) = u_{C_2}(C_2, Z_2)$$

For these consumers, the standard Euler Equation holds; the marginal utility of consumption is the same in the second and third periods. As a result, the size of the loan payment does not affect consumption, as larger loan payments are offset one-for-one by lower savings or greater borrowing elsewhere. Going into the run-off, unconstrained borrowers either draw down their non-mortgage savings or accrue non-mortgage debt to make the mortgage principal payments. When this stops after the run-off, net non-mortgage savings increase. We think about these consumers as being unconstrained because the first order conditions hold with equality; they have to ability to either save or borrow, respectively.

A.6. Corner Solutions for "Constrained" Consumers Who Neither Save Nor Borrow

Consumer who choose neither to save nor to borrow in the second period ($B_2^* = 0$) declined the option to save or borrow; marginal adjustments to saving must make the consumer at least weakly worse off. This implies the following first order conditions for those who choose to neither save nor borrow:

$$\beta(1 + r^l)u_{C_3}(C_3^*, Z_3^*) \leq u_{C_2}(C_2^*, Z_2^*) \leq \beta(1 + r^c)u_{C_3}(C_3^*, Z_3^*).$$

Note that at least one of the two weak inequalities must be a strict inequality because $r^l < r^c$. We think about these consumers as being constrained in the sense that one or both of the first order conditions do not hold with equality. For constrained consumers, the marginal utility of consumption in period three is smaller than in period two, when the loan has to be repaid.