Consumption responses to rising mortgage rates: unpacking the cash-flow channel of monetary policy*

Asger Lau Andersen (University of Copenhagen, CEBI)
Andreas Jakobsen (Danske Bank)
Mads Rahbek Jørgensen (University of Copenhagen, CEBI)
Niels Johannesen (Oxford University, CEPR)

September 12, 2025

PRELIMINARY VERSION
(please do not cite or circulate)

Abstract

How do households with adjustable-rate mortgage loans respond to rising interest rates, and are the responses guided by current mortgage payments or by expectations about future mortgage payments? This paper uses granular customer data from the largest bank in Denmark to address these questions in the context of the dramatic rise in interest rates in 2022-2023. First, to identify the effect of current payments, we compare two highly similar groups of households who - due to decisions made 5-10 years earlier - differ slightly in the timing of interest rate reset on their adjustable-rate mortgage loans. We find that the two groups remain on parallel spending trajectories even after one of them experiences a sharp increase in interest payments, while the other does not. Our estimates suggest that each additional dollar of current mortgage payments reduces spending by 1 cent, with an upper bound of the confidence interval of 5 cents, whereas liquid buffers decrease by almost a dollar. Second, to identify the effect of expectations about future payments, we compare a group of households with adjustable-rate mortgage loans to a control group with fixed-rate loans. We focus on their spending behavior in the pre-reset period where market expectations about future rates are increasing, but current mortgage payments are unchanged. During this period, the former group reduces spending differentially compared to the control group, indicating a modest but economically meaningful negative effect of larger expected future payments. Overall, the evidence is consistent with forward-looking households who adjust spending moderately in anticipation of future increases in their mortgage payments and rely heavily on liquid buffers to smooth spending.

*Asger Lau Andersen: asger.lau.andersen@econ.ku.dk. Andreas Jakobsen: ajak@danskebank.dk. Mads Rahbek Jørgensen: mads.jorgensen@econ.ku.dk. Niels Johannesen: niels.johannesen@sbs.ox.ac.uk. The activities of CEBI are financed by the Danish National Research Foundation, Grant DNRF134. Declarations of interest: none

1 Introduction

A key channel of monetary policy transmission is the pass-through of policy rates to the interest rates facing homeowners on their mortgage loans. In many countries, the majority of mortgage loans have adjustable rates that are reset at regular intervals, for instance every year or every five years. This means that monetary policy shocks have an immediate impact on expected future mortgage payments and a lagged impact on actual current mortgage payments. The strength and the timing of monetary policy transmission to aggregate consumption through the cash-flow channel therefore depends crucially on household responses to expected as well as current mortgage payments.

Standard theory of household consumption and savings provides some guidance on these questions. On the one hand, it predicts that households with sufficient liquidity should adjust spending in response to shocks that change expectations about future mortgage payments and smooth spending through fully expected changes in current mortgage payments. On the other hand, it posits that households whose spending is constrained by a low level of liquidity may respond strongly to changes in current mortgage payments and perhaps not at all to changes in expectations about the future. The broader empirical household finance literature documents a range of settings where households exhibit a high sensitivity to current cash-flows, even when they are fully anticipated (e.g. Kueng, 2018).

In this paper, we study household responses to the strong surge in interest rates in the first half of 2022 and the pass-through to mortgage rates in the following years. Our laboratory is Denmark where the interest rate on adjustable-rate mortgage loans with 5-year interest fixation periods soared sharply from around 0% to around 3% in just five months between February and June 2022. This drastic increase implied that mortgage payments on such loans more than doubled in April 2023 and April 2024 when rates were reset for large groups of households. We use transaction data, highly granular loan data and other customer data from Danske Bank, the largest retail bank in Denmark, which allows us to track mortgage payments, household spending, and savings in deposits and securities for a large number of customers at the monthly frequency.

This setting allows us to unpack the cash-flow effect of monetary policy by estimating, with two separate quasi-experimental designs, the response to changes in current mortgage payments (holding constant expectations) and the response to changes in expected future mortgage payments (holding constant current cash-flows). Both designs aim to shut down other channels of monetary policy such as wealth effects and labor market effects. Importantly, we do not have

information about subjective expectations, so the latter set of estimates capture responses to market expectations.

The first quasi-experiment identifies the effect of *current mortgage payments* on household spending, saving and investment decisions. It compares two groups of households who are essentially identical in terms of ex ante spending, income and balance sheet structure. Both groups had adjustable-rate mortgage loans with a 5-year interest fixation period when they entered the period with surging market interest rates; however, past timing differences in home purchase and financing decisions creates variation in the exact time at which mortgage rates were reset to a higher level. Specifically, through a four-year window from April 2020 to March 2024, we compare a treatment group whose mortgage rate reset during the window, in April 2023, and a control group whose mortgage rate reset after the window, in April 2024. The key identifying assumption is that the two groups are exposed similarly to other channels of monetary policy, including the effect on medium-term and long-term mortgage costs. Under this assumption, the effect of current mortgage payments is identified as the differential behavioral change of the treatment group at the reset in April 2023.

The results suggest that anticipated changes in current mortgage payments, holding constant expectations about future mortgage rates, had little or no effect on the spending of the households in our sample. For every dollar that the treatment group's monthly mortgage payments increased at reset, they reduced monthly spending by only 1 cent relative to the control group, a very low and statistically insignificant marginal propensity to consume of around 0.01 (confidence interval: [-0.03, 0.05]).[1] To sustain spending through the substantial increase in mortgage payments, households reduced portfolio investment (6 cents lower monthly flows per dollar of additional mortgage payments) and drew down balances on deposit and current accounts (85 cents decrease per dollar of additional mortgage payments). We also find a small positive effect on after-tax employment income, which at least partly reflects the increase in tax deductible interest payments.

The second quasi-experiment identifies the effect of *expected future mortgage payments*. It compares two groups of households who are similar in terms of observable characteristics but differ in their exposure to the looming pass-through of higher market interest rates to mortgage rates because of past mortgage financing choices. Specifically, through the four-year window from April 2020 to March 2024, we compare a treatment group whose 5-year adjustable-rate mortgage loans were due to reset immediately after the window, in April 2024, and a control

[1]To be precise, the spending change is measured relative to the exogenous increase in monthly mortgage payments that would have occurred absent any active refinancing choices around reset.

group whose fixed-rate mortgage loans, originating in the same period as the adjustable-rate loans of the treatment group, were not affected. For both groups, current mortgage payments are fixed throughout the window; however, the treatment group is exposed to a shock to expected future mortgage payments during the window, while the control group is not.

The results suggest that the shock to expected future mortgage payments, absent any changes in current mortgage rates, had a significant negative effect on the spending of the households in our sample. For every dollar that the treatment group's monthly mortgage payments were to increase in April 2024, they reduced monthly spending by around 16 cents in the period *before* April 2024. Through this and other channels, they significantly increased saving in liquid accounts, raising monthly portfolio investment and saving in deposit accounts by 20 cents and 48 cents per dollar expected increase in future monthly mortgage payments, respectively.

Overall, these results on household responses to the surging interest rates in 2022 align well with standard theory for unconstrained households. First, the households in our sample lower spending significantly and increase their buffer of liquid assets when a shock to market interest rates raises expectations about future mortgage payment. Second, they make no further spending adjustments, but instead draw on liquid buffers, when the higher market rates pass through to current mortgage payments.

These findings have important practical implications for monetary policy. Most importantly, they suggest that household consumption adjusts quickly to a new interest rate environment, even if the pass-through to existing loan payments takes longer to materialize. Specifically, our analysis reveals that mortgage borrowers are forward-looking and adjust their spending before loan payments actually change. Rather than waiting for payment adjustments to occur, they respond to rising expectations of future interest rates, modifying their consumption in anticipation of higher costs.

Our paper contributes to a limited but growing literature that uses granular microdata to study the propagation of monetary policy through the cash-flow channel. Closely related to our analysis of current mortgage payments, Di Maggio et al. (2017) study spending and leverage responses to mortgage rate reset in an environment where interest rates are falling, so that reset implies an increase in disposable income. Contrary to our finding that spending barely responds to current mortgage payments, they find significant increases in car purchases at the time of reset. The apparent conflict between our finding and theirs is consistent with recent evidence from the context of tax refunds that anticipated cash-flows may have asymmetric effects on spending, with households increasing spending immediately in response to positive cash-flows

while smoothing the spending adjustment to negative cash-flows (Baugh et al, 2021).

There are other notable contributions to this literature: Galaasen et al. (2024) use transaction data from Norway to estimate the cash-flow effect of monetary policy, exploiting cross-sectional variation in the size of household debt size for identification. Unlike in our case, the iinstitutional context of their analysis is a setting where policy rates pass through almost immediately to mortgage rates. Floden et al. (2021) use an imputed measure of consumption to measure cash-flow effects while comparing households with and without debt for identification. Finally, Druedahl et al. (2022) use a transaction-based measure of spending to document that while constrained households respond to decreases in current mortgage payments at reset, unconstrained households respond a few months earlier when the mortage bank informs them about mortgage payments after reset.

Compared to this set of papers, our paper stands out by identifying the consumption effects of expectations about future mortgage payments, in addition to but separately from the effects of changes in current payments. This is important from a theory perspective, but, as explained above, it also has important implications for policy makers in countries where the pass-through from monetary policy to actual mortgage rates is delayed by the existence of loans with interest rates that are fixed for at least some short period.

Another difference compared to existing papers is that we study spending responses to rising rather than falling mortgage rates. This reflects that policy rates were mostly decreasing or flat for the decades preceding the sharp increase in 2022. This feature of our study is crucial given recent evidence documenting in a different context that cash-flow effects need not be symmetric. Moreover, our measures of spending, deposits, investment and employment income are close to comprehensive. This enables us to, first, directly estimate the marginal propensity to consume and, second, recover the full array of household responses to rising interest rates with estimates that, at least approximately, respect the adding-up properties coming from the intertemporal budget constraint.

We also contribute to the broader empirical household finance literature studying how spending and savings decisions are shaped by changes in the economic environment. A central question concerns the effect of anticipated cash-flows, positive or negative, on household consumption. The findings are mixed with some papers documenting a high sensitivity to cash-flows (Parker, 1999; Souleles, 1999; Kueng, 2018) and others finding no such sensitivity (Browning and Collado, 2002; Hsieh, 2003). Our small and precise estimate of the marginal propensity to consume out of current mortgage payments places our paper in the latter camp. Our finding is consis-

tent with arguments that households are more likely to smooth large cash-flows (Browning and Collado, 2002) and negative cash-flows (Baugh et al, 2021).

The paper proceeds in the following way. Section 2 lays out the institutional setting. Section 3 describes the data sources and the variables and provides summary statistics. Section 4 explains how we study the effect of current mortgage payments and reports the results. Section 5 explains how we study the effect of expected future mortgage payments and reports the results. Section 6 concludes.

2 Background: The Danish mortgage market and the 2022 increase in interest rates

Households in Denmark typically finance home purchases through long-term mortgages with a duration of up to 30 years. Danish banks fund these loans by issuing covered bonds backed by the pool of loans. The banks act as intermediaries between borrowers and bond investors and carry the credit risk in case of borrower default. However, mortgages are full recourse, the legal process in case of foreclosure is fast and low-cost, and default rates are very low. Households can borrow up to 80% of the property value with bond-financed mortgage loans. They can top up beyond the 80% mark with other types of collateralized loans, but these are typically more expensive, as mortgage lenders have a senior claim on the collateral in the event of borrower default.

As in the U.S., the traditional Danish mortgage loan was for many years a 30-year fixed-rate mortgage (FRM) with no prepayment penalty. However, adjustable-rate mortgages (ARM) were introduced in the 1990s and have since grown considerably in popularity. These loans also have terms up to 30 years, but the interest rate is adjusted at regular, predefined intervals, typically of 1, 3 or 5 years. Both FRM and ARM loans come with an option of interest-only payments for a limited period, in most cases up to 10 years.

Table 1 shows aggregate statistics for households with a mortgage in Denmark at the end of 2021. Of the 1.1 million households with a mortgage, roughly half had an ARM, and one quarter had an ARM with a five-year interval between rate adjustments (ARM5). The latter group held 30% of total household debt in 2021 (mortgage debt as well as other types) and about 20% of total household interest payments, reflecting that interest rates at the time were generally lower on ARM5 loans than on FRM loans.

For both FRM and ARM loans, the interest rate paid by the borrower is determined directly by the yield on the bonds issued to finance them. Interest rates are therefore determined solely

by market conditions and the choice of loan type and do not depend on individual borrower characteristics.[2] For FRM loans, the interest rate is determined at origination and stays constant during the term of the loan. FRM borrowers have the option to prepay at either face or market value, however, and can thus refinance to a lower rate if market rates fall.

For ARM borrowers, the interest rate adjustments during the loan's term are determined by bond market conditions at the time of the adjustment. About 2 months prior to the adjustment date, banks issue new bonds to refinance the loans, and the new interest rate is then calculated as the yield on the new bonds. ARM borrowers must decide whether to keep or refinance their loans about 3 months before the adjustment. At that time, the bank will typically send a letter to the borrower informing them about the upcoming adjustment, the bank's expectations for the new interest rate, and their options for refinancing.

Figure 1 shows the evolution in interest rates on new ARM5 loans issued by Realkredit Danmark, the mortgage credit branch of Danske Bank. Interest rates on ARM5 loans were very low in 2021 but then rose sharply during 2022, as central banks raised policy rates to combat mounting inflationary pressures following the Covid-19 pandemic and the onset of the war in Ukraine. By the end of 2022, they had increased by more than 3 percentage points.

Figure 1 also shows Danske Bank's forecast, made 12 months earlier, for the ARM5 interest rate in each month. The forecast series illustrates two important points: First, the one-year-ahead forecasts for 2022 are only slightly increasing and far below actual realized rates, demonstrating that the steep increase came as a surprise even to professional analysts. Second, the forecasts closely track current rates with a one-year lag, indicating that at any point during this period, forecasters expected the interest rate 12 months in the future to remain close to its current level. For example - and particularly important for our purposes - the bank's expectation in early 2023 was that interest rates would remain at roughly the same elevated level over the next year—an expectation that ultimately proved accurate.

3 Data

Data sources. We employ customer data from Danske Bank, the largest retail bank in Denmark. The data includes loan-level data on mortgage and other loans with detailed information about loan characteristics and payments of interest and fees. It also includes transaction-level data about consumer expenditure made with cards, bills and about cash withdrawals.

[2]Banks redirect interest and principal payments from borrowers to bond holders. On top of these, they also charge an administrative fee from borrowers to cover their own costs. The fee is proportional to loan balances and may depend on the loan-to-value ratio, but is otherwise independent of borrower characteristics.

Analysis period. Our analysis covers the 36-month period between April 2021 and March 2024. This period covers two key events: the beginning of the rise in market interest rates in Spring 2022 and the reset of rates of 5-year ARMs in April 2023. It excludes most of the Covid-19 pandemic, which had a profound impact on spending patterns (Andersen et al, 2022).

Sample. We conduct the analysis at the household level and use loan information to delineate three samples. First, a sample whose 5-year adjustable mortgage rate was reset in April 2023. Second, a sample whose 5-year adjustable mortgage rate was reset in April 2024. Third, a sample with fixed-rate mortgage loans. The first and second samples consist of households whose 5-year ARM loans originated 5 or 10 years before the reset in April 2023 and April 2024, respectively.[3] We restrict the third sample to households whose FRM loans originated in the same period as the second sample.

We impose two additional sample restrictions to address the concern that spending measures based on transaction data from a single bank are incomplete when households spend through multiple banks (Baker, 2018). We aim to exclude households who mainly use other banks than Danske Bank by requiring that households have at least five spending transactions through Danske Bank per month throughout the analysis period and that the unique bank account designated for transactions with the public sector is held at Danske Bank. Finally, we exclude business customers because their personal balance sheets are difficult to disentangle from those of their businesses.

After applying these sample restrictions, we are left with 6,874 households in the ARM sample with reset in 2023 (first sample), 6,891 households in the ARM sample with reset in 2024 (second sample), and 6,154 households in the FRM sample (third sample).

Exogenous effect of reset. Some households change their mortgage loan type at the time of the interest rate reset. They may opt for a loan with a fixed rate or a 1-year adjustable rate or they may choose to make their loan interest-only. Conceptually, we consider changes in the loan type as endogenous responses to the reset. We think of the *exogeneous* effect of reset as the change in mortgage payments a household would experience absent any active change of loan type, i.e. if it would continue with its existing ARM5 loan after the reset. To measure this, we project the contractual payments on the loans that the household holds as of December 2021

[3]The first sample thus consists of households who financed their home with a 5-year ARM in the period March 2013 - February 2014 or in the period March 2018 - February 2019. The second sample consists of households who financed their home with a 5-year ARM in the period March 2014 - February 2015 or in the period March 2019 - February 2020.

and compute the exogenous effect as the change in projected payments at the time of reset. For households who do not alter their loans between December 2021 and the time of reset, this coincides with the actual change in mortgage payments at reset. We present results validating our projection method in Online Appendix A.

Outcomes. We use the customer data from Danske Bank to construct a number of household-level outcomes. First, we measure monthly *mortgage payments* with information from the loan dataset. The measure includes mortgage interest payments as well as fees related to the mortgage loan. Second, we measure monthly consumer *spending* by summing payments made with cards and bills as well as cash withdrawals while excluding transaction categories such as tax payments and debt service that we do not consider spending. Our approach follows existing papers that construct spending measures from bank transaction data (e.g., Ganong et al., 2019; Andersen et al., 2023, 2024) Third, we measure *net saving in deposits* as the change in balances on all current accounts and deposit accounts from the beginning to the end of the month. Fourth, we measure *net investment in securities* as net flows into securities investment accounts from current and deposits accounts. Our measure includes flows to and from investment accounts at Danske Bank as well as at the two main online investment platforms in Denmark. Fifth, we measure income by summing over incoming flows categorized as income by the banks' classifier.

Summary statistics. Table 1 shows summary statistics for each of the three samples: households with an ARM5 loan with reset in April 2023 (Column 1) and April 2024 (Column 2) originating 5 or 10 years before and households with an FRM originating in the same period (Column 3). It also reports formal tests of the null hypothesis that the sample means are the same for the first and the second sample (Column 4) and for the first and the third sample (Column 5).

The two ARM samples are highly comparable in terms of age, balance sheet structure, monthly income and spending, geographical location and family structure. This is intuitive given that they have selected the same type of mortgage loan at almost the same point in time. The FRM sample is slightly different in terms of observable characteristics. Specifically, the FRM households are younger, have smaller balance sheets and lower income, are less likely to live in the Copenhagen region and are more likely to have children. The differences motivate the use of a battery of control variables, all interacted with time indicators, in the regressions below.

4 Analysis #1: Current mortgage payments

The goal of our first analysis is to estimate responses to the increase in current mortgage payments occurring at the time of the mortgage rate reset. While theory suggests that households with no significant liquidity constraints should smooth spending in response to fully anticipated changes in payments , many empirical studies show that household spending exhibits a high sensitivity to cash-flows, even when they are fully anticipated .

4.1 Empirical strategy

Our design relies on quasi-random differences in the timing of mortgage rate reset following the shock to market interest rates in 2022. Specifically, in a window around April 2023, we compare a *treatment group* with ARM5 loans resetting in April 2023 to a *control group* ARM5 loans resetting in April 2024. Assuming that the two groups would have remained on similar behavioral trajectories absent the difference in reset dates, we interpret any divergence around April 2023 as the effect of the differential change in current mortgage payments.

The comparison of two cohorts of ARM borrowers arguably controls for other channels through which higher interest rates and broader changes in the macro-economic environment affected household behavior in the period. First, the two groups are highly similar in terms of observable characteristics such as age, income and balance sheets, suggesting that labor market effects and wealth effects are equally similar. Second, the two groups have selected the exact same type of mortgage loans (albeit at a slightly different point in time), suggesting that they have comparable risk preferences and similar expectations about mortgage costs over the medium and long run. The only salient difference between the two groups is in the timing of the increase in mortgage payments, which reflects a minor difference in the timing of loan origination 5-10 years earlier.

We first explore the differential developments of key outcomes in a dynamic difference-in-differences analysis. Specifically, we estimate the following equation for the period between April 2021 and March 2024:

$$y_{i,t} = \alpha_i + \gamma_t + \sum_{m \neq Apr23} \left((\beta_m ARM5_i^{23} + \boldsymbol{\delta}'_m \boldsymbol{X}_i) \cdot \mathbb{1}(t = m) \right) + \epsilon_{i,t} \tag{1}$$

where $y_{i,t}$ is the outcome (e.g. spending) for household i in month t, α_i is a household fixed effect, γ_t is a month fixed effect, $ARM5_i^{23}$ is a dummy for belonging to the group with reset in

April 2023, $\mathbb{1}(t = m)$ is an indicator for month m, and X_i is a vector of controls evaulated in December 2021. The controls are categorical variabales indicating birth year (5-year interval), gross income (quintile group), total debt (quintile group), total bank deposits (quintile group), and area of residence (11 regions). The β estimates from this model capture the differential development in the outcome for households in the treatment group relative to control group households with similar observable characteristics.

In the next step of our analysis, we estimate static summary measures of the average effects on key outcomes per DKK change in current mortgage payments. To do this, we estimate the following instrumental variables framework:

$$y_{i,t} = \alpha_i + \gamma_t + \lambda \cdot \Delta payment^{exo}_{i,Apr23} \cdot post_t + \sum_{m \neq Apr23} \left((\boldsymbol{\delta}'_m \boldsymbol{X}_i) \cdot \mathbb{1}(t = m) \right) + \epsilon_{i,t} \tag{2}$$

where $post_t$ is an indicator for months after the mortgage rate reset in April 2023 (i.e. taking the value one from April 2023 onwards). The key explanatory variable is $\Delta payment^{exo}_{i,Apr23}$, which captures the increase in monthly mortgage payments occurring in April 2023, absent any refinancing. For the control group of households with loans resetting in April 2024, this is zero by construction. The λ coefficient captures the effect on the outcome associated with a one DKK increase in current mortgage payments in an average month after April 2023.

To isolate the variation in $\Delta payment^{exo}_{i,Apr23}$ related to the quasi-random differences in the timing of reset, we instrument it with $ARM5^{23}_i$, the indicator for belonging to the group with reset in April 2023 (as opposed to April 2024). The reduced-form version of the IV model thus corresponds to a standard static difference-in-differences analysis between the two groups. It follows that any variation in $\Delta payment^{exo}_{i,Apr23}$ within the treatment group, created by differences in loan amounts, does not contribute to the identification of λ.

The first outcome we consider is current mortgage payments. The results from this analysis indirectly quantify the effect of refinancing decisions on monthly payments. Indeed, if all households in the treatment group kept their existing ARM5 contracts completely unaltered until April 2023, the estimated λ coefficient will be unity by construction. To the extent that some households mitigated the increase in interest rates by moving into other loan types, for instance interest-only loans, the resulting effect on monthly payments for the average household will show up as a deviation from unity.

For the outcome of main interest, household spending, equation 2 yields estimates of the change in spending relative to the exogenous increase in current mortgage payments at reset,

i.e. a type of marginal propensity to consume. We also explore the behavioral margins that households adjust to sustain spending through the surge in mortgage payments. Specifically, we quantify the extent to which households draw on liquid buffers (deposits and stocks) or increase labor supply in response to the mortgage rate reset.

In principle, all these responses are tied together by the households' intertemporal budget constraint. The exogenous increase in mortgage payments should approximately match the sum of (i) the reduction in mortgage payment due to active refinancing, (ii) the reduction in spending, (iii) the reduction in saving in liquid assets, and (iv) the increase in income. The equality is only approximate because there are some potential margins that we do not observe well, such as money transfers to and from friends and family, and real estate transactions.

4.2 Results

Dynamics. We begin with a descriptive analysis of the developments in our two main outcomes - mortgage payments and spending - in the time period around April 2023. Figure 2 shows raw averages of these variables for the group of households with an ARM5 loan resetting in that month (the treatment group) and the group with an ARM5 loan resetting one year later, in April 2024 (the control group). Panel A shows that monthly mortgage payments roughly double in April 2023 for the average household in the treatment group, from just over DKK 3,000 per month to more than DKK 6,000, while they remain constant for the control group. [4].

As shown in Panel B, monthly spending is generally somewhat higher for the treatment group than for the control group, but the trajectories are almost perfectly parallel throughout the sample period. There is significant variation in the level of spending across months, due to differences in the number of days, the number of weekends and public holidays, but this variation is remarkably similar across the two groups. Strikingly and most importantly for our purposes, there are no visible signs that the spending of the treatment group changes differentially in April 2023 when their mortgage payments double.

This finding is supported by Figure 3, which shows estimated β coefficients from equation 1 with monthly spending as the outcome. The estimates are generally small and statistically insignificant with no apparent change after April 2023, reflecting that the two groups are on parallel spending trajectories both before and after the interest rate reset for the treatment group.

[4]The slight increase in the months before reset for the treatment group reflects that a minority of households hold other mortgage loans in addition to their ARM5 loans. Some of these have shorter interest rate fixation periods and are therefore affected by the increase in current market rates before April 2023

Summary measures Next, we provide summary estimates of the effects of the mortgage rate reset in an average month after April 2023. Table 3 reports both standard static difference-in-differences estimates from the reduced-form version of equation 2, estimated by OLS, and 2SLS estimates that express the results as *marginal effects* per one DKK exogenous change in current mortgage payments. [5].

As shown in Column 1, the results indicate that the monthly mortgage payments of the treatment group increased differentially by around DKK 3,700 when comparing the period before and after April 2023 while spending decreased differentially by only around DKK 50. These estimates mirror the differential surge in mortgage payments and the parallel trends in spending illustrated in Figures 2 and 3.

We also explore which behavioral margins households adjusted to sustain spending through the surge in mortgage payments in the same empirical framework. The results indicate that they draw heavily on liquid buffers. Monthly saving in deposit accounts and net investment in securities decrease differentially by around DKK 3,300 and DKK 200, respectively, compared with the period before April 2023. We also find a differential increase in after-tax income of around DKK 400, which may reflect real labor supply responses or that households adjust montly tax withholding to account for the increase in deductible interest expenses.

The estimates almost respect the adding-up properties implicit in the intertemporal budget constraint. The additional expense on mortgage payments ($\approx$ DKK 3,700) are partly offset by decreases in spending (DKK $\approx$ 50) and investment ($\approx$ DKK 200) and by an increase in income ($\approx$ DKK 400). This suggests a net monthly impact on deposits of around DKK 3050, which is not far off of our estimate of around DKK 3,300.

Column 2 of Table 3 expresses these results as marginal effects, capturing how households adjust the various behavioral margins per DKK of exogenous increase in monthly mortgage payments. Current mortgage payments increase by 0.96 DKK for each DKK increase in mortgage payments, suggesting that households on average mitigate 4% of the interest rate shock by switching to other loan types, such as interest-only loans. The results further indicate that spending drops by 0.01 DKK per DKK increase, which suggests a very low marginal propensity to consume out of current disposable income net of mortgage payments. The MPC estimate is relatively precise with an upper bound of the confidence interval around 0.05. Finally, we find that decreases in investment and increases in income contribute 0.06 and 0.11 DKK, respectively, to cover a one DKK increase in mortgage payments, while the negative impact on

[5]The reduced-form version of equation (2) is obtained by replacing the continous $\Delta payment^{exo}_{i,Apr23}$ with the instrument, the binary treatment indicator $ARM5^{23}_i$

deposit balances is 0.86 DKK.

Again, our estimates are reasonably close to respecting the intertemporal budget constraint, despite the limitations of our measurement discussed above. The additional expense on mortgage payments ($\approx$ 0.96 DKK per 1 DKK exogenous increase) is partly offset by decreases in spending ($\approx$ 0.01 DKK) and investment ($\approx$ 0.06 DKK) and by an increase in income ($\approx$ 0.11 DKK). This leaves a residual of 0.78 DKK per DKK of exogenous increase in mortgage payments, which is not far off of our 0.86 DKK estimate for the drop in saving in deposits.

5 Analysis #2: Expected future mortgage payments

The goal of this analysis is to estimate responses to shocks to expected future mortgage payments. Such shocks occur for ARM borrowers when market rates surge before the actual reset of the rate on their own loans. While theory suggests that households should make behavioral adjustments when expectations change, empirical evidence confirming such behavior remains limited.

5.1 Empirical strategy

Figure 1 illustrates that the sharp increase in current market interest rates following the Russian invasion of Ukraine in February 2022 was accompanied by an equally large increase in expectations about future rates among professional forecasters. Changes in mortgage rates routinely make headlines in major Danish news outlets - and especially did so during spring 2022 - and bank representatives often appear as experts in news stories where they share their views on expected future developments. It is therefore plausible that mortgage borrowers also adjusted their expectations about future rates upwards, but with different implications for expected future payments: While ARM borrowers were facing drastically increasing future payments, households with fixed-rate mortgages (FRM) had no reason to change their expectations.

Our empirical design exploits this asymmetry in exposure to increasing rates. Specifically, we compare a *treatment group* of borrowers with ARM5 loans resetting in April 2024 to a *control group* of households with fixed-rate mortgages originated in the same period. Note that "treatment" here refers to a change in expectations about *future* payments, holding current payments fixed: According to their loan contracts and expert forecasts, households in the treatment group should expect to pay significantly more on their loans in the future, but not until their scheduled interest rate reset in April 2024, i.e. more than two years after rates on new loans began to increase. Assuming that the two groups would have remained on similar behavioral trajectories

absent the surge in market interest rates, we therefore interpret any divergence around the surge as the effect of the differential change in expected future mortgage payments, holding constant current payments.

As discussed in section 3, the households in the treatment and control groups are highly similar in terms of age, income and balance sheets, suggesting that many of the alternative channels through which higher interest rates may affect household behavior are comparable for the two groups. However, the fact that we are comparing households who have selected into different loan products renders identification slightly less compelling than in analysis #1. Most importantly, the households in the two groups may have different risk preferences, which could cause differential responses to the increased macroeconomic uncertainty, unrelated to the differential impact on expected future mortgage payments.

As in analysis #1, we implement our strategy in two steps. First, we estimate a fully dynamic difference-in-differences model for the period April 2020 to March 2024, during which the mortgage payments of both groups were approximately fixed:

$$y_{i,t} = \alpha_i + \gamma_t + \sum_{m \neq Jan22} \left((\beta_m ARM5_i^{24} + \boldsymbol{\delta}'_m \boldsymbol{X}_i) \cdot \mathbb{1}(t = m) \right) + \epsilon_{i,t} \tag{3}$$

Here, the key explanatory variable is $ARM5_i^{24}$, an indicator for belonging to the treatment group with an ARM5 loan resetting in April 2024. All other variables, including the controls, are the same as in equation 1.

Next, we estimate static summary measures expressing the effect on outcomes of the increase in expected future rates in an average month after February 2022, as well as marginal effects on the outcomes per DKK change in expected future mortgage payments. For the former, we do a standard static difference-in-differences analysis, comparing the changes in outcomes from before to after February 2022 for the treatment group vs. the control group.[6]

For estimating the marginal effects, we need a measure of expectations that reflects both *a)* the variation across households in how much their mortgage payments would change in April 2024 for a given change in the interest rate, and *b)* the variation over time in expectations about what the interest would be in April 2024. We construct such a measure by combining information about each household's loans as of December 2021 with the bank's forecasts about the change in ARM5 interest rate in April 2024. Specifically, we construct the variable $E_t[\Delta payment^{exo}_{i,Apr24}]$ as the change in monthly payments that household i would have experienced in April 2024,

[6]That is, we estimate the model $y_{i,t} = \alpha_i + \gamma_t + \lambda \cdot ARM5_i^{24} \cdot post_t + \boldsymbol{\delta}' \boldsymbol{X}_i \cdot post_t + \epsilon_{i,t}$, where $ARM5_i^{24}$ is a treatment group indicator, and $post_t$ is an indicator taking the value 1 from February 2022 onwards.

absent any refinancing and assuming that the bank's forecast in month t for the interest rate in April 2024 had turned out accurate. It should be noted that this does not necessarily capture the subjective expectations held by each household, but it represents what a household in the treatment group would have been told had they at any point contacted the bank and asked what to expect about their future payments. As such, it arguably serves as a useful proxy for the subjective expecations. For the households in the control group of FRM borrowers, $E_t[\Delta payment^{exo}_{i,Apr24}]$ is equal to zero by construction.

We then analyze the effect of expectations about future mortgage payments by estimating the following IV model for the period April 2021 to March 2024:

$$y_{i,t} = \alpha_i + \gamma_t + \lambda \cdot E_t[\Delta payment^{exo}_{i;Apr24}] + \sum_{m \neq Jan22} \big((\boldsymbol{\delta}'_m \boldsymbol{X}_i) \cdot \mathbb{1}(t = m)\big) + \epsilon_{i,t} \tag{4}$$

where $E_t[\Delta payment^{exo}_{i;Apr24}$ is instrumented by $ARM5^{24}_i \cdot E_t[\Delta r_{Apr24}]$. $ARM5^{24}_i$ again denotes the binary indicator for belonging to the treatment group of households with ARM5 loans resetting in April 24, while $E_t[\Delta r_{Apr24}]$ denotes Danske Bank's forecast for the change in the interest rate at the April 2024 reset. The instrument thus gets times series variation from changes in the bank's forecast, and cross-sectional variation from households' treatment status only. As in analysis #1, this means that variation in $E_t[\Delta payment^{exo}_{i;Apr24}$ stemming from variation in household loan balances within the treatment group does not contribute to the identication of λ in equation 4.

5.2 Results

Dynamics. Figure 5 shows the raw trends in monthly mortgage payments and spending for the treatment group (blue line) and control group (gray line) for the full analysis period between April 2021 and March 2024.

As shown in Panel A, mortgage payments are significantly lower for the treatment group than for the control group, reflecting the general cost advantage of ARM loans over FRM loans in the preceding decade. The main thing to notice, however, is that monthtly mortgage payments are stable for *both* groups during the whole period, despite the sharp increase in market interest rates on new loans beginning in February 2022.

Panel B shows that monthly spending is somewhat higher for the treatment group than for the control group in the beginning of the sample period, which may partly reflect their lower mortgage costs, but following a highly similar dynamics. Around the surge in market interest rates in Spring 2022, the spending gap between the two groups is largely eliminated, indicating a

differential increase in spending for the treatment group relative to the control group beginning at this point.

This can be seen more clearly in Figure 6, which shows results from the dynamic difference-in-differences model in equation 3 with monthly spending as the outcome. The DiD estimates are generally insignificant and with no apparent trend before early 2022, but then turn consistently negative in the months when market rates on new loans soar. At the lowest points in late 2023, the point estimates indicate a drop in monthly spending of more than DKK 1,000 for the treatment group relative to the control group.

Summary measures. We provide static difference-in-differences estimates for the effect of the shock to expected future mortgage payments in Table 4. These estimates compare the treatment and control groups in terms of the change in outcomes from the period before the surge in market rates, i.e. April 2021-January 2022, to the period between the surge in market rates and the pass-through to mortgage payments at reset, i.e. February 2022 - March 2024.

As shown in Column 1, the results document an immaterial differential increase in the current mortgage payments of the treatment group of around DKK 100 from the pre-shock to the post-shock period, but a decrease in spending of almost DKK 400. These estimates are consistent with the roughly constant level of mortgage payments shown in Figure 5 and the difference in spending dynamics between the two groups shown in Figure 6.

In the same empirical framework, we explore if households adjust other behavioral margins than spending in response to the shock to expected future mortgage payments. The results indicate that they build up liquidity buffers on both deposit and securities accounts. Specifically, monthly saving in deposit accounts increases differentially by around DKK 1,000, and net portfolio investment increases differentially by around DKK 400. Finally, we find a small and statistically insignificant differential increase in after-tax income of around DKK 200.

Column (2) reports estimates expressing these behavioral adjustments in terms of marginal effects per DKK of exogenous increase in expected future monthly mortgage payments, based on the instrumental variables model in equation 4. Monthly spending decreases by around 0.16 DKK for each DKK expected increase in mortgage payments. Saving in deposit and securities accounts increase by 0.48 and 0.20 DKK, respectively, while income increases by 0.08 DKK.

6 Conclusion

This paper analyzes the transmission of monetary policy to consumption operating through the cash-flow effect of changes in mortgage payments. Using highly granular data transaction and mortgage loan data from a major Danish bank, we study how households responded to the historically sharp increase in interest rates in 2022-2023.

Exploiting differences in exposure to the rise in mortgage rates among otherwise-similar households, we find that households reduce spending swiftly in response to expectations about higher payments in the future: Relative to fixed-rate borrowers, households with adjustable-rate mortgages resetting in April 2024 cut back on spending already in 2022 when interest rates began to rise - about two years before the impact on their own payments would materialize. With current mortgage payments initially unchanged, the cut in spending helped these households build up of liquid buffers to prepare for the future hike in payments.

Consistent with this idea, we find that the anticipated increases in mortgage payments did not have any additional impact on spending once they materialized: Comparing adjustable-rate mortgage borrowers with interest rates resetting in 2023 vs 2024, we find no difference in spending dynamics between the two groups around April 2023 when the former group saw a drastic increase in their mortage payments. Instead, the shock to cash-flows was fully absorbed by reduced saving in liquid assets.

These findings offer important insights for monetary policy, and in particular the speed of its transmission: although interest rates on most mortgage loans are fixed for at least some period, meaning it can take several years for changes in policy rates to fully pass through to actual mortgage payments, our results indicate that the effect on consumption occurs much more quickly. In particular, our analysis shows that households do not wait for their loan payments to adjust before altering their spending. Instead, they respond quickly to changes in expected future interest rates, adjusting consumption in anticipation of higher payments rather than in reaction to their eventual realization.

The results of our analysis are consistent with standard theories of forward-looking and unconstrained households using liquid buffers to smooth consumption in the presence of fluctuations in disposable income. Going forward, we plan to further probe the robustness of these results and the conclusions that follow from them. Heterogeneity in responses will be a key focus point. In particular, we plan to study whether our results differ depending on whether the household faces binding liquidity constraints, or by key household characteristics such as age or income.

From a theory perspective, an interesting question is whether households think of the increase in interest rates as a transitory or persistent shock. The magnitude of the estimated MPC out of changes in expected future payments can help shed light on this, as a persistent shock should, in theory, be associated with a higher MPC than a transitory one. We plan to examine this issue further by analyzing heterogeneity in MPCs by remaining maturity, and by revealed-preference measures signaling subjective expectations that we can observe in the bank data.

References

[1] Galaasen, S., Maehlum, M., and Ahn, S. (2024). The Cash-Flow Channel of Monetary Policy-Evidence from Billions of Transactions. Available at SSRN 5089327.

[2] Andersen, A. L., Hansen, E. T., Johannesen, N., and Sheridan, A. (2022). Consumer responses to the COVID-19 crisis: Evidence from bank account transaction data. *Scandinavian Journal of Economics*, 124(4), 905-929.

[3] Baker, S. R. (2018). Debt and the response to household income shocks: Validation and application of linked financial account data. *Journal of Political Economy*, 126(4), 1504-1557.

[4] Baugh, B., Ben-David, I., Park, H., and Parker, J. A. (2021). Asymmetric consumption smoothing. *American Economic Review*, 111(1), 192-230.

[5] Browning, M., and Collado, M. D. (2001). The response of expenditures to anticipated income changes: panel data estimates. *American Economic Review*, 91(3), 681-692.

[6] Di Maggio, M., Kermani, A., Keys, B. J., Piskorski, T., Ramcharan, R., Seru, A., and Yao, V. (2017). Interest rate pass-through: Mortgage rates, household consumption, and voluntary deleveraging. *American Economic Review*, 107(11), 3550-3588.

[7] Di Maggio, M., Kermani, A., and Palmer, C. J. (2020). How quantitative easing works: Evidence on the refinancing channel. *Review of Economic Studies*, 87(3), 1498-1528.

[8] Druedahl, J., Jensen, E. B., and Leth-Petersen, S. (2022). The intertemporal marginal propensity to consume out of future persistent cash-flows: Evidence from transaction data (No. 13/22). CEBI Working Paper Series.

[9] Flodén, M., Kilström, M., Sigurdsson, J., and Vestman, R. (2021). Household debt and monetary policy: Revealing the cash-flow channel. *Economic Journal*, 131(636), 1742-1771.

[10] Hsieh, C. T. (2003). Do consumers react to anticipated income changes? Evidence from the Alaska permanent fund. *American Economic Review*, 93(1), 397-405.

[11] Kaplan, G., Moll, B., and Violante, G. L. (2018). Monetary policy according to HANK. *American Economic Review*, 108(3), 697-743.

[12] Kueng, L. (2018). Excess sensitivity of high-income consumers. *Quarterly Journal of Economics*, 133(4), 1693-1751.

[13] Parker, J. A. (1999). The reaction of household consumption to predictable changes in social security taxes. *American Economic Review*, 89(4), 959-973.

[14] Souleles, N. S. (1999). The response of household consumption to income tax refunds. *American Economic Review*, 89(4), 947-958.

Figure 1. Actual and forecasted interest rates on new adjustable-rate mortgages with 5-year interest fixation period

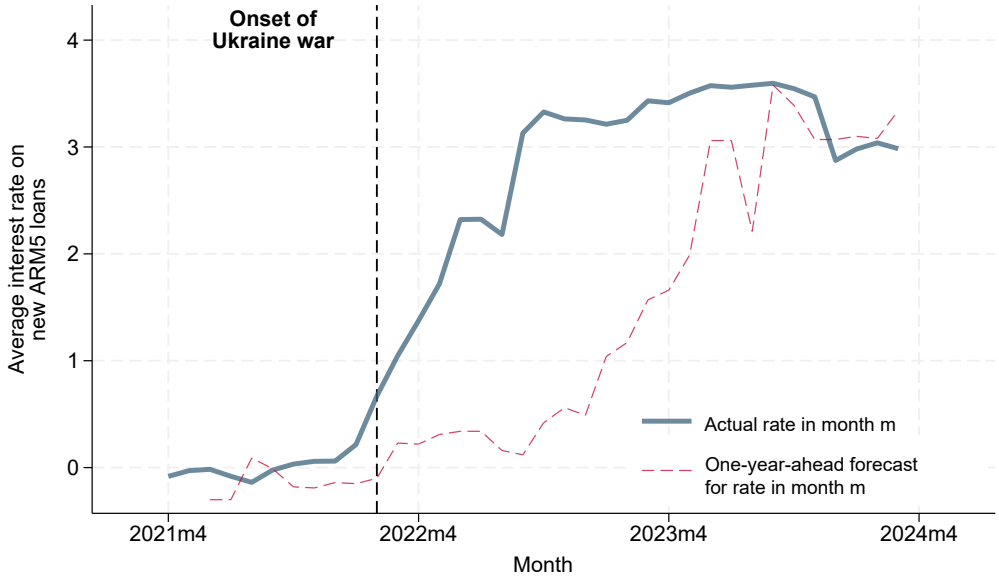


Figure 2. Monthly averages for ARM borrowers with reset in 2023 vs 2024 The figure shows raw averages of monthly mortgage payments (Panel A) and spending (Panel B) for the group of households wilth an ARM5 loan resetting in April 2023 ("Treatment group)" or in April 2024 ("Control group").

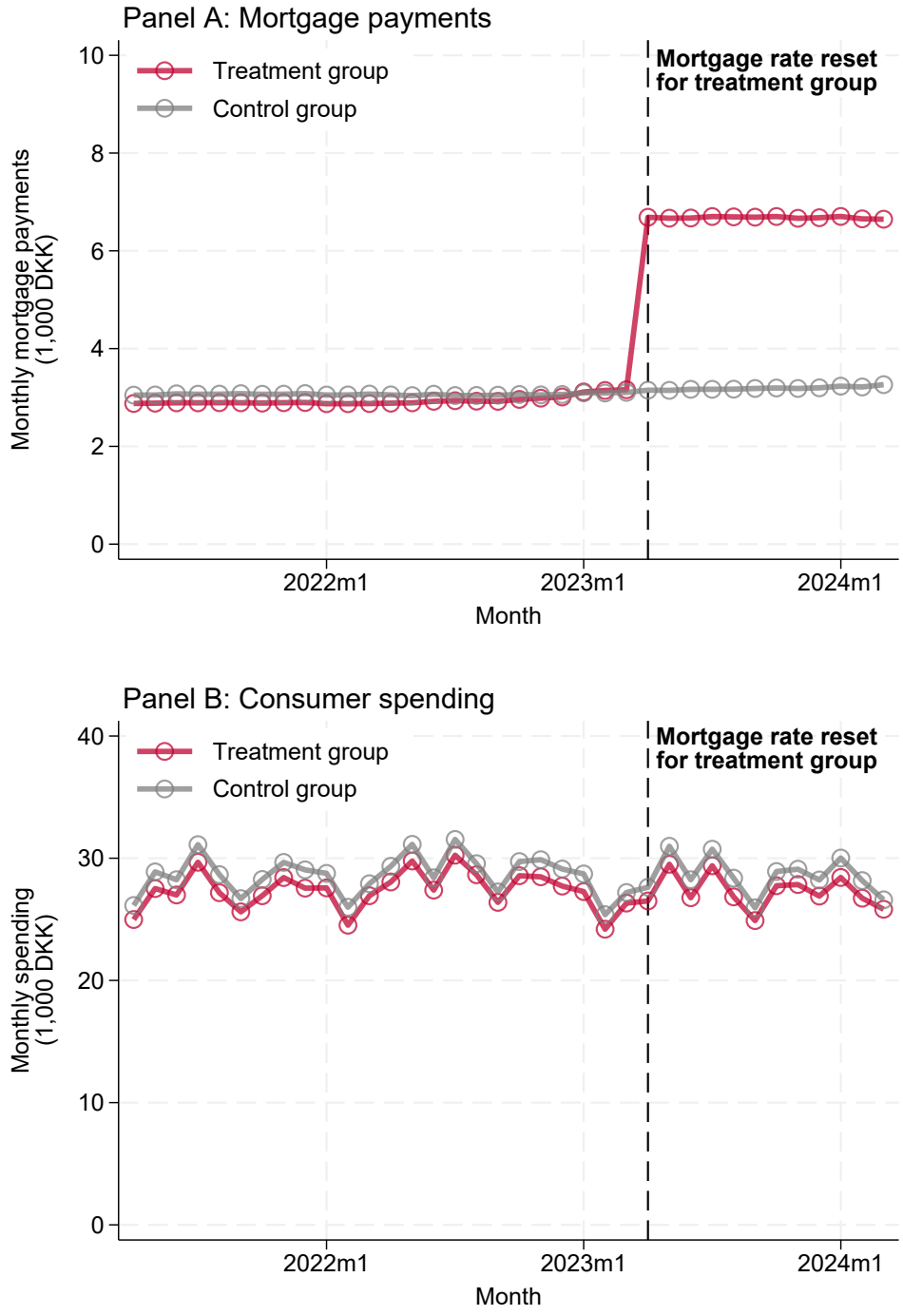


Figure 3. The effect of current mortgage payments on spending: Dynamic Diff-in-diff estimates The figure shows estimates of the β parameters in model 1 with monthly spending as the outcome. Each estimate captures the differential increase in spending since April 2023 for the treatment group of households with ARM5 loans resetting in April 2023 vs. the control group of households with ARM5 loans resetting in April 2024.

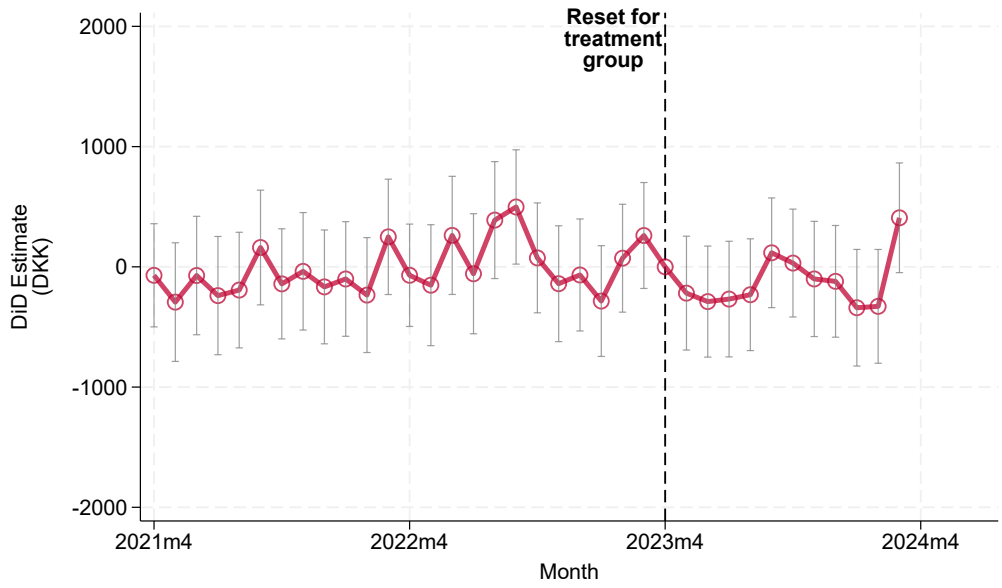


Figure 4. Monthly averages for ARM borrowers vs. FRM borrowers The figure shows the average levels of monthly mortgage payments (Panel A) and monthly spending (Panel B) for the group of households with an ARM5 loan resetting in April 2023 ("Treatment group") and the group with an FRM loan originated in the same period as the ARM5 loans ("Control group").

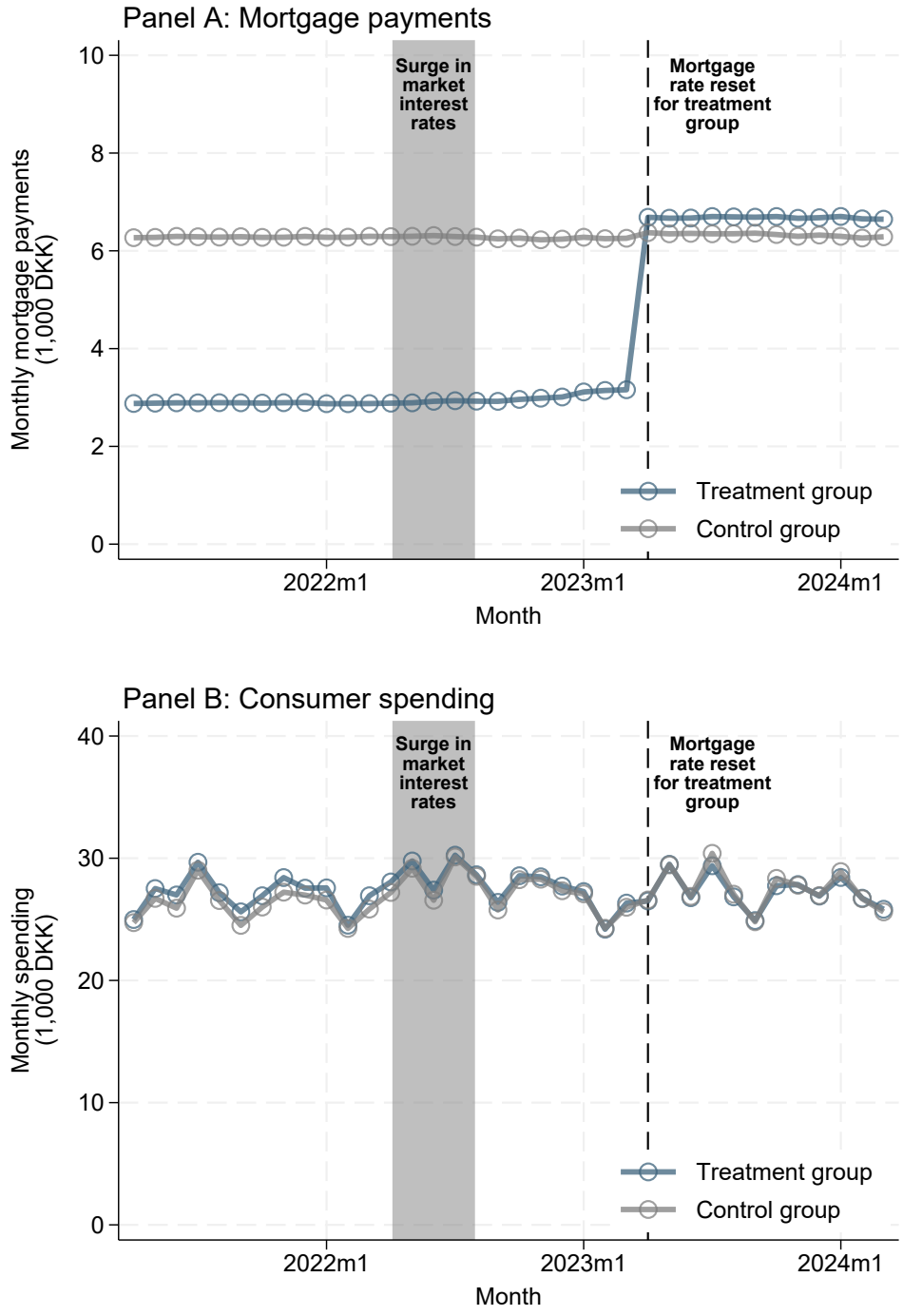
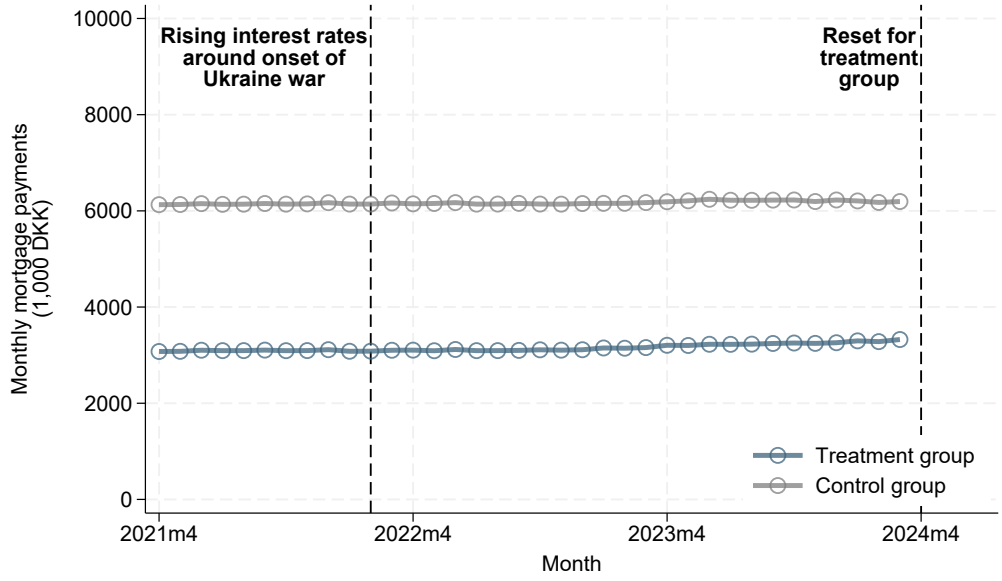


Figure 5. Monthly averages for ARM borrowers vs. FRM borrowers The figure shows the average levels of monthly mortgage payments (Panel A) and monthly spending (Panel B) for the group of households with an ARM5 loan resetting in April 2024 ("Treatment group") and the group with an FRM loan originated in the same period as the ARM5 loans ("Control group").

Panel A: Mortgage payments



Panel B: Consumer spending

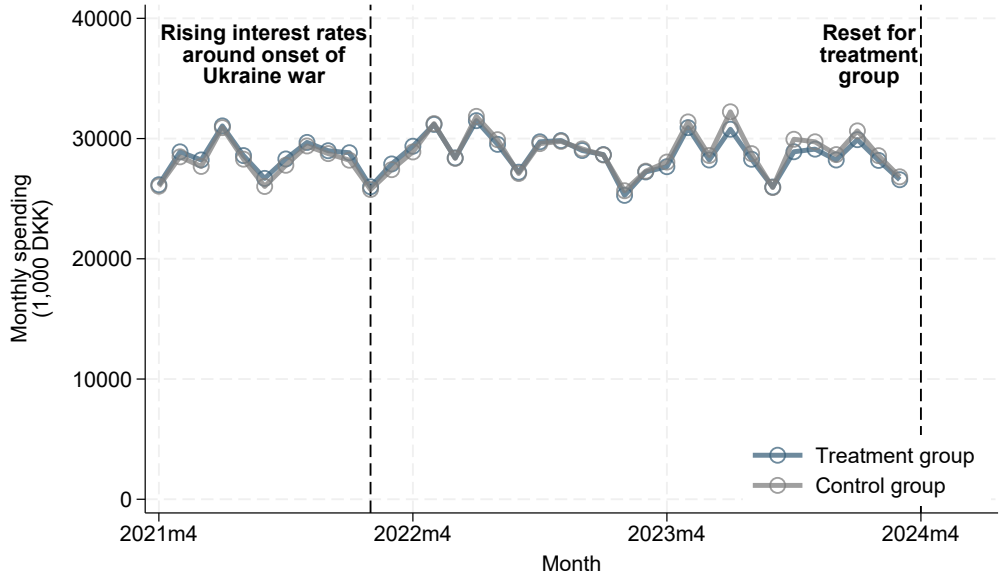


Figure 6. The effect of expected future mortgage payments on spending: Dynamic Diff-in-diff estimates The figure shows estimates of the β parameters in model 3 with monthly spending as the outcome. Each estimate captures the differential increase in spending since January 2022 for the treatment group of households with ARM5 loans resetting in April 2024 vs. the control group of households with FRM loans originated in the same period as the ARM5 loans.

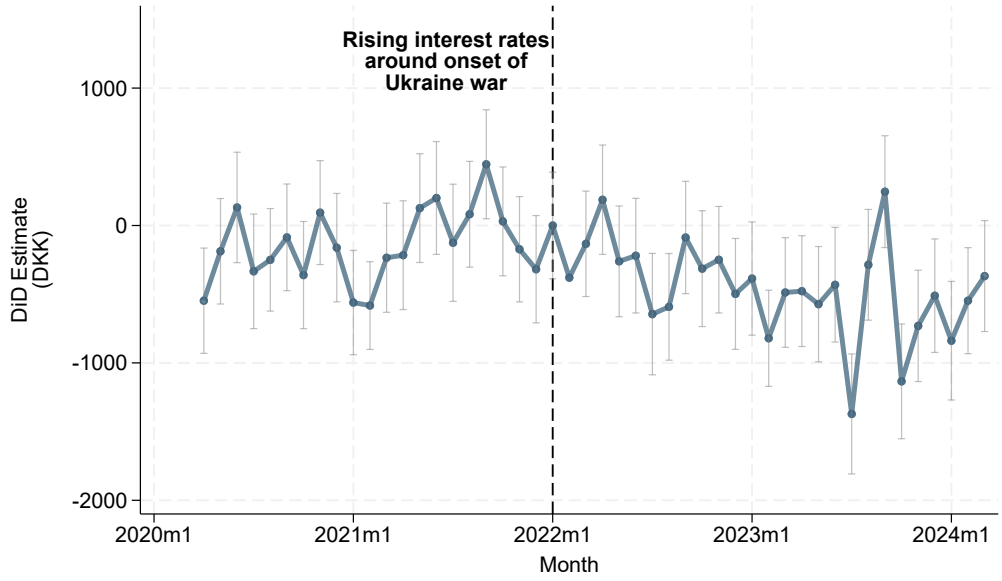


Table 1. Mortgage borrowers by type of loan The table shows aggregate statistics for the universe of households with mortgage loans in Denmark as of December 2021. Column 1 shows statistics for all households with a mortgage, regardless of type. Column 2 shows statistics for households with an adjustable-rate mortgage (ARM) of any type, while column 3 focuses on households who have an adjustable-rate mortgage with a five-year interest fixation period (ARM5). All statistics are own calculations based on matched individual-level data from administrative registers.

	(1) All households with mortgages	(2) Households with adjustable-rate mortgages, any fixation period (ARM)	(3) Households with adjustable-rate mortgages, 5-year fixation period (ARM5)
No. of households	1,123,985.0	520,427.0	262,297.0
Total debt, bn. DKK	2,134.5	1,150.7	638.6
Mortgage debt, bn. DKK	1,817.7	967.4	562.4
Total interest payments, bn. DKK	32.6	12.8	7.0
Mortgage interest payments, bn. DKK	23.6	8.5	5.0

Table 2. Summary statistics For a range of observable characteristics, the table shows the means for each of the three samples used in the analysis: households with an ARM5 loan with interest rate reset in April 2023 and originating 5 or 10 years before (ARM-2023, Column 1), households with an ARM5 loan with interest rate reset in April 2024 and originating 5 or 10 years before (ARM-2024, Column 2), households with a FRM loan originating in the same period as the ARM-2023 sample (FRM, Column 3). The table also compares these means across samples: ARM-2023 vs ARM-2024 (Column 4) and ARM-2023 vs FRM (Column 5).

	(1) 5-year ARM Reset April 2023	(2) 5-year ARM Reset April 2024	(3) FRM No reset	(4) Difference Col (2) - Col (1)	(5) Difference Col (3) - Col (1)
Age, years	62.2	61.7	53.3	-0.5*	-8.9*
Mortgage debt, 1.000 DKK	1884.9	1980.5	1294.9	95.6*	-590.0*
Mortgage payment, 1.000 DKK	2.9	3.1	6.3	0.2*	3.4*
Deposits, 1.000 DKK	290.8	329.0	253.6	38.2*	-37.2*
Spending, 1.000 DKK	27.6	29.1	27.0	1.5*	-0.6*
Income, 1.000 DKK	35.5	37.7	40.2	2.3*	4.7*
ΔDeposits, 1.000 DKK	-2.3	-0.7	1.9	1.6*	4.2*
Net investment inflow, 1.000 DKK	-0.1	0.0	-0.6	0.1	-0.5*
Loans to value ratio, pct.	49.2	48.3	50.3	-0.8	1.2
Copenhagen region, pct.	44.4	44.2	32.5	-0.2	-11.9*
Couple with children, pct.	14.7	15.8	24.6	1.1	9.9*
Couple without children, pct.	56.5	57.6	46.4	1.1	-10.1*
Other, pct.	0.9	0.9	1.1	0.0	0.2
Single, pct.	25.9	23.7	25.1	-2.1*	-0.7
Single w. children, pct.	2.1	2.0	2.8	-0.1	0.7*

Table 3. The effect of current mortgage payments The table displays standard static difference-in-difference estimates (Column 1) and IV estimates of marginal effects (Column 2) of a surge in current mortgage payments. The estimates are identified from a comparison of households with ARM5 loans, of whom some have mortgage rate reset in April 2023 ("treatment group") and others have reset in April 2024 ("control group"). The sample period is the 36-month period from April 2021 to March 2024 and the estimates compare levels of the outcomes before and after the mortgage reset of the treatment group. Estimates in column (1) are OLS estimates of the reduced-form version of equation 2) where $\Delta payment^{exo}_{i,Apr23}$ is replaced with the treatment group indicator $ARM5^{23}_i$. Estimates in column (2) are 2SLS estimates where $ARM5^{23}_i$ is used as an instrument for $\Delta payment^{exo}_{i,Apr23}$.

	(1) Static DiD estimates (Ordinary Least Squares)	(2) Marginal effects (Two-stage Least Squares)
Mortgage payments	3673.2*	0.96*
	(43.284)	(0.009)
Spending	-56.4	-0.01
	(80.109)	(0.021)
Net saving in deposit accounts	-3277.76*	-0.85*
	(260.02)	(0.069)
Net investment in securities	-219.01*	-0.06*
	(73.859)	(0.02)
Income	434.51*	0.11*
	(128.234)	(0.034)

Table 4. The effect of expected future mortgage payments The table displays displays standard static difference-in-difference estimates (Column 1) and IV estimates of marginal effects (Column 2) of an increase in expected future mortgage payments. The estimates are identified from a comparison of households with ARM5 loans resetting in April 2024 ("treatment group") and households with FRM loans originating in the same period ("control group"). The sample period is covers April 2021 to March 2024. Estimates in column (1) are OLS estimates of the reduced-form version of equation 4) where $E_t[\Delta payment^{exo}_{i,Apr24}]$ is replaced with $ARM5^{24}_i \cdot E_t[\Delta r_{Apr24}]$. Estimates in column (2) are 2SLS estimates where $ARM5^{24}_i \cdot E_t[\Delta r_{Apr24}]$ is used as an instrument for $E_t[\Delta payment^{exo}_{i,Apr24}]$.

	(1) Static DiD estimates (Ordinary Least Squares)	(2) Marginal effects (Two-stage Least Squares)
Mortgage payments	109.85*	0.07*
	(25.25)	(0.012)
Spending	-223.71*	-0.16*
	(103.23)	(0.041)
Net saving in deposit accounts	1443.02*	0.48*
	(285.67)	(0.113)
Net investment in securities	582.18*	0.20*
	(85.75)	(0.031)
Income	185.1	0.08
	(141.74)	(0.056)