Household Debt and Monetary Policy: Revealing the Cash-Flow Channel*

Martin Flodén
Sveriges Riksbank and CEPR

Matilda Kilström
Stockholm School of Economics

Jósef Sigurdsson
Bocconi University

Roine Vestman
Stockholm University and CEPR

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Abstract

We examine the effect of monetary policy on household spending when households are indebted and interest rates on outstanding loans are linked to short-term interest rates. Using administrative data on balance sheets and consumption expenditure of Swedish households, we reveal the cash-flow transmission channel of monetary policy. On average, indebted households reduce consumption spending by an additional 0.23–0.55 percentage points in response to a one-percentage-point increase in the policy rate, relative to a household with no debt. We show that these responses are driven by households that have some or a large share of their debt in contracts where interest rates vary with short-term interest rates, such as adjustable-rate mortgages (ARMs), which implies that monetary policy shocks are quickly passed through to interest expenses.

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1 Introduction

A fundamental question in macroeconomics is how monetary policy exerts its influence on the real economy. In standard macroeconomic models, the interest-rate channel is the primary transmission mechanism. According to this mechanism, forward-looking households change the slope of their consumption profiles when interest rates change. Although monetary policy indeed appears to affect the real economy, the empirical support for this mechanism is mixed and the evidence indicates that the effects are both stronger and of a different character than predicted by the interest-rate channel. This suggests that other mechanisms may also be at work.[1]

One such potential mechanism is the *cash-flow channel*.[2] According to this mechanism, monetary policy has a direct effect on household spending through households' cash flows and disposable incomes. When the central bank raises its policy interest rate, the interest-rate expenses of households with debt tightly linked to short-term rates—such as adjustable-rate mortgages (ARMs)—rise, thus reducing the households' disposable income. If households are forward-looking and have good access to financial markets, such variations in cash flows need not result in tangible consumption responses. But if households are myopic, liquidity constrained, or for some other reason unable or unwilling to draw on savings or increase debt in response to temporarily lower disposable income, monetary policy-induced interest rate increases will reduce their consumption spending. Under these circumstances, monetary policy affects private spending through this cash-flow channel, in addition to the conventional channels.

In this paper, we assess the empirical support for this channel using administrative data on Swedish households. We argue that Sweden offers an ideal laboratory for three reasons. First, in Sweden, household debt is relatively high and ARMs are common. Throughout our sample period, ARMs accounted for 30 to 40 percent of the aggregate value of outstanding mortgage debt. These ARMs typically have an interest fixation period of only three months.[3] Second, ARMs are standard products on the Swedish mortgage market, and most households have adjustable rates on at least some share of their debt. That is, they are neither disproportionally held nor directly targeted to particular types of households. Moreover, the characterization of the Swedish mortgage market is such that it is unlikely that our results are contaminated by important selection into different types of loan portfolios depending on household characteristics or spending behavior.[4] In support of this notion, we find that households that we classify in our data as holders of

[1] Attanasio and Weber (2010) and Jappelli and Pistaferri (2010) survey the empirical support for the consumption theories that underpin the interest-rate channel. Boivin et al. (2011) discuss the different transmission mechanisms that have been suggested in the literature, and the (often weak) empirical support for these mechanisms.

[2] This terminology has previously been used by, e.g., Cloyne et al. (2019), whereas Berben et al. (2004) and Di Maggio et al. (2017) refer to the same channel as the "income channel." However, Boivin et al. (2011) do not mention this channel in their survey.

[3] According to Statistics Sweden's Financial Markets Statistics, the fraction of mortgages that had an interest-rate fixation period of one year or shorter at origination varied between 42 and 58 percent in 2003 to 2007.

[4] In general, a possible concern is that households may select into ARMs based on household-specific characteristics that correlate with the sensitivity to the macroeconomic environment. For theoretical arguments in this direction, see, e.g., Campbell and Cocco (2003), Campbell and Cocco (2015) and Badarinza et al. (2018) for recent empirical evidence.

ARMs are observationally similar along a variety of important dimensions to households holding fixed-rate mortgages (FRMs).[5] Third, studying the importance of this channel in Sweden offers an empirical setting with access to detailed household-level data. A common challenge in previous studies on the impact of monetary policy on consumption is the lack of suitable data sets that feature both a high-quality measure of consumption and data on households' wealth and balance sheets that are representative for the population. We overcome this problem by using administrative panel data from tax returns and other registry-based data. This data source provides us with detailed information on all income, assets, and debt. As in Koijen et al. (2015), the details of these data enable us to impute a measure of consumption expenditure using the accounting identity that total consumption expenditure equals the sum of total income and capital gains minus the change in wealth. Furthermore, analyzing responses at the level of the individual household mitigates the common problem when trying to evaluate the impact of monetary policy on economic outcomes that changes in monetary policy are endogenous to the development of the economy. In our setting, all households are affected by the same monetary policy, but if the cash-flow channel is important, the households' consumption responses vary, depending on their debt contracts and balance sheets.

Guided by theory, we examine how monetary policy affects consumption for households with a large debt-to-income ratio relative to households with a smaller debt-to-income ratio, and for households with ARMs relative to households with FRMs. We also examine how debt-to-income ratios and debt contracts interact with households' liquid assets-to-income ratios. We report three kinds of results that lend strong support to the importance of the cash-flow channel of monetary policy.

Our first result is that households with high levels of debt relative to their income respond substantially more to a change in the monetary policy interest rate than households with little or no debt. OLS estimates imply that when the central bank raises its interest rate by one percentage point, the average household, which has debt roughly equal to one year's disposable income, reduces its consumption by about 0.23 percentage points relative to a similar household with no debt. This analysis faces a standard problem of a possible reverse causality when assessing the effects of macroeconomic policy: households respond to monetary policy, but monetary policy may also respond to the economic conditions of households. To overcome this issue, we measure innovations in monetary policy that are entirely due to policy shifts and not to the macroeconomic development. This enables us to identify consumption responses to unanticipated changes in interest rates, separated from those that are anticipated based on macroeconomic conditions. Following recent examples from the literature on monetary non-neutrality, we use monetary policy shocks as an instrumental variable for changes in the policy rate. Our IV estimates are fifty to one-hundred percent greater than our OLS estimates. Translating our estimates into a relative marginal propensity to consume (MPC) out of changes in disposable income, or cash flow, they

[5] As further support of this notion, previous analysis has found that outcomes related to households' financial health, such as the probability of mortgage default, do not correlate with the choice of interest-rate fixation (Holmberg et al., 2015).

imply an MPC in the interval 0.19–0.50. Importantly, our results are robust to using the average aggregate interest rate faced by households instead of the monetary policy rate.

Although our estimates depend on the exact empirical specification, they can be compared to regression estimates on data generated from model simulations. Our comparisons suggest that our estimates are at least three times as large as those from households with ARMs that respond optimally, according to standard neoclassical theory, to a temporary shock. Rather, our estimates are consistent with responses to a persistent shock to the interest rate where half of households have ARMs (and the remainder have FRMs) and where half of households respond optimally, and the remainder display hand-to-mouth behavior.

Our second result is that households' consumption responses crucially depend on the interest-rate fixation of their mortgages. Using a proxy measure for the shares of ARMs and FRMs in the loan portfolio of each household, we estimate responses by households' share of debt in ARMs. Separating the consumption responses of households along this dimension reveals a substantial difference in elasticities and MPCs out of an interest rate change. Households with a high share of ARMs respond strongly to a change in the policy rate, whereas households with a low share of ARMs (high share of FRMs) do not.

Our third result highlights the strong interaction between mortgage type and the level of liquid assets-to-income. We consistently reject that responses of households with ARMs and low liquid assets-to-income are equal to responses of households with ARMs and high liquid assets-to-income. In contrast, this is not the case for households with FRMs.

In sum, our findings are consistent with widespread hand-to-mouth behavior among households. Furthermore, they suggest a high prevalence of relatively wealthy hand-to-mouth households. In line with this interpretation, we note that only 22 percent of the homeowners' net worth are in liquid assets, whereas 78 percent are tied to illiquid assets. Moreover, there is a strong negative correlation between debt and liquid assets. While the average homeowner has liquid assets corresponding to eight months of disposable income, homeowners with a high debt-to-income ratio have less than three months' worth of income in liquid assets.

Our paper contributes to a recent empirical literature on the relation between household debt, mortgage markets, and the transmission of monetary policy. Di Maggio et al. (2017) study a group of U.S. households with mortgages that face interest rates that are held fixed for five years before being automatically adjusted. They exploit the staggering of such contracts to estimate consumption responses to changes in interest rates and find strong responses in car purchases to a change in interest expenses. An important difference between their study and ours is that we use a comprehensive expense-based measure of consumption rather than being limited to a measure of durable consumption such as car purchases. La Cava et al. (2016) explore the cash-flow channel in Australia using the large decline in interest rates early on in the financial crisis. They find that durable consumption responds more strongly to changes in cash flows for borrowers than savers, in particular for borrowers that hold debt with variable interest rates. Cloyne et al. (2019) study the response of expenditure and income to monetary policy in the United Kingdom and the United

States.[6] In the absence of detailed balance sheet information, they use housing tenure status as a proxy for debt positions, finding that the consumption response to a temporary cut in interest rates depends on households' balance sheets. However, they argue that the general equilibrium effect of monetary policy on income is quantitatively more important than the direct effect of cash flows. In contrast to Cloyne et al. (2019), we are able to study responses across the distribution of debt positions even among households with the same housing tenure status, and thus shed some further light on the mechanisms at work. Jappelli and Scognamiglio (2018) study the consumption responses to interest rate reduction for holders of ARMs relative to those with FRMs in Italy during the Great Recession. Different from our study and other related studies, they find a very weak consumption response to a change in interest expenses and therefore limited support for the cash-flow channel. Using aggregate data, Calza et al. (2013) document that the transmission of monetary policy shocks to residential investment and house prices is stronger in countries with more flexible and developed mortgage markets, and that responses in consumption are stronger in countries where there is a higher prevalence of ARMs.

The long period with an extraordinarily expansionary monetary policy after the outbreak of the financial crisis has resulted in a discussion about the distributional impact of monetary policy (see, e.g., Bullard, 2014; Mersch, 2014; Bernanke, 2015). Our findings of heterogenous effects of monetary policy on household spending complements a recent but growing literature studying heterogeneous and distributional effects of monetary policy. Recent empirical papers that more directly study the distributional impact of monetary policy include Sterk and Tenreyro (2018), Casiraghi et al. (2018), and Wong (2019), whereas Garriga et al. (2017), Gornemann et al. (2016) and Auclert (2019) are recent theoretical contributions to this literature.

More generally, our study is related to an extensive literature studying household consumption responses to fiscal stimulus programs, such as tax rebates, as well as other shocks to unearned income. This includes Shapiro and Slemrod (2003), Johnson et al. (2006), Agarwal et al. (2007), Shapiro and Slemrod (2009), and Parker et al. (2013), who study the effect of the 2001 and 2008 economic stimulus payments in the United States on consumer spending.[7] In all cases, the authors find a considerable consumption response to these income shocks, and the response is stronger for those that are more likely to be liquidity constrained. We view our paper as a monetary-policy analog to this work.

The remainder of the paper proceeds as follows. In Section 2, we provide a theoretical motivation for our empirical strategy, illustrating how the consumption behavior underlying the cash-flow channel differs from the standard consumer theory behind the interest-rate channel. Section 3 provides details on the data we use in our analysis and the background to our empirical setting. In Section 4 we outline our empirical strategy and in Section 5 we present our empirical results. Section 6 then summarizes a range of checks that illustrates the robustness of our results. Sec-

[6] Like in Sweden, ARMs make up a large share of the mortgages in the United Kingdom, whereas FRMs are more prevalent in the United States.

[7] Studies of consumption responses to other sources of shocks to disposable income include, e.g., Stephens (2008), Kueng (2018), Hsieh (2003), and Agarwal and Qian (2014).

tion 7 concludes the paper. Some additional material, supplementary analyses and details of our theoretical framework are relegated to an Online Appendix.

2 Theoretical motivation

Our analysis rests partly on theories of hand-to-mouth behavior and partly on recent models in which mortgage contracts are a source of transmission of monetary policy. Deviations from standard consumption smoothing have been considered for a long time. Carroll and Kimball (1990) show that the average marginal propensity to consume increases in the presence of borrowing constraints and uncertainty. Campbell and Mankiw (1990) introduce "rule-of-thumb" consumers as a potential explanation for the excess sensitivity of consumption. The role of mortgages in the transmission of monetary policy has also been discussed for a long time. Bernanke and Gertler (1995) and Mishkin (2007) point out that changes to short-term nominal interest rates affect households' mortgage burden, in turn affecting housing demand. Recently, models with mortgages demonstrate a more direct effect on households' overall consumption spending (see e.g. Garriga et al., 2017; Wong, 2019).

We structure our argument regarding the cash-flow transmission channel using two models. We first consider hand-to-mouth behavior in a model of an infinitely lived household with no nominal rigidities (see Online Appendix A for full details). Consider a household whose financial wealth is small relative to its interest-only ARM, implying that net financial assets is approximately equal to minus the balance of the household's ARM.[8] Let d_t denote this mortgage debt. The intertemporal budget constraint reads $c_t - d_{t+1} = y_t - d_t(1 + r_t)$, where c_t is consumption, y_t is labor income, and r_t is the real interest rate. By definition, hand-to-mouth households (henceforth HtM households) hold net financial assets constant. Hence consumption obeys $c_t = y_t - r_t \cdot d_t$. In other words, the marginal propensity to consume out of a change to the short-term interest rate is equal to one. This is the response if a household is borrowing constrained or if it behaves in such a way for other reasons (e.g., due to deviations from rationality). To obtain a measure of the elasticity in the response, we log-linearize the consumption function around steady state to get:

$$\Delta \log c_t \approx \theta \cdot \Delta \log y_t - \theta \cdot \frac{d}{y} \cdot \Delta r_t, \tag{1}$$

where θ is the inverse of the household's (steady-state) consumption-to-income ratio and $\frac{d}{y}$ the (steady state) debt-to-income (DTI) ratio. This equation shows that the percentage consumption response to interest rate changes is proportional to the household's DTI ratio. Note also that the response of HtM households does not depend on when information about the interest rate change arrives. Their consumption responds when their cash flow changes, irrespective of whether the change was anticipated or not. In contrast, rational consumption smoothers have an identical elasticity in their consumption response, regardless of their DTI ratio (provided that wealth effects

[8] Notice that for the typical mortgage holder, gross financial assets is small relative to the value of the mortgage.

and the likelihood of becoming constrained in the future can be ignored).[9]

Let us now consider a more complex partial equilibrium model (see Online Appendix B for full details). In this model, building on Garriga et al. (2017), households' life spans are finite, there is persistence in interest rate shocks, and mortgage contracts are nominal and in the form of either ARMs or FRMs. To mimic the Swedish setting, the FRM has a 5-year interest-rate fixation period. Rational optimizing households have access to a one-period nominal bond. The shocks to the short-term nominal interest rate may be equivalent to a real shock (i.e., inflation is unaffected) or partially nominal (i.e., positively correlated with inflation). In the extreme, the shocks are purely nominal and the Fisher equation holds.[10]

We first consider optimizing households' consumption response to a change in the nominal interest rate in the case when inflation is unaffected. For optimizing households with ARMs, the response is immediate and uniform across DTI ratios, as in the simpler model (ignoring differences in remaining life span that imply a small difference in wealth effects). The response is entirely a function of intertemporal substitution. For a temporary positive shock, optimizing households intertemporally smooth consumption by borrowing some more in the one-period bond so that the consumption response is small (i.e., the optimal response requires access to a buffer). The greater the persistence of the shock in the interest rate, the greater the response in consumption. For optimizing households with FRMs, the response is immediate too, provided that the shock is persistent and lasts longer than the interest-rate fixation period of the households' mortgage. Optimizing households with FRMs strive to smooth consumption over time and achieve this by saving more and consuming less today. So for optimizing unconstrained households with either kind of mortgage contract, the consumption response is essentially independent of the DTI ratio, but somewhat stronger for households with ARMs than for households with FRMs. The magnitude of optimizing households' responses depends on how inflation is affected. In the extreme case when the Fisher equation holds, households with ARMs are compensated exactly by opposing short-term and long-term wealth effects and their consumption does not respond at all (though changes in the bond positions are large). In this extreme case, households with FRMs gain from higher inflation.

We now turn to HtM households. As in the simpler model, HtM households' consumption response is not uniform but rather proportional to the DTI ratio. HtM households with ARMs

[9]Rational unconstrained households' responses can be thought of as obeying $\Delta \log c_t = \delta_t$, where δ_t is a time fixed effect common to everyone.

[10]We focus on the income effect of Garriga et al. (2017) and abstract from the price effect on housing associated with housing transactions. This is consistent with our empirical approach, where we exclude households that transact housing (yet, all households are exposed to a common house price effect). Another related model is Wong (2019). In an incomplete markets model calibrated to the United States, she highlights the role of refinancing of FRMs for monetary policy transmission. In a counterfactual analysis, she also finds that the monetary policy transmission through mortgages is stronger in an economy with ARMs. Greenwald (2018) sets up a general equilibrium model with loan-to-value and payment-to-income constraints and studies monetary policy transmission in it. Auclert (2019) develops a consumer theoretic framework where households' net nominal positions and unhedged interested exposure matter for the response. See further discussion in Online Appendix B.

respond immediately, whereas HtM households with FRMs respond with a delay (i.e., only when the interest-rate fixation period ends). Finally, HtM households do not consider future inflation. Hence, the short-term consumption response of HtM households with ARMs is essentially independent from the shock's effect on inflation.

We highlight four implications from our model for household behavior. First, HtM households' responses are approximately proportional to their DTI ratio, whereas optimizing households' responses are independent of their DTI ratio (ignoring borrowing constraints) and smaller than HtM households' as long as the shock to the interest rate is not very persistent. Second, HtM households respond to both anticipated and unanticipated changes, whereas optimizing households respond only to unanticipated changes. Third, how shocks to the nominal interest rate affects inflation matters little for the short-term consumption response of HtM households with ARMs. Fourth, we note that consumption of optimizing households with ARMs responds stronger than consumption of households with FRMs and that optimal responses of households with ARMs requires access to a buffer of liquid assets or to credit.

3 Data and Institutional Background

3.1 Data description

The main data set we use is the Swedish registry-based panel data set LINDA (Longitudinal INdividual DAta for Sweden). This data set is representative of the Swedish population, covering a random sample of 300,000 households and their members. Since in Sweden, as in other Scandinavian countries, each taxpayer has a unique social security number, we are able to construct a panel using several sources of administrative data. Our sample period covers 2000–2007. During this period, Sweden levied a wealth tax that required every financial institution to provide the tax authority with comprehensive information on all taxpayers' wealth, in addition to information on earnings and income.[11] The tax registers therefore include information on all taxable income and transfers, tax payments, liabilities and taxable wealth, including the value of real estate (i.e., houses, apartments, and cabins), cash holdings on bank accounts, bonds, stocks, and mutual funds.[12]

The market values of single-family houses and cabins are assessed by Statistics Sweden. They are a function of a long list of characteristics of the property and updated yearly using a price index constructed from transactions in a given municipality in each year. The market values of apartments (shares in co-op associations) are also assessed by Statistics Sweden but with more noise. The values of financial assets are detailed, and, for instance, each household reports each and every listed stock or mutual fund it holds in its tax filings (see Calvet et al., 2007). The data

[11]Most of this information was submitted automatically to the tax authority by employers, banks, and public authorities and registers.

[12]For further details on the data set used in the current paper, see Koijen et al. (2015), and for a detailed account of the data collection process for LINDA, see Edin and Fredriksson (2000).

set contains information on total household debt, which is the debt measure we use in the empirical analysis. The data set also contains information about annual interest expenses on that debt. Finally, the data set includes residential location for each household and various demographic variables.

The unit of analysis is the household, meaning that individual data have been aggregated to the household level using marital status, residential location, and parent-child linkages (household identifiers are constructed by Statistics Sweden based on this information). Household characteristics, such as age and education, represent a household head, which we take as the oldest individual in the household unless more than one individual is of that same age, in which case we choose the oldest male.

3.2 Imputing consumption

We use this detailed data set to impute a measure of consumption expenses based on the approach first developed by Browning and Leth-Petersen (2003) and that has been adapted and applied to Swedish data in Koijen et al. (2015). This is a necessary step in our exercise, as our main outcome of interest is in terms of household spending.

A common way of describing a given household i's budget constraint in year t is as follows:

$$c_{i,t} = y_{i,t} + \Delta d_{i,t} - r^d_{i,t} d_{i,t-1} - \Delta a_{i,t} + r^a_{i,t} a_{i,t-1}. \tag{2}$$

That is, consumption, c, is constrained by disposable income, y, the change in outstanding debt, Δd, interest payments, $r^d d$, savings, Δa, and their returns $r^a a$. Based on the notion that the budget constraint can serve as an accounting identity in a given year, it can be used to impute a measure of consumption as total income net of change in wealth from the previous period. This is possible since all terms on the right-hand side of equation (2) are observable in our data. Mapping equation (2) into the detailed structure of our data gives the identity:

$$c_{i,t} = y_{i,t} + \Delta d_{i,t} - r^d_{i,t} d_{i,t-1} - \Delta b_{i,t} - \Delta v_{i,t} - \Delta \psi_{i,t} - \omega_{i,t}, \tag{3}$$

where the household's disposable income, y_i, includes labor income, transfers and benefits (all net of taxes), and financial income; Δd is the change in debt; $r^d d$ are interest payments; Δb is the change in deposits on bank accounts; Δv is an active re-balancing of mutual funds, stocks, and bonds; $\Delta \psi$ are changes in capital insurance accounts; and ω are contributions to private pension savings. Equation (3) is identical to the imputation method in Koijen et al. (2015), which describes the accuracy of this method through a comparison with additional information and surveys.[13]

[13] Relative to Koijen et al. (2015), one refinement has been made that concerns bank accounts. Bank account deposits are reported only if certain criteria are met, and those changed in 2006. In 2000–2005, a deposit in a bank account was reported in the Swedish tax records if the earned interest from that account exceeded SEK 100, while in 2006 and 2007, the deposit was reported only if the balance in the account exceeded SEK 10,000. Overall, the new rule implies an improvement in accuracy. However, to avoid over-stating the savings between 2005 and 2006, we artificially implement the reporting rule of 2000–2005 also on the latter period when imputing consumption.

3.3 Sampling restrictions

Our household-level panel data set is outstanding in that it contains detailed information about the households' balance sheets at an annual frequency. Nevertheless, we impose a few restrictions on our sample, most of which are related to the construction of the consumption measure where we follow Koijen et al. (2015). First, we require households to be present for two consecutive years. Second, we drop households that transact in real estate or apartments because such events require additional careful adjustments that rely on additional non-registry-based data (see, e.g., the discussion in the Appendix of Sodini et al. (2017)). In addition, we exclude observations with outliers in disposable income, the debt-to-income ratio, or the consumption measure. All in all, our sample corresponds to approximately 25 percent of the LINDA households in 2002–2007. Table A.4 in the Appendix C reports incremental changes to the sample as restrictions are imposed.

3.4 The Swedish mortgage market

Our proposed transmission channel of monetary policy relies on a high prevalence of ARMs. Figure 1a displays the division of new mortgages in Sweden by the duration of interest-rate fixation, where ARMs are defined as those where interest rates are adjusted every three months or more frequently. The figure shows that a large share, almost half, of the new mortgages issued during our sample period were on adjustable rates. In terms of the total stock of the outstanding mortgage debt, Figure 1b reports that the value-weighted share of ARMs was between 30 and 40 percent during the sample period.[14] Furthermore, FRMs in Sweden have a fairly short interest-rate fixation period. 90 percent of the new mortgages have a fixation period of less than five years. In addition to mortgage debt, a large part of other loans to households, such as car and consumption loans, has adjustable rates. This implies that lenders, at least partially, pass through a rise in their own borrowing costs by raising their interest rates. Taken together, these aggregate statistics imply that changes in the monetary policy rate are quickly passed through to changes in households' interest expenses.

An important characterization of the Swedish mortgage market is that households frequently hold a combination of ARMs and FRMs, rather than one or the other. These components have different durations of interest-rate fixation, which differ from that of the mortgage itself, meaning that their rates will be reset at different points in time (Sveriges Riksbank, 2014). There are two reasons for households to choose ARMs. First, interest rates on ARMs have historically often been lower than rates on FRMs. Second, if a household with an FRM wants to repay, refinance, or change conditions on the mortgage—e.g., negotiate a new interest rate—it has to compensate the bank for the interest rate differential if market rates have fallen. In other words, the borrower bears the cost of refinancing to adjustable rates. In this way, households with FRMs cannot respond to decreasing interest rates by simply changing contract type during the interest-rate fixation period. Banks therefore frequently recommend a combination of FRMs vs. ARMs as it lowers the risk

[14]Since then, the share with adjustable interest rates has continued to increase. In 2018, approximately 70 percent of outstanding mortgage debt had a duration of less than one year.

that the whole loan will be adjusted to a higher rate, while enabling households to benefit from decreasing interest rates. How households choose the shares of FRMs and ARMs is then likely to depend on current market conditions when the mortgages were issued, for instance at times of house purchases, and are therefore predetermined at the time when we study the effects of interest rate changes on their consumption expenditure.

These aforementioned characteristics of the Swedish mortgage market lessen the concerns over selection into one type of mortgage contract relative to another. As discussed below and presented in the Appendix, we find evidence in our data that households that we identify as holders of ARMs are observationally similar to FRM holders along a variety of important dimensions. In support of this notion, previous analysis has found that outcomes related to households' financial health, such as the probability of mortgage default, do not correlate with the choice of interest-rate fixation (Holmberg et al., 2015). Moreover, across households with different cash-flow margins and debt-to-income ratios, there are limited indicators of systematic differences in the duration of interest-rate fixation. Households with low cash-flow margins do, if anything, hold a somewhat lower share of their debt in adjustable rates (Finansinspektionen, 2017). Other things equal, this would imply that households with a larger share in ARMs should be better equipped to take on an unexpected increase in expenses, e.g., due to higher interest rates.

3.5 Characteristics and indebtedness of Swedish households

We wish to highlight some general characteristics of Swedish households and their balance sheets. Table 1 reports summary statistics for our sample as a whole as well as separated into renters and homeowners. Homeowners are more resourceful than renters along essentially any dimension. For instance, they are more educated and have higher incomes. Adult equivalent disposable income differs by 29 kSEK and adult equivalent consumption by 19 kSEK.[15] Homeowners have more liquid assets than renters, 168 kSEK compared with 69 kSEK. However, most of their wealth is in illiquid assets. The average loan-to-value ratio is 0.45, and 78 percent of the net worth is illiquid assets.

Figure 2 graphically illustrates why homeowners in our sample with a high debt relative to income (DTI) are likely to be more sensitive to interest rate changes than relatively less indebted homeowners. The top panels display the mean and median asset and debt balances in relation to disposable income for three groups: renters, homeowners with a DTI less than 3, and homeowners with a DTI equal to or greater than 3 (we refer to the latter as high DTI households). The group of homeowners with a high DTI ratio comprises 9.2 percent of all homeowners. Whereas illiquid assets are relatively evenly distributed among homeowners—the mean is 4 for homeowners, and 6 for the high DTI group—liquid assets are less evenly distributed. The average homeowner has liquid assets worth approximately 8 months of disposable income. In contrast, the most highly indebted group has less than 4 months of disposable income. These statistics relate to a growing

[15] The exchange rate during our sample period was approximately 7.50 SEK/USD, so 1 kSEK is approximately equal to USD $133.

literature (e.g., Kaplan et al. (2014)) emphasizing the importance of the liquidity of households' wealth for understanding consumption responses to income shocks and emphasizing the significant share of wealthy HtM households in the population.

The bottom panels of Figure 2 display a cross-sectional variation in interest expenses relative to disposable income and consumption. Homeowners with a high DTI ratio spend on average 15 percent of their yearly disposable income on interest expenses. A doubling of the interest rate that homeowners face would thus imply that the median homeowner in the high DTI category would deplete the liquid assets within one year, unless they adjust their income or consumption. These households are wealthy in terms of illiquid wealth but hold very little liquid wealth. Thus, these households are likely to have a high propensity to consume out of changes in transitory income and to not react strongly to news about future income changes. Another measure of interest rate risk is the ratio of liquid assets to interest expenses. There are substantial differences in this ratio between renters, homeowners, and homeowners with high DTI. The median homeowner has liquid assets that are 2.6 times higher than their annual interest expenses, whereas this ratio is only 0.86 for the median homeowner with high DTI, meaning that their annual interest expenses are larger than their liquid assets.

Combined with a high prevalence of ARMs, these empirical patterns lend support to our hypothesis of the sensitivity of a significant share of indebted households to changes in interest expenses.

4 Empirical Strategy

4.1 Econometric specification

In Section 2 we outlined our theoretical argument for the cash-flow channel being operational among HtM households that have a large share of their debt in ARMs. The theory predicts that, for these households, the magnitude of the consumption response is approximately proportional to the DTI ratio. Building on these theoretical predictions, our main specification is:

$$\Delta \log c_{i,t} = \alpha_i + \delta_t + \beta \Delta r_t \times \mathrm{DTI}_{i,t-2} + \mathbf{X}'_{i,t}\gamma + \varepsilon_{i,t}, \tag{4}$$

where $\Delta \log c_{i,t}$ denotes the percentage change in consumption spending of household i in year t. The variable Δr_t is the change in the relevant interest rate, which, depending on the specification, is either the monetary policy interest rate (i.e., the *repo rate*) or an aggregate household interest rate measured by Statistics Sweden using data on all loans to households.[16] The variable $\mathrm{DTI}_{i,t-2}$ is the household's DTI ratio, which we lag by one year so that it is predetermined with respect to $c_{i,t-1}$.

[16]Note that this specification relates household spending to an aggregate interest rate, Δr_t, with no subindex i. Specifically, it does not use a measure of a household-specific interest rate. Thus, we avoid a potential bias that would arise if unobserved idiosyncratic events, for instance, negative news about future income, affect both the household's consumption path and the household's creditworthiness. We provide further discussion on this in Section 5.2 as well as reporting results from other alternative specifications in the Online Appendix.

We denote individual fixed effects and year fixed effect by α_i and δ_t, respectively. Individual fixed effects capture any time-invariant cross-sectional heterogeneity, such as in borrowing behavior or portfolio choice. Year fixed effects capture all common macroeconomic effects and responses to aggregate shocks, including intertemporal consumption responses of optimizing households. The vector $\mathbf{X}_{i,t}$ collects a set of controls, including demographic characteristics; a fourth-order polynomial in age, the number of children and the change in the number of children, and an interaction between Δr_t and dummy variables for being young (< 40), being old (≥ 60), and having children, aimed at accounting for characteristics that may, on average, interact with the sensitivity to changes in aggregate interest rates.

The coefficient β captures the effect of interest rate changes on consumption, operating through the cash-flow channel. It measures consumption responses to changes in the interest rate that vary systematically due to differences in DTI. If all households are optimizers, theory predicts $\beta = 0$. Conversely, if all households are HtM and obey equation (1), theory instead predicts that β equals the average income-to-consumption ratio (θ), which is likely close to 1.[17] Regression estimates of β will therefore capture the average response in our sample, weighted by the relative size and responses of the different household groups.

4.2 Identification using monetary policy shocks

Under the cash-flow channel, HtM households respond to interest rate changes when their cash flow changes, irrespective of whether the change was anticipated or unexpected. The coefficient β in equation (4) captures this effect. Importantly, our empirical specification includes both year fixed effects—accounting for the overall aggregate effects of monetary policy on household spending, including intertemporal substitution of consumption—and household fixed effects—accounting for time-invariant individual differences, including those in consumption growth. As a result, β captures consumption responses due to cross-sectional variation in interest-rate sensitivity, less the aggregate effect.

However, our empirical analysis faces the standard problem of reverse causality in estimating the effects of monetary policy, namely that households respond to monetary policy but monetary policy may also respond to the economic conditions of households. In particular, this concern arises if the central bank responds to macroeconomic development that relates to the conditions of more indebted households.

To overcome this issue, we separate unanticipated changes in interest rates from those that are anticipated based on macroeconomic conditions and use this measure of monetary policy shocks as an instrumental variable in our estimation. To this end, we measure monetary policy shocks using an approach similar to what is used in recent literature studying monetary non-neutrality, including Gürkaynak et al. (2005), Gertler and Karadi (2015), Hanson and Stein (2015), and Nakamura and Steinsson (2018), building on an approach pioneered by Kuttner (2001) and Cochrane and Piazzesi (2002). Using data at high frequency, this literature seeks to identify innovations in

[17] In our sample, the average income-to-consumption ratio is 0.98.

monetary policy that are due entirely to policy shifts and not to macroeconomic development. Following this approach, we use a tight window around the time of a monetary policy announcement to isolate the effect of a policy surprise on market interest rates. During our sample period, the Swedish market on futures, called STINA, was still undeveloped and illiquid. Unlike the aforementioned studies who use data from the U.S. and measure shocks using changes in the federal funds futures, we are unable to measure shocks using futures. Instead we therefore use the yield at a daily frequency of a one-month Swedish Treasury bill, computing a difference in the interest rates between the beginning and end of the days of monetary policy announcements.[18]

4.3 Threats to identification

The identification strategy of using monetary policy shocks as instruments for changes in interest rates does not come without challenges. The key challenge we face is the discrepancy between the frequency at which we measure monetary policy shocks and at which we observe changes in spending. Following precedent from earlier work, including Romer and Romer (2004), Coibion (2012) and Cloyne et al. (2019), we time-aggregate the monetary policy shocks to a yearly frequency by summing up measured shocks from all announcements in a year.[19]

In Figure 3 we document two important correlations for our empirical strategy. First, in Panel (a) we document that the average interest rate on household debt closely follows the monetary policy rate, which is expected given the large share of debt with adjustable interest rates. Second, in Panel (b), we document how our measure of monetary policy shocks covaries with the monetary policy rate. While, as expected, the magnitude of these unanticipated changes in monetary policy rates is considerably smaller than the overall changes in interest rates, there is a strong positive comovement of the shocks and the policy rate over the sample period. This 'first stage' validates their use as an instrumental variable in our estimation.

The second challenge we face using this identification strategy is the concern that monetary policy shocks may influence consumption through other channels than interest rates, violating the exclusion restriction. While we cannot rule out this possibility, we argue that such effects would need to run through channels that affect households differentially across the DTI distribution, since all aggregate channels through which monetary policy shocks, and changes in interest rates more generally, affect consumption are captured by year fixed effects.

In addition to the aforementioned challenges, one caveat to our empirical analysis is that, given the data at hand, we are not able to observe if households refinance their debt or adjust their

[18] The lack of futures data also prevents us from exploring responses to shocks of different persistence – e.g., by separating policy shocks into a "target factor" and a "path factor" following Gürkaynak et al. (2005). This might, for example, allow us to separately identifying responses of HtM households to temporary shocks from responses of optimizing households. However, as highlighted in Online Appendix B the latter are likely to be small.

[19] We acknowledge that this method allocates equal weights to shocks independent of whether they occur early or late in the year. We have explored the robustness of our results to alternative approaches to aggregation, including using within-year duration weights, which provides more weight to shocks the earlier in the year that they occur. We find that this does not have a meaningful effect on our estimates.

amortization in response to interest rate changes. Any strategic response of that kind would be subsumed into the estimated cash-flow effect. But since borrowers must compensate the bank for changes in market interest rates when refinancing a FRM, we argue that it is unlikely that refinancing correlates systematically with changes in the monetary policy rate. Moreover, for highly indebted and constrained households that consume most of their disposable income, a decrease in the short-term interest rate implies an increase in disposable income and by that increased consumption possibilities, which are likely to be highly valued. Therefore, we expect any strategic refinancing or amortization to come from *less* constrained (less indebted) households, which would bias our estimate of β toward zero.

5 Results

5.1 Consumption responses to interest rate changes by indebtedness

Table 2 reports OLS estimates of consumption responses to changes in the the monetary policy (repo) interest rate, based on the regression equation (4). Column (1) reports a coefficient estimate of β of -0.26. The interpretation of this estimate is that the average household, which has a DTI of 0.88, reduces its consumption spending by an additional 0.23 percentage points (0.88×0.26) in response to a one-percentage-point increase in the monetary policy rate, relative to a household with no debt. Households that differ in their indebtedness and therefore, according to our hypothesis, in their consumption sensitivity to monetary policy, may also differ in their holdings of liquid assets. If households with high DTI hold disproportionally more liquid assets, our measure of the cash-flow channel will be muted. To investigate the importance of this effect, Column (2) controls for the ratio of liquid assets-to-income, lagged in the same way as the DTI ratio. The coefficient estimate is only marginally affected by this control. In Columns (3) and (4), we repeat these regressions for the sample of homeowners. The heterogeneous response of homeowners with different DTI ratios is about the same as in the greater population. The estimated coefficient is between -0.20 and -0.21, indicating that the average homeowner with a DTI of 1.27 reduces its consumption spending by an additional 0.27 percentage points (1.27×0.21) in response to a one-percentage-point change in the monetary policy rate, relative to homeowners without mortgage debt.[20] These results imply that indebtedness matters not only in terms of the relative responses of (indebted) homeowners and renters, as found in Cloyne et al. (2019), but also within the group of homeowners where more indebted households reduce their consumption spending disproportionately relative to those less indebted.[21]

[20] A potential concern with using DTI lagged two years is that the behavior of households that make large changes to their DTI between t and $t-2$ is ill-measured. To evaluate the implication that this might have for our estimates, we exclude households with large increases (top 10%) and decreases (bottom 10%) in the DTI ratio. Our main estimates are robust to this exclusion. The estimated coefficients are somewhat more negative compared with Table 2.

[21] We also consider the potentially differential consumption responses to a change in the monetary policy rate among households in different parts of the DTI distribution. In a regression specification alternative to equation (4), instead of including the DTI ratio in levels we construct five indicator variables for quantiles of the DTI distribution and interact

As we have emphasized above, consumption responses operating through the cash-flow channel occur in response to any interest-expense driven change in cash flow, irrespective of whether the change was anticipated or not. However, in estimating these responses we face the problem of reverse causality: households respond to monetary policy-induced interest changes while monetary policy may also respond to the economic conditions of households. While we account for all aggregate effects of monetary policy on consumption by including year fixed effects, there is still a concern that monetary policy responds to the conditions of highly indebted households. We address this issue by using monetary policy shocks—variations in the policy rate not driven by changes in macroeconomic conditions—as instruments for changes in the interest rate.

The bottom panel of Table 2 presents two-stage least squares estimates of equation (4) where changes in interest rates are instrumented with monetary policy shocks. This isolates consumption responses to changes in interest rates that are unanticipated. Columns (1) through (4) report coefficient estimates of β between -0.40 and -0.42. This implies that, on average, households in the full sample reduce their consumption spending by an additional 0.35 percentage points in response to a one-percentage-point increase in the monetary policy rate, relative to a household with no debt. For homeowners, the corresponding number is 0.53. Compared to the OLS estimates, these estimates are fifty to one-hundred percent greater and imply considerably stronger cash-flow effects. This may both reflect that the IV estimates capture only responses to unanticipated changes in interest expenses, which could even be lower if some near-constrained households are able to smooth their consumption, or the fact that the OLS estimate might be biased towards zero, e.g., due to strategic responses such as refinancing or amortization. All in all, our results are consistent with presence of households that display HtM behavior, as discussed in Section 2. More precisely, our estimates can be compared to regression estimates on data generated from model simulations, reported in Online Appendix B. Comparisons suggest that our estimates are at least three times as large as those generated by optimal consumption responses of households with ARMs, and of similar magnitude to estimates on model data based on a configuration such that fifty percent of households have ARMs, and the remainder have FRMs, and such that fifty percent of households respond optimally, and the remainder display HtM behavior.

As an alternative to our estimates of responses to changes in the policy rate, Table 3 documents responses to aggregate interest rate faced by households. This rate, which we obtain from Statistics Sweden, is the average of interest rates across all loans to households. By focusing on responses to this interest rate, we ignore the first step in the transmission of monetary policy into households' interest payments. As documented in Figure 3a, the average interest rates on household debt closely follow the monetary policy rate.[22] Column (1) in the top panel of Table 3 reports a coefficient estimate of β of -0.62. This implies that a one-percentage-point increase in the lending

these indicators with the change in the monetary policy rate. The estimated coefficients are negative for all five groups and largest in absolute value for the two upper quantiles. Results are available upon request.

[22] To further gauge the passthrough of monetary policy rates to interests on household debt, we estimate a regression of the change in the average household rate on the change in the policy rate, which gives a coefficient estimate of about 0.68.

rate reduces the consumption spending of the average household by an additional 0.55 percentage points (0.62×0.88) relative to those without debt. As for the response to changes in the policy rate, the magnitudes are similar when controlling for holdings of liquid assets and when restricting the sample to homeowners only. The difference between the estimates in Tables 2 and 3 reflect that responses to changes in the monetary policy rate are muted due to an incomplete transmission to household interest rates. This is expected as changes in the policy rate get transmitted into changes in household interest rates and expenses only for those with adjustable rates.

In the bottom panel of Table 3, we report IV estimates where the average household interest rate is instrumented with monetary policy shocks. These estimates are similar to the OLS estimates in magnitude—if anything, slightly smaller in absolute value—implying that consumption responds equally strongly to anticipated and unanticipated changes in interest expenses, as predicted by the theory laid out in Section 2.

The estimates of β can be translated into a relative marginal propensity to consume (MPC) out of changes in disposable income, or cash flow, as a result of a change in the interest rates. Under a perfect passthrough of interest rate changes to households' interest payments, the above estimates imply an MPC in the interval 0.22–0.53 out of a one-unit increase in interest expenses.[23]

5.2 The role of mortgage types

Our point of departure, theoretically motivated by Section 2, is that if the interest rates on household debt are tightly linked to short-term interest rates, changes in monetary policy will have a direct effect on households' interest expenses, which will translate into a reduction in household consumption expenditure if they are HtM households. This is what we refer to as the cash-flow channel. We argue that Sweden offers an ideal setting for evaluating the importance of this channel due to generally short interest-rate fixation periods and, in particular, a high prevalence of adjustable-rate mortgages and loans. However, our analysis until now has not differentiated between households with different types of mortgage contracts. We now provide more direct evidence illustrating how our estimates of differential consumption responses to interest rate changes operating through the cash-flow channel.

Since our data originate from tax records and do not include any contract details, we do not directly observe which households have a mortgage with an adjustable rate, a fixed rate, or, which is common, more than one mortgage and a mixture of the two. We also do not directly observe the interest rate that the household pays on its debt. Instead our approach is to first compute the implied household-specific interest rate using information on interest expenses and the amount

[23]The average consumption in our sample is 241k Swedish krona (SEK), and average debt is 284k SEK. A one-percentage-point increase in the interest rate reduces household cash flows by 0.01 × 284=2.84k SEK under perfect passthrough. According to the estimate in Table 2, top panel Column (1), the average reduction in consumption to a one-percentage-point interest rate increase is 0.26 × 0.88 × 0.01 × 241=0.55. This implies an MPC of 0.19 (0.55/2.84). Similar calculations based on the IV estimates in the bottom panel imply an MPC of 0.30–0.34. The estimates in Table 3 imply an MPC of 0.40–0.50. For homeowners, we use a consumption value of 285 kSEK and a debt value of 444 kSEK in these calculations.

of debt. Then, for each household, we calculate the correlation between its implied interest rate and the monetary policy rate. We use that correlation as a proxy for the impact of changes in the monetary policy rate on the interest expenses of that particular household, or to which extent each household has adjustable- or fixed-rate mortgages.

More precisely, we first calculate the interest rate $r^d_{i,t}$ for household i in year t as total interest expenses divided by average debt (in t and $t-1$):

$$r^d_{i,t} = \frac{\text{interest payment}_{i,t}}{0.5 \cdot \text{debt}_{i,t} + 0.5 \cdot \text{debt}_{i,t-1}}. \tag{5}$$

Based on this definition, we construct value-weighted and equally weighted household interest rates in our sample. Figure 3a illustrates the evolution of these rates and how they co-move with the monetary policy rate and the aggregate household interest rate reported by Statistics Sweden. Over our sample period, the household rates display the same U-shape as the monetary policy rate, which highlights the prevalence of ARMs. The value-weighted rate almost perfectly tracks the monetary policy rate with some lag. The equally weighted rate also tracks the fluctuation well, but the level is too high, indicating that small credits carry a higher interest.

As we discuss in Section 3.4, it is very common in Sweden to hold a portfolio of loans with a different duration of interest-rate fixation. Therefore, in our setting, holding debt with adjustable rates is not a binary variable. To obtain a proxy measure for how closely a household's interest rates react to short-term rates—i.e., what is the prevalence of ARMs vs. FRMs in households' debt portfolios—we compute the correlation between household-specific interest rates, $r^d_{i,t}$, and the monetary policy rate. We document the cross-sectional distribution of these correlation coefficients in Figure A.11 in the Online Appendix. Consistent with a high prevalence of ARMs, the median correlation in the population is 0.61.[24]

To evaluate the differential consumption response of holders of ARMs versus FRMs, we estimate an extended version of regression equation (4). First, we construct five indicator variables for quantiles of the correlation distribution, $\text{Interest fixation}_q$, where q=1 denotes the quantile with the lowest correlation—interpreted as reflecting households with loan portfolio consisting mainly of FRMs—and q=5 denotes the quantile with the highest correlation—interpreted as reflecting households with high prevalence of ARMs in their loan portfolio. We then run the following regression:

[24]One obvious concern is that few observations are used for each household in computing these correlations. However, measurement error due to misclassification into ARMs vs. FRMs would result in an attenuation bias, as the differential responses would be muted. Another concern, which we highlight in Section 4.3, is that changes in computed interest rates due to the resetting of interest rates cannot be separated from changes due to refinancing or loan repayment. This explains, e.g., the fact that we estimate a negative correlation coefficient for some households.

$$\Delta \log c_{i,t} = \alpha_i + \delta_t + \sum_{q=1}^{5} \lambda_q \text{ Interest fixation}_q \times \Delta r_t \times \text{DTI}_{i,t-2}$$
$$+ \sum_{q=1}^{5} \eta_g \text{ Interest fixation}_q \times \Delta r_t + \mathbf{X}'_{i,t}\gamma + \varepsilon_{i,t}. \quad (6)$$

Table 4 reports estimates of regression equation (6). For the two groups with the lowest correlation—higher prevalence of FRMs—the λ_q coefficients are not statistically significant. For the groups with higher correlation—higher prevalence of ARMs—the estimated responses are negative and stronger at the top of the distribution. There is a statistically significant difference between each of the two top quantiles and the bottom two quantiles. Comparing the OLS and IV estimates, the estimates are similar in magnitude although the IV estimates at the lower quantiles are larger (in absolute value) than the corresponding OLS estimates.[25]

In order to compute 'quantile effects' from these estimates, we multiply the estimates of λ_q by the average DTI ratio for that quantile group and add the corresponding η_q coefficient estimate.[26] We find that the heterogeneity in responses between the quantiles is sizeable: households with higher prevalence of ARMs display strongest responses. The differences in elasticities across the quantiles is approximately 0.90. Furthermore, F-tests imply that the differences between the top three quantiles relative to the bottom two are statistically significant. This implies that the responses reported so far are driven not only by differential responses of more indebted households but among them by those with a higher prevalence of debt with adjustable interest rates.

Figure 4 graphically illustrates our findings. The figure plots yearly changes in the repo rate—displaying a distinct U-shape during 2002–2007—as well as the difference in consumption growth for households with similar levels but different composition of debt. The left panel plots the median consumption growth of homeowners that belong to the high DTI group minus the median consumption growth of homeowners that belong to the high DTI group and have an interest-rate correlation with the repo rate above median (i.e., a proxy for having ARMs). The right panel displays the same group-differences in means instead of medians. In line with our regression estimates, the figure shows a strong positive correlation between this measure and the repo rate. As the repo rate increases, consumption falls behind among the highly indebted homeowners with ARMs.

5.3 The role of liquid assets

So far we have focused on differential responses due to differences in DTI ratios and interest-rate fixation on the mortgage. We now analyze the role of a third characteristic of the household

[25]Table A.9 in the Online Appendix reports results for a sample restricted to homeowners, finding similar results although the coefficients are less precisely estimated.

[26]The average DTI ratios for the different quantiles are $\{0.83, 1.17, 1.36, 1, 36, 1.23\}$. To illustrate, for the top quantile (i.e., the highest correlation) the group response is equal to $-0.440\times$ 1.23 + 0.421 = -0.120.

balance sheet, namely the level of liquid assets-to-income. Kaplan et al. (2014) emphasize that having low levels of liquid wealth is associated with hand-to-mouth behavior and one of the take-aways of Section 2 is that access to a buffer is critical for optimal consumption responses to increases in the mortgage interest rate.

To examine how liquid assets shape consumption responses, we group households by three characteristics: DTI ratios, interest-rate fixation, and liquid assets-to-income. For interest-rate fixation, a correlation below the median is taken as a proxy for the household having an FRM and a correlation above is taken as a proxy for the household having an ARM. This is broadly consistent with the aggregate shares. In addition, we classify households as having either low or high liquid assets-to-income. Again, the cut-off is at the median. Based on these three balance sheet characteristics we form eight (2×2×2) groups of households.

Panel A of Table 5 reports summary statistics for the groups. Households with high DTI ratios have higher levels of disposable income, on average, than those with low DTI ratios, have more household members, and have a household head that is slightly younger. Higher DTI ratios are also associated with higher levels of illiquid wealth, i.e., higher real estate value. Looking within groups with similar DTI and liquid assets-to-income ratios, households with ARMs and FRMs appear similar.

We extend our baseline regression (4) to include a sum of terms, $\sum_{k=1}^{8} \omega_k \text{Group}_k \times \Delta r$. The coefficient ω_k is an estimate of group k's response to changes in the monetary policy rate.[27] Panel B of Table 5 reports OLS estimates from this regression. Groups 1 and 8 are the two polar extremes from our classification and this is reflected in our estimates. The coefficient estimates vary from -0.69 to 0.97. For the other groups, estimates are in between. Since the groups are small and our imputed measure of consumption is noisy, some caution is warranted. We therefore complement the point estimates with F-tests of equality of estimates across groups. We report tests of equality for groups with similar DTI ratios and mortgage types but different levels of liquid assets-to-income. The tests indicate that for households with ARMs we can reject equal responses (columns 1 vs. 2 and columns 5 vs. 6) whereas this is not the case for households with FRMs (columns 3 vs. 4; columns 7 vs. 8). Groups with ARMs and low liquid assets-to-income display stronger responses (i.e., more negative consumption responses) relative to households with high liquid assets-to-income. This is consistent with households with little liquid assets displaying HtM behavior, and hence facing difficulties responding optimally to sudden increases in interest expenses. For households with high DTI ratios but FRMs, there is no direct effect on expenses in the short run, only future expenses if the interest rate increase is expected to be long lasting, and spending responses are independent of liquid assets. Consistent with this, the F-tests cannot reject equal responses.

Panel C of Table 5 reports IV estimates. Consistent with previous analysis in the paper, the

[27] We also include the lagged value of liquid assets-to-income in the vector of control variables, as in previous extensions of (4). Notice that the difference to (6) is that this regression specification only contains one set of terms with Δr_t which simplifies interpretation. Unlike the specification in (6), the classification prior to estimation already takes into account the household's DTI.

IV estimates display greater variation than the OLS estimates. One reason could be comparably weak first-stage effects for FRM households. We focus on equality of coefficients rather than point estimates. As in Panel B, we reject equality for households with ARMs and similar DTI ratios but different levels of liquid assets-to-income (columns 1 vs. 2; columns 5 vs. 6). In our IV estimation there is also a difference between households with low DTI and FRMs that have different liquid assets-to-income ratios (columns 7 vs. 8). However, some caution is warranted since the OLS and IV estimates of Group 7 are quite different. We conclude that responses of households with ARMs to a greater extent depend on their liquid assets-to-income.

6 Robustness

In this section we document a range of statistics and checks to evaluate the robustness of our results.

6.1 Savings in bank deposits

As discussed in Section 3, we only observe bank account deposits in our data if certain criteria on deposit amount are met. Thus, one potential concern is that if households choose to save slightly more or less in response to interest rate changes, this would be unobserved. However, if households save more in bank accounts in response to increased deposit rates, induced by a change in the monetary policy rate, and this is unobserved to us, it would overstate the change in consumption. In turn, this would lead to a bias towards zero in the estimates of β. We have evaluated the basis for this concern and document two pieces of relevant evidence. First, Figure A.10 in the Online Appendix shows that the monetary policy rate and the bank deposit rate are positively correlated. Regressing changes in the aggregate deposit rate on changes in the monetary policy rate gives a coefficient estimate of 0.62. Second, we find there to be a positive correlation between bank deposit rates and flows into bank account deposits. From this we conclude that it is likely that our estimates are biased towards zero due to this source of measurement error.

6.2 Heterogeneity in consumption-to-income ratios

The theoretical motivation for our empirical analysis, described in Section 2, implies that if all households are HtM consumers, the consumption response to a change in interest rates that directly translates into a change in interest expenses will be proportional to the consumption-to-income ratio (see equation (1)). While our empirical specification (4) captures the response of households to interest rate changes that vary in their effect by households' indebtedness, it assumes that individuals' consumption-to-income ratio is constant and subsumed in the individual fixed effects. However, it is possible that there is household-level variation in consumption-to-income ratios that are correlated with the consumption responses to changes in interest expenses. This would bias our estimates. We investigate this concern in Tables A.5 and A.6 in the Online Appendix, finding relatively similar but, if anything, somewhat stronger responses when accounting for individuals' consumption-to-income ratios.

6.3 Heterogeneity in income growth

As Section 2 describes, for HtM consumers, consumption moves closely with changes in interest rates but also with changes in income. If changes in monetary policy affect not only interest payments but also labor income directly, the effect that our empirical specification measures might not only measure the consumption response to changes in interest payments as a result of changes in the policy rate but also the response to a change in income from changes in monetary policy. To shed some light on this concern, we estimate equation (4) including income growth as an additional explanatory variable. As documented in Tables A.5-A.8 in the Online Appendix the estimates are largely unaffected by the inclusion of this control. While this exercise implies robustness of our results to the aforementioned concern, we are cautious when interpreting the results as including income growth as a control may itself introduce a bias to our estimates. As income growth should rather be thought of as an outcome variable itself, it is a "bad control" in the language of Angrist and Pischke (2008), and is therefore not included as a control in our main specification.

6.4 Further analysis of interest rate flexibility

In order to evaluate our results on the differential responses by our measure of interest-rate fixation, we compare the characteristics of households at the two sides of the spectrum. Table A.3 in the Online Appendix reports differences across households based on whether they have a correlation above or below the median. We denote these groups as holders of ARMs and holders of FRMs, respectively. We find that households with ARMs have higher income and consumption on average, but they also have more household members than holders of FRMs. Households with ARMs have more debt as well as more illiquid assets, but, importantly from the perspective of our analysis, there is no statistical difference in liquid assets. While the groups are statistically different along those dimensions, the differences are economically small. This is consistent with the conventional Swedish view that an ARM is not an exotic mortgage product and that households tend to hold more than one mortgage, often with interest rates of different duration.

To further evaluate the non-linearities in responses by interest rate flexibility, Table A.10 in the Online Appendix reports estimates of equation (6) where instead of interactions based on five quantile groups we use a continuous correlation measure (i.e., the triple interaction $\text{Corr}_i \times \Delta r_t \times \text{DTI}_{i,t-2}$). The estimates imply that households holding only ARMs ($\text{Corr}_i \approx 1$) respond to a one-percentage-point increase in interest rates by reducing their consumption by about 0.4–0.6 percentage points more than households holding only FRMs. These results are somewhat stronger when restricting the sample include only to homeowners.[28]

[28] As discussed above and reported in Figure A.11 in the Online Appendix, some households have a negative correlation, which may result from changes in interest rates due to refinancing or loan repayment. When restricting the

6.5 Household-specific interest rates

To this point, our analysis has focused on consumption responses to aggregate interest rates. There are two reasons for this choice. First, our aim is to shed light on a transmission mechanism of monetary policy that operates through the direct effect of changes in policy rates on households' interest expenses. Since the passthrough to household interest rates is not perfect, estimating responses to changes in household interest rates directly moves us further from this goal. Second, as our data neither include details about loan contracts nor refinancing of loans, we cannot separate changes in interest expenses that are due to changes in the policy rate from those due to other factors.

To evaluate the implication of this restriction, Table A.11 in the Online Appendix reports consumption responses to two measures: individual households' interest rates and their total interest expenses. Columns (1) and (2) report estimates of equation (4) where the interest rate is the household-specific interest rate rather than the monetary policy rate. The coefficient estimate implies a similar but somewhat weaker response than what is reported in Section 5.1. The estimates imply that the average household reduces its consumption spending by an additional 0.25 percentage points (1.4×0.18) in response to a one-percentage-point increase in its average interest rate, relative to a household with no debt. The results, as before, are robust to controlling for differences in liquid asset holdings. Columns (3) and (4) report estimates from an alternative specification where we relate the change in consumption directly to changes in households' interest expenses. The coefficient estimates, which can be interpreted as the MPC out of a one unit increase in interest expenses, imply an MPC of about 0.16. Possibly consistent with our concerns, both sets of estimates imply weaker responses than our preferred estimates reported in Section 5.1.

7 Conclusion

Using detailed data on consumption and balance sheets of Swedish households, we find evidence of the cash-flow channel of monetary policy transmission. Households with higher levels of debt relative to their income respond more strongly to changes in the policy interest rate than those that are less indebted. This is true even among homeowners and households with high levels of illiquid wealth, who hold disproportionally little liquid wealth. Our results document that these responses are driven by households that hold some or a large share of their debt in contracts where interest rates are linked to short-term rates, such as ARMs, and are therefore at short notice directly exposed to monetary policy changes.

Our results highlight the importance of other channels of monetary policy transmission than the conventional interest-rate channel. The findings indicate that monetary policy is more potent in economic environments where households hold high levels of debt relative to their income face

sample to households with a non-negative correlation, the coefficient estimates are broadly similar and, if anything, stronger than for the full sample.

a restricted access to credit, and changes in policy rates are quickly passed through to changes in lending rates and interest expenses. We demonstrate this in a setting where households are relatively highly indebted and loan and mortgage contracts with variable interest rates are standard and non-exotic, covering nearly half of the outstanding debt during our sample period. Under such conditions, monetary policy can have a stronger effect on real economic activity than what is predicted by conventional estimates where transmission operates first and foremost through intertemporal substitution.

It is necessary to emphasize the limitations of our study and the generalizability of our results. Our empirical analysis is directed and limited to illustrating the cash-flow effect of changes in interest rates and cannot speak directly to the effects that monetary policy may have on the supply of credit. This may be an important channel, particularly at times when central banks make large changes to their policy rates. More generally, we are unable to characterize the general equilibrium effect of the cash-flow channel on aggregate consumption in the economy, has been highlighted in recent and contemporaneous research (Cloyne et al., 2019). Another channel that we have not been able to incorporate into our analysis, but is likely to be important, is that monetary policy may have heterogeneous effects on household consumption by affecting the distribution of wealth in the economy. This mechanism has been highlighted in recent theoretical work (Auclert, 2019). Empirically evaluating these other mechanisms remains an interesting, yet challenging, task for future research.

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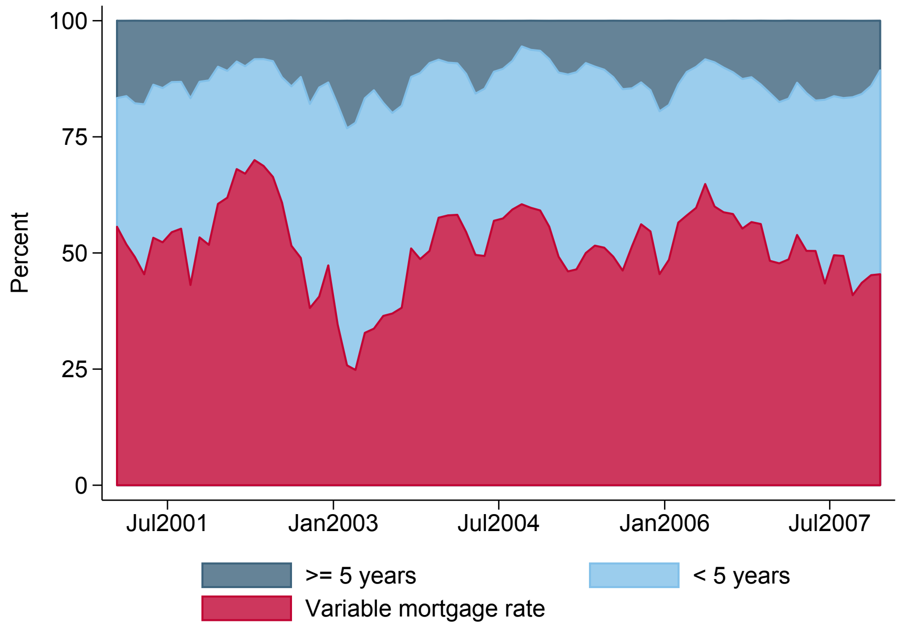
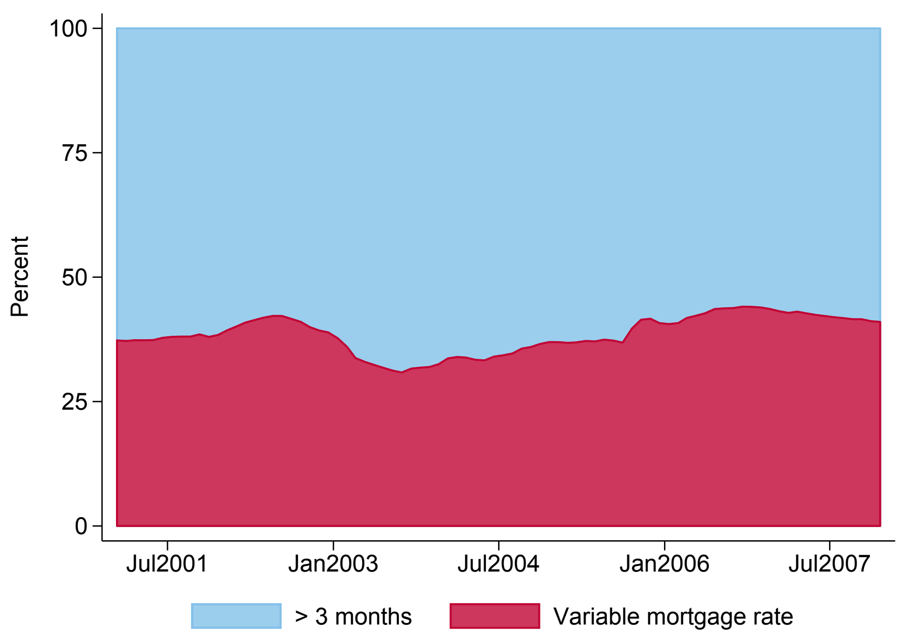
Figure 1: Mortgage stock and new issuances by duration of interest-rate fixation

(a) New issuance of mortgages

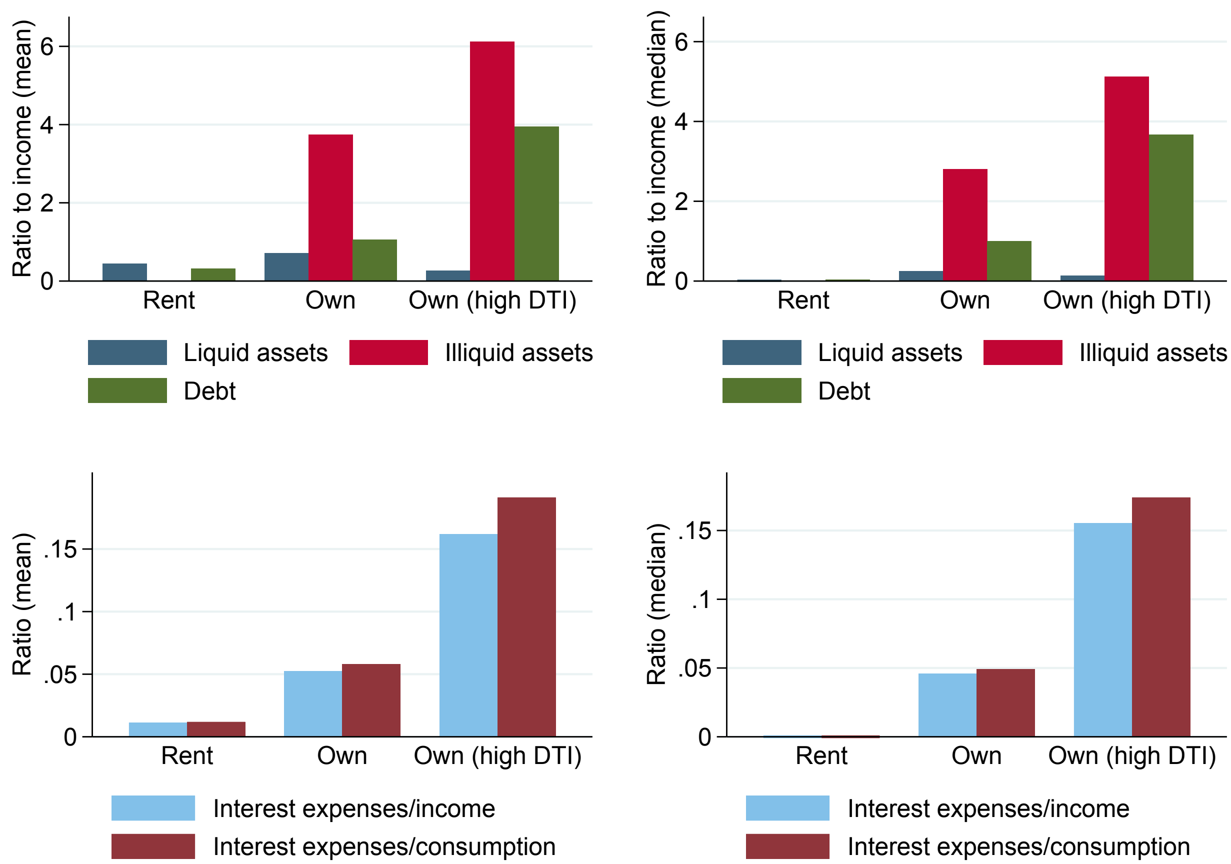


(b) Mortgage stock



Notes: Variable mortgage rate is defined as 3 months or shorter. Panel (a) plots the share of mortgage issuances by duration of interest-rate fixation. Source: Sveriges Riksbank (2012), Figure A18. Panel (b) plots the shares of the mortgage stock by duration of interest-rate fixation. Source: Sveriges Riksbank (2015), Figure A30.

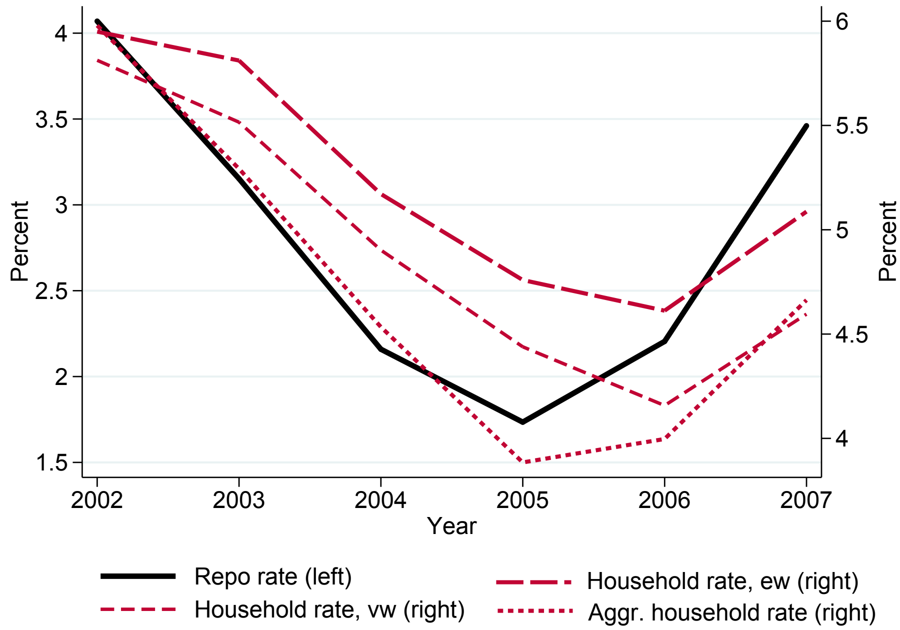
Figure 2: Assets, debt, and interest expenses



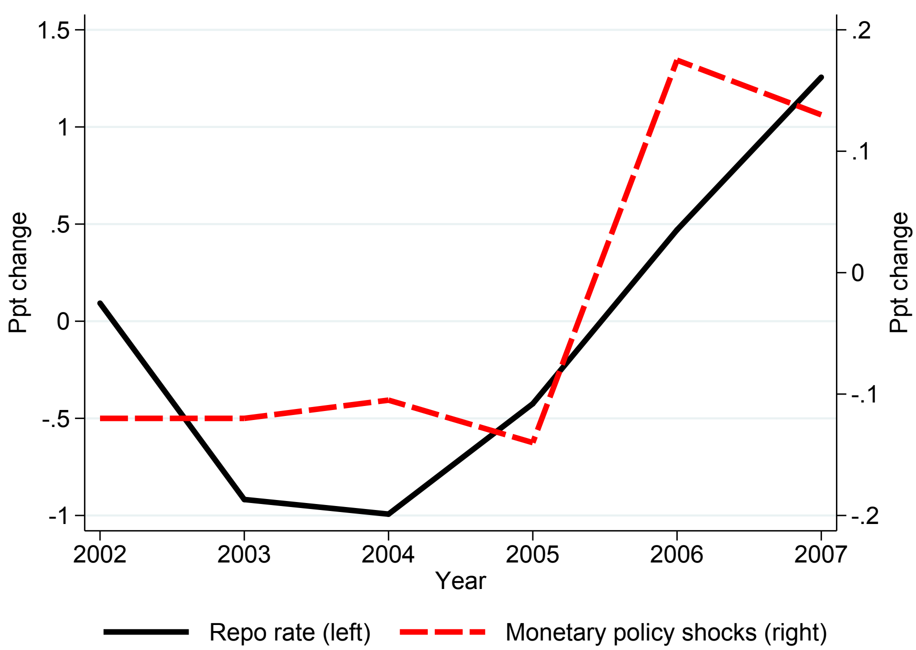
Notes: The figure displays renters' and homeowners' assets, debt, and interest expenses normalized by disposable income. The second and third category report homeowners with a debt-to-income ratio of less than 3 and equal or greater than 3, respectively. The last category is referred to as "high DTI" homeowners. 9.2 percent of all homeowners belong to this category. The left-hand panels display means and the right-hand panels display medians within each group.

Figure 3: Repo rate, household interest rates and monetary policy shocks

(a) Repo rate and household interest rates

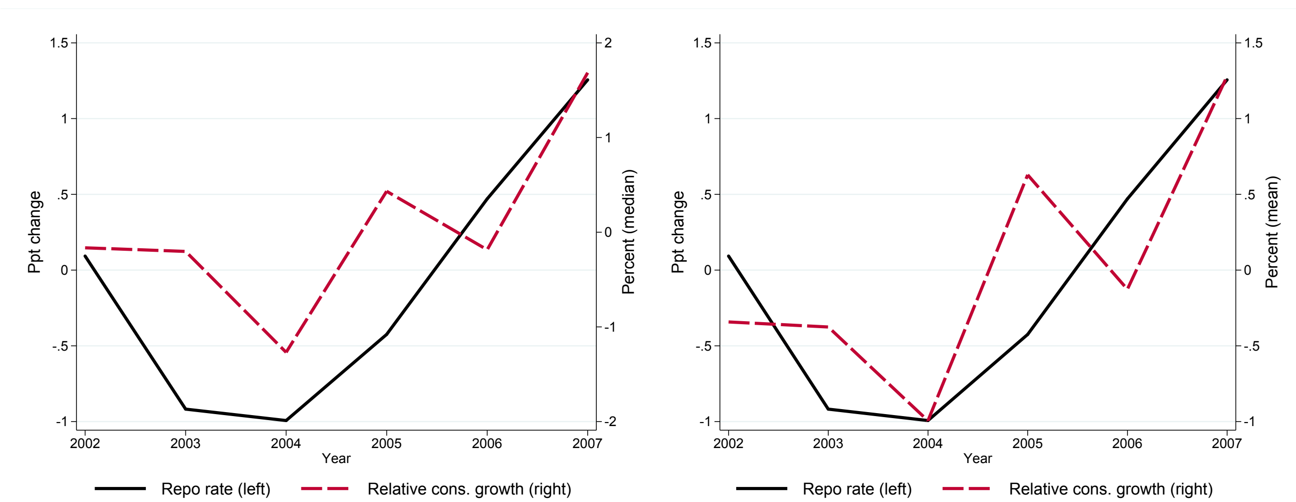


(b) Monetary policy shocks and changes in the repo rate



Notes: Panel (a) plots the repo rate (solid), the average household interest rate (dashed lines) in our sample, both equally weighted (ev) and value weighted (vw), and an aggregate household interest rate from Statistics Sweden (dotted line). Panel (b) plots the monetary policy shocks and changes in the repo rate.

Figure 4: The repo rate and relative consumption growth



Notes: The left panel depicts relative consumption growth measured as the median consumption growth among homeowners with a high DTI ratio minus the median consumption growth of homeowners with a high DTI ratio and an interest-rate correlation with the repo rate above median—a proxy for households with ARMs. The right panel depicts the same group-differences evaluated at the mean instead of median.

Table 1: Summary statistics

	All	Renters	Homeowners
	(1)	(2)	(3)
Sociodemographics			
Disposable income	251	180	303
	(151)	(89)	(148)
Disposable income a.e.	148	131	160
	(55)	(46)	(57)
Age	55	56	54
	(17)	(19)	(16)
Household size	2.26	1.77	2.62
	(1.48)	(1.33)	(1.49)
< High school (share)	15.31	19.58	12.22
High school (share)	61.04	62.77	59.79
> High school (share)	23.64	17.65	27.99
Consumption measure			
Consumption	241	180	285
	(137)	(93)	(147)
Consumption a.e.	143	132	151
	(58)	(50)	(61)
Balance sheet items			
Debt	284	65	444
	(422)	(121)	(486)
Debt-to-income	0.88	0.33	1.27
	(1.10)	(0.64)	(1.19)
Interest rate*	5.19	5.21	5.18
	(3.44)	(5.06)	(2.20)
Correlation measure*	0.37	0.18	0.46
	(0.55)	(0.61)	(0.49)
Interest share	4.10	1.14	6.24
	(5.35)	(2.54)	(5.82)
Illiquid assets	635	-	1,096
	(901)	-	(946)
Liquid assets	126	69	168
	(247)	(186)	(277)
Liquid assets-to-income	0.58	0.45	0.68
	(1.30)	(1.24)	(1.34)
Loan-to-value*	0.45	-	0.45
	(0.001)	-	(0.001)
Unique households	64,158	26,611	37,547

Notes: Values are in 1,000 Swedish Krona or in percent (averages). Values in parenthesis are (s.d.). 'a.e.' refers to adult equivalent. The scaling factor follows OECD, assigning a weight of 1 to the first household member, 0.7 to each additional adult and 0.5 to each child. Age and education refer to the household head. *) There are fewer observations for the interest rate and for the correlation measure. For the loan-to-value ratio the mean for percentile 99 and below is reported.

Table 2: Consumption responses to changes in the monetary policy rate

	(1)	(2)	(3)	(4)
	OLS			
	All Households		Homeowners	
$\Delta r \times$ DTI	-0.260***	-0.266***	-0.199***	-0.211***
	(0.058)	(0.058)	(0.075)	(0.075)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	0.88	0.88	1.27	1.27
Observations	265,675	265,675	153,997	153,997
Clusters (households)	64,158	64,158	37,547	37,547
	IV			
	All Households		Homeowners	
$\Delta r \times$ DTI	-0.400***	-0.400***	-0.413***	-0.415***
	(0.078)	(0.078)	(0.103)	(0.103)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	0.88	0.88	1.27	1.27
Observations	265,642	265,642	153,964	153,964
Clusters (households)	64,125	64,125	37,514	37,514

Notes: Each column in both panels presents results from a separate regression estimate of equation (4). In all regressions, Δr is the year-on-year change in the monetary policy (repo) interest rate, set by the Central Bank's monetary policy committee. DTI denotes the ratio of debt-to-income. The top panel presents results estimated using ordinary least squares (OLS). The bottom panel presents results estimated using instrumental variables (IV), where changes in interest rates are instrumented with monetary policy shocks. All regressions include individual fixed effects, year fixed effects and a set of controls containing a fourth polynomial in age, the number of children, change in number of children as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60) and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parenthesis.*** p<0.01, ** p<0.05, * p<0.1

Table 3: Consumption responses to changes in aggregate household interest rate

	(1)	(2)	(3)	(4)
	OLS			
	All Households		Homeowners	
$\Delta r \times$ DTI	-0.622***	-0.631***	-0.594***	-0.616***
	(0.087)	(0.087)	(0.114)	(0.114)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	0.88	0.88	1.27	1.27
Observations	265,675	265,675	153,997	153,997
Clusters (households)	64,158	64,158	37,547	37,547
	IV			
	All Households		Homeowners	
$\Delta r \times$ DTI	-0.529***	-0.528***	-0.538***	-0.539***
	(0.111)	(0.111)	(0.146)	(0.146)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	0.88	0.88	1.27	1.27
Observations	265,642	265,642	153,964	153,964
Clusters (households)	64,125	64,125	37,514	37,514

Notes: Each column in both panels presents results from a separate regression estimate of equation (4). In all regressions, Δr is the year-on-year change in the average household interest rate computed by Statistics Sweden based on all loans to households. DTI denotes the ratio of debt-to-income. The top panel presents results estimated using ordinary least squares (OLS). The bottom panel presents results estimated using instrumental variables (IV), where changes in interest rates are instrumented with monetary policy shocks. All regressions include individual fixed effects, year fixed effects and a set of controls containing a fourth polynomial in age, the number of children, change in number of children as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60) and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parenthesis.*** p<0.01, ** p<0.05, * p<0.1

Table 4: Consumption responses by interest-rate fixation

	(1)	(2)	(3)	(4)
	OLS		IV	
Interest fixation$_1$ $\times$ Δr $\times$ DTI	-0.102	-0.107	0.000	-0.004
	(0.147)	(0.147)	(0.193)	(0.193)
Interest fixation$_2$ $\times$ Δr $\times$ DTI	-0.072	-0.074	-0.447***	-0.448***
	(0.132)	(0.132)	(0.168)	(0.168)
Interest fixation$_3$ $\times$ Δr $\times$ DTI	-0.381***	-0.384***	-0.492***	-0.495***
	(0.141)	(0.141)	(0.176)	(0.176)
Interest fixation$_4$ $\times$ Δr $\times$ DTI	-0.438***	-0.439***	-0.383**	-0.385**
	(0.129)	(0.129)	(0.174)	(0.174)
Interest fixation$_5$ $\times$ Δr $\times$ DTI	-0.440***	-0.448***	-0.395*	-0.406*
	(0.145)	(0.144)	(0.194)	(0.193)
Interest fixation$_1$ $\times$ Δr	0.626***	0.608***	-0.322	-0.312
	(0.205)	(0.205)	(0.271)	(0.271)
Interest fixation$_2$ $\times$ Δr	0.626***	0.611***	0.391	0.405
	(0.225)	(0.225)	(0.296)	(0.296)
Interest fixation$_3$ $\times$ Δr	0.520**	0.507**	-0.024	-0.009
	(0.249)	(0.249)	(0.323)	(0.323)
Interest fixation$_4$ $\times$ Δr	0.272	0.262	-0.532	-0.508
	(0.245)	(0.245)	(0.329)	(0.329)
Interest fixation$_5$ $\times$ Δr	0.421*	0.421*	-0.215	-0.189
	(0.237)	(0.237)	(0.320)	(0.320)
Liquid assets-to-income	No	Yes	No	Yes
Observations	265,675	265,675	265,675	265,675
Clusters (households)	64,158	64,158	64,158	64,158

Notes: Δr is the year-on-year change in the monetary policy (repo) interest rate, set by the Central Bank's monetary policy committee. *DTI* denotes the ratio of debt-to-income. *Interest fixation$_q$* refer to 5 indicator variables for quantiles of the distribution of correlation coefficients between the household-specific interest rate and the monetary policy rate; see main text for details. All specifications include individual fixed effects, year fixed effects and a set of controls containing a fourth polynomial in age, the number of children, change in number of children as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60) and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parenthesis.*** p<0.01, ** p<0.05, * p<0.1

Table 5: Consumption Responses by Liquid Assets-to-Income

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
DTI	High	High	High	High	Low	Low	Low	Low
Mortgage type (proxy)	ARM	ARM	FRM	FRM	ARM	ARM	FRM	FRM
Liquid assets-to-income	Low	High	Low	High	Low	High	Low	High
A. Summary statistics								
Disposable income	308	359	278	344	211	260	207	257
Age	47	50	46	49	50	56	49	56
Household size	2.84	3.01	2.68	2.92	2.12	2.02	2.27	2.03
Consumption	290	331	265	314	210	255	208	253
Debt	573	604	470	563	49	49	45	42
Debt-to-income	1.77	1.66	1.61	1.60	0.22	0.18	0.21	0.16
Interest rate	5.26	4.71	4.98	4.87	6.90	5.51	6.72	5.62
Interest share	8.58	7.56	7.43	7.60	1.37	0.95	1.24	0.79
Illiquid assets	873	1,390	623	1,254	114	579	83	517
Liquid assets	23	196	20	189	12	241	10	227
Liquid assets-to-income	0.07	0.57	0.06	0.57	0.05	0.92	0.04	0.87
Loan-to-value	0.74	0.52	0.72	0.52	0.27	0.13	0.23	0.12
Observations	34,054	36,247	33,387	26,778	14,714	11,103	22,548	13,411
Households	11,158	11,827	10,829	9,075	4,891	3,959	7,158	4,702
B. Consumption responses (OLS)								
$\text{Group}_k \times \Delta r$	-0.689***	-0.234	0.325*	-0.065	0.202	0.942***	0.667***	0.969***
	(0.201)	(0.207)	(0.195)	(0.226)	(0.223)	(0.305)	(0.192)	(0.283)
F-test	0.060		0.125		0.040		0.340	
C. Consumption responses (IV)								
$\text{Group}_k \times \Delta r$	-1.786***	-0.550*	-0.789***	-0.566*	-0.890***	0.744*	-0.306	1.120***
	(0.280)	(0.287)	(0.267)	(0.307)	(0.303)	(0.409)	(0.254)	(0.368)
F-test	0.001		0.504		0.001		0.001	

Notes: Group_k refers to eight indicator variables for group defined by DTI, interest duration, and liquid assets-to-income. Δr is the year-on-year change in the monetary policy (repo) interest rate. The OLS and IV regressions include individual fixed effects, year fixed effects and a set of controls containing a fourth polynomial in age, the number of children, change in number of children, the twice lagged value liquid assets-to-income as well as interactions between Δr and *young* (dummy for < 40), *old* (dummy for ≥ 60) and *children* (dummy for having children). The number of observations are 265,675 and the number of households are 64,158. Robust standard errors, clustered at the household level, are in parenthesis. The F-tests report p-values for equality of coefficients between two groups with equal debt-to-income and mortgage type but different liquid assets-to-income. *** p<0.01, ** p<0.05, * p<0.1. See Table 1 for further details on the summary statistics.

Appendix for Online Publication

Household Debt and Monetary Policy: Revealing the Cash-Flow Channel

Martin Flodén, Matilda Kilström, Jósef Sigurdsson and Roine Vestman

This appendix contains four sections. Sections A and B contain further details on the theoretical background to our analysis and supplements to Section 2 in the main text. Sections C and D contain, respectively, figures and tables supplementary to the main text.

A A Simple Infinite Horizon Model

We begin with a characterization of hand-to-mouth behavior in a simple infinite horizon model that abstracts from inflation. Section B then presents a quantitative partial equilibrium model.

For now, consider a_t to be net financial assets, including the mortgage. Strict hand-to-mouth behavior then implies that in every time period, consumption is equal to:

$$c_t = y_t + r_t \cdot a_t \tag{7}$$

where y_t is disposable income and r_t is the return on net financial assets. We then want to approximate:

$$\log(c_t) = \log(y_t + r_t \cdot a_t). \tag{8}$$

We use a first-order Taylor approximation of the form $f(x) = f(x^*) + (x - x^*)f'(x^*)$. The left-hand side in (8) is then approximated by:

$$\log(c_t) = \log(c^*) + (c_t - c^*)\frac{1}{c^*}, \tag{9}$$

while the right-hand side is approximated by (remember that we assume that the net financial assets are kept constant):

$$\log(y_t + r_t \cdot a_t) = \log(y^* + r^* \cdot a^*) + [(y_t + r_t \cdot a_t) - (y^* + r^* \cdot a^*)]\frac{1}{y^* + r^* \cdot a^*}. \tag{10}$$

Now, use $y^* + r^* \cdot a^* = c^*$ to simplify (10):

$$\begin{aligned} \log(y_t + r_t \cdot a_t) &= \log(c^*) + [(y_t + r_t \cdot a_t) - (y^* + r^* \cdot a^*)]\frac{1}{c^*} \\ &= \log(c^*) + \frac{y_t - y^*}{c^*} + \frac{(r_t - r^*)a^*}{c^*} \\ &= \log(c^*) + \frac{y^*}{c^*}\frac{y_t - y^*}{y^*} + \frac{y^*}{c^*}\frac{a^*}{y^*}(r_t - r^*) \\ &= \log(c^*) + \theta\frac{y_t - y^*}{y^*} + \theta\frac{a^*}{y^*}(r_t - r^*). \end{aligned} \tag{11}$$

Substitute (9) and (11) into (8) to obtain:

$$\frac{(c_t - c^*)}{c^*} = \theta\frac{y_t - y^*}{y^*} + \theta\frac{a^*}{y^*}(r_t - r^*). \tag{12}$$

Finally, use the approximation $\frac{x_t - x^*}{x^*} = \log(x_t) - \log(x^*)$ to obtain:

$$\Delta\log(c_t) = \theta\Delta\log(y_t) + \theta\frac{a^*}{y^*}\Delta r_t. \tag{13}$$

B A Quantitative Partial Equilibrium Model

The model follows the partial equilibrium model of Garriga et al. (2017), but is modified and tailored to suit our paper. A household is born at age $t = 1$ and lives for T periods. It solves the perfect-foresight problem:

$$\max_{D_1,\{c_t\}_1^T} \sum_{t=1}^{T} \beta^{t-1} u(c_t)$$

subject to the constraint:

$$P_1(c_1 + h) + A_1 = P_1 w + D_1 + (1 + i_1) A_0, \tag{14}$$

and the following constraints for $2 \leq t \leq T - 1$:

$$P_t c_t + A_{t+1} = P_t w + (1 + i_t)A_t - i_t^D D_t - \gamma D_1 \tag{15}$$

and, finally, the constraint in the last period:

$$P_T c_T = P_T w + (1 + i_T) A_T - (1 + i_T) D_T + \alpha P_T h. \tag{16}$$

The law of motion for nominal debt is $D_2 = D_1$ and then $D_{t+1} = D_t - \gamma D_1$ until $t = T - 1$. The initial condition for financial assets is A_0. The real value of the household's house is h, and the real value of labor income is w. The house value is exogenously given, and the house has to be purchased in the beginning of period 1. We follow Garriga et al. (2017) by assuming that there are no maintenance costs on the house but that the real value of the house falls over time. In contrast, we allow for the possibility that the house still has a value when it is sold after T periods. The parameter α denotes the fraction of the value that remains at age T.

The household chooses a nominal mortgage D_1 and a real consumption path $\{c_t\}_1^T$ to maximize lifetime utility. In our baseline specification, the paths of the price level, $\{P_t\}_1^T$, and the nominal interest rate, $\{i_t\}_1^T$, are also exogenous and known in advance, and the Fisher equation holds:

$$1 + i_t = (1 + r) \cdot \frac{P_t}{P_{t-1}}, \tag{17}$$

where r is the real interest rate.

B.1 ARMs

The interest rate on the adjustable rate mortgage (ARM) is identical to the nominal interest rate (i.e., $i^D = i$). Because of equality between these two interest rates, the household is indifferent between (negative) first-period asset holdings A_1 and the mortgage. Amortization is specified as a fixed nominal amount, here represented by γD_1. The parameter γ is thus the amortization rate in the first period of the mortgage contract.

B.2 FRMs

We mimic the typical Swedish FRM. This implies that the mortgage rate is held fixed for five years and is then reset to be equal to the nominal interest rate prevailing at that point in time.

B.3 Solutions to the model

B.3.1 Ex ante solutions

Let $\left\{D_1^*, \{c_t^*\}_1^T\right\}$ denote the optimal, unconstrained solution to the above problem as interest rates and the price level remain on their paths.

To mimic a hand-to-mouth household (once the household has purchased the house), we also solve the model with the additional constraint that $A_t = 0$ for $t \geq 1$. After having taken up the mortgage, this solution represents a hand-to-mouth household. Let $\left\{D_1^{\text{HtM}}, \{c_t^{\text{HtM}}\}_1^T\right\}$ denote the solution to this problem. This solution resembles the partial equilibrium model of Garriga et al. (2017).

B.3.2 Ex post solutions

We will also shock the nominal interest rate i_i unexpectedly.

We label a solution where the household reoptimizes when it receives new information about the interest rate (and the price level) as an ex post solution.

More specifically, in the beginning of period τ, the household learns that the interest-rate and price paths have changed from $\left\{i_{\tau+j}, i_{\tau+j}^D, P_{\tau+j}\right\}_{j=0}^{\infty}$ to $\left\{\hat{\imath}_{\tau+j}, \hat{\imath}_{\tau+j}^D, \hat{P}_{\tau+j}\right\}_{j=0}^{\infty}$. The household then re-optimizes, again assuming perfect foresight. A household of age $\hat{t}$ at date τ thus solves:

$$\max_{\{c_{t,\hat{t}}\}_{t=\hat{t}}^T} \sum_{t=\hat{t}}^{T} \beta^{t-\hat{t}} u\left(c_{t,\hat{t}}\right)$$

with $D_{1,\hat{t}}$ and $D_{\hat{t},\hat{t}}$ given, with information about the new prices, but otherwise subject to the same constraints as above.

Let $\left\{\hat{D}_1^*, \{\hat{c}_t^*\}_1^T\right\}$ denote the optimal, unconstrained solution to the above problem. Let $\left\{\hat{D}_1^{\text{HtM}}, \{\hat{c}_t^{\text{HtM}}\}_1^T\right\}$ denote the solution to the hand-to-mouth household's problem under this sequence of interest rates and prices.

B.3.3 Shocks to the real interest rate versus shocks to the nominal interest rate

A noteworthy feature of the cash-flow channel is that it is operational regardless of the relationship between the nominal interest rate and inflation. For hand-to-mouth households with ARMs and no financial assets ($A_t = 0$), a change in the nominal interest rate affects real mortgage payments and real consumption instantaneously. The consumption function follows from the budget constraint (15):

$$c_t = w - i_t^D \frac{D_t}{P_t} - \gamma \frac{D_1}{P_t}. \tag{18}$$

For such a household, a shock to i_t (and hence i_t^D) is equivalent to a shock to r_t if the price level is constant. However, whether the price level is affected, or not, matters little quantitatively. The short-term effect on consumption is essentially the same even in the extreme case when the nominal interest rate and inflation move together so that the Fisher equation, (17), continues to hold. We label this case as "$\Delta\pi = \Delta i$".

For optimizing households with ARMs, the relationship between the nominal rate and inflation matters more. If there is no effect on inflation (i.e., the shock has identical effects on i_t, i_t^D and r), optimizing households' response is determined by intertemporal substitution to smooth out the wealth effect. This implies that for a positive shock the household borrows in the financial asset to smooth consumption. If the Fisher equation holds so the inflation increases, there are opposing short-term and long-term wealth effects. A short-term increase in the nominal interest rate leads to a short-term increase in real mortgage payments which is off-set by a long-term decrease in real mortgage payments. The wealth effects cancel so the optimizing households off-set the effects on consumption by borrowing even more in the financial asset.[29]

B.3.4 Relationship to previous literature

In our analysis, households cannot adjust their housing upon the shock. Thus we focus entirely on what Garriga et al. (2017) label as the income effect, and ignore what they label as the price effect (i.e., the cost of capital's effect on house prices). This also corresponds well to our empirical analysis in which we exclude households in the periods when they transact apartments or real estate.

In our analysis, we consider different scenarios for the persistence of the shock and whether inflation and interest rates move in tandem (i.e., whether the Fisher equation holds also after the shock). If the price level is unaffected by the shock, then the shock is equivalent to a shock to the real interest rate. A household with an FRM is partly insured against this shock, until the interest-rate fixation period ends. Auclert (2019) labels the differences between ARM and FRM holders as differences in unhedged interest rate exposure (URE). If the price level does move with the shock, there is an additional effect from households' nominal debt. Auclert (2019) labels this additional effect as differences in net nominal positions (NNPs).[30] If there is a positive relationship between

[29] This discussion abstracts from effects on house prices which are exogenous in our model.

[30] See also Doepke and Schneider (2006).

the nominal rate and inflation, households with mortgages are compensated when the nominal interest rate increases by deflation of their nominal debt balance. The magnitude of this wealth effect depends on the debt balance, D_t, the asset balance A_t, and the path of the mortgage rate i_t^D, which depends on whether the household has an ARM or FRM. Therefore, in this case, the shock has heterogenous effects through UREs as well as through NNPs.

B.4 Calibration and solution of baseline specification

We assume that utility is logarithmic, i.e., $u(c) = \log c$. One period is one year, and the household lives for $T = 50$ years. Real labor income (w) is normalized to 1. The discount factor is set to $\beta = 0.98$. In our baseline specification, nominal prices are constant: $P_t = 1$ for all t. Hence the nominal interest rates are also constant and equal to $i_t = i_t^D = 1/\beta - 1 = r$.

The remaining value of a house after T years is set to $\alpha = 0.5$, which in combination with the amortization rate implies that the house value equals the remaining mortgage in T, if the price level evolves as expected. Finally, we set $w = 1$ as a normalization and the amortization rate to $\gamma = 0.01$, which is consistent with the fact that amortization on mortgages in Sweden was small in the early 2000s, which is the sample period for our analysis.

B.4.1 Persistent shocks to the interest rate

We will also consider persistent shocks to the interest rate. In this case, households learn in the beginning of period τ that $i_{\tau+j} = r + \delta\rho^j$ for all $j \geq 0$ where $\rho \in [0, 1]$ is a persistence parameter. In the examples below, we set $\rho = 0.8145$, corresponding to a quarterly persistence of 0.95. Henceforth, a configuration with temporary shocks to the interest rate refers to $\rho = 0$ and persistent shocks to $\rho = 0.8145$.

B.5 Illustration of the solutions

We first illustrate the model dynamics graphically in Figures A.1 to A.8. In these examples, the house value in time period 1 ($P_1 h$) is 4 and initial financial wealth (A_0) is 0. The interest rate is shocked (unexpectedly) in $t = 2$ by one percentage point. We consider both the case when the shock is temporary and the case when it is persistent. We also consider the case where the inflation rate and interest rate move together so that the Fisher equation continues to hold along the new paths. We compare $\{c_t^*\}_1^T$ to $\{\hat{c}_t^*\}_1^T$ and $\{c_t^{\text{HtM}}\}_1^T$ to $\{\hat{c}_t^{\text{HtM}}\}_1^T$.

B.5.1 ARMs and temporary interest rate shocks

Figure A.1 shows the paths for an optimizing household with an ARM. The blue solid line indicates the paths if there is no change to the short-term interest rate (and hence no change to the mortgage rate either), and the red dashed line indicates the path if the household unexpected faces a temporarily higher short-term interest rate in $t = 2$. Whereas the shock to the mortgage interest expense is substantial (upper right panel), the consumption response is miniscule (bottom right panel) because of the household's ability to smooth consumption by additional borrowing (bottom left panel).[31]

Figure A.2 shows the corresponding paths for a hand-to-mouth household with an ARM. The response to the shock is immediate and is not smoothed over several periods. The one-percentage-point change in the short rate leads to a response in consumption of about 4.5%.

Figure A.1: Household response to a temporary interest rate shock (Optimizer, ARM)

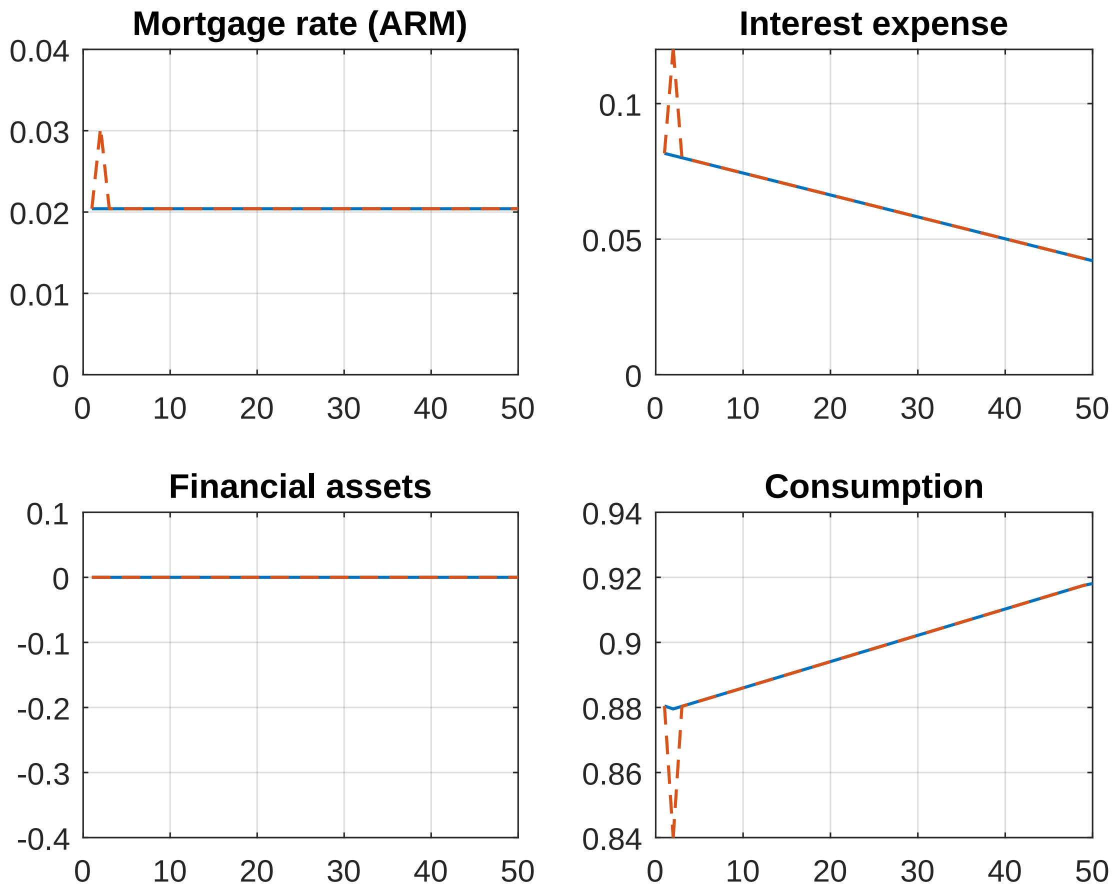
Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the ex post solution.

B.5.2 Persistent shocks to the interest rate (ARM)

Figures A.3 and A.4 display the response when the shock to the interest rate is persistent. Figure A.3 indicates that an optimizing household adjusts its financial assets less when the shock is persistent. Hence, the response to consumption is much greater compared with the case of a temporary shock (compare with Figure A.1). For an HtM household, the consumption response

[31]Notice that the household borrows when not exposed to any shock. This is because of the amortization rate on the mortgage, which is not an annuity loan.

Figure A.2: Household response to a temporary interest rate shock (HtM, ARM)



Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the ex post solution.

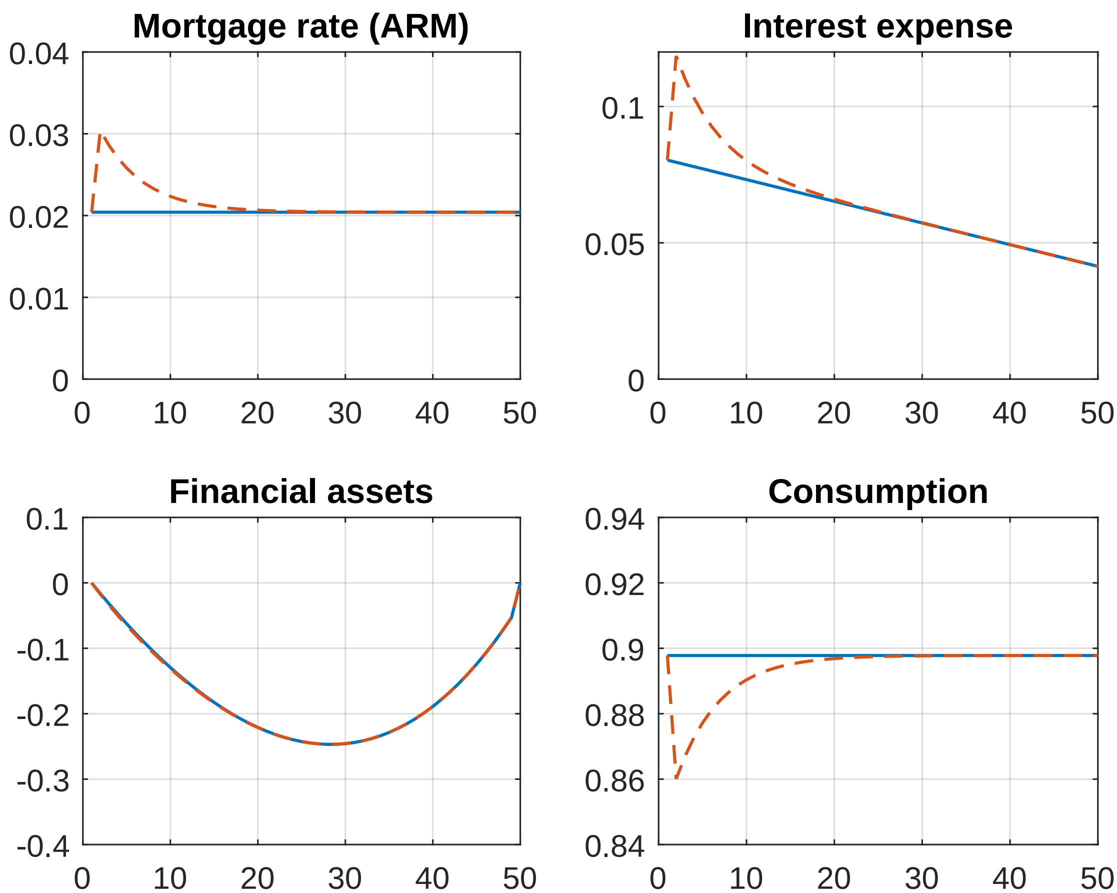
at impact is identical regardless of whether the shock is transitory or persistent (compare Figure A.4 with Figure A.2).

Note that the consumption response in this configuration is similar for optimizing households and HtM households (compare Figure A.3 with Figure A.4). The responses are, however, generated by different mechanisms. For the optimizing household, the response is mostly generated by intertemporal substitution, while the response is mostly generated by changes to cash flow for the HtM household. The effect through intertemporal substitution is the same irrespective of the household's wealth position, but the cash-flow effect depends on the household's debt-to-income (DTI) ratio (see Section B.6.1 and Figure A.9).

B.5.3 Persistent shocks to the interest rate (FRM)

We now consider households' responses if they have FRMs (they do not respond to transitory shocks). Figure A.5 shows the response of an optimizing household with an FRM. Upon a persis-

Figure A.3: Household response to a persistent interest rate shock (Optimizer, ARM)



Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the ex post solution.

tent shock to the interest rate, the household saves more. This is because it faces a higher savings rate in the financial asset, but another motive is to smooth out the future increase in the mortgage expense. Hence, consumption decreases immediately. The response is a bit more than half of the magnitude for a household with an ARM.

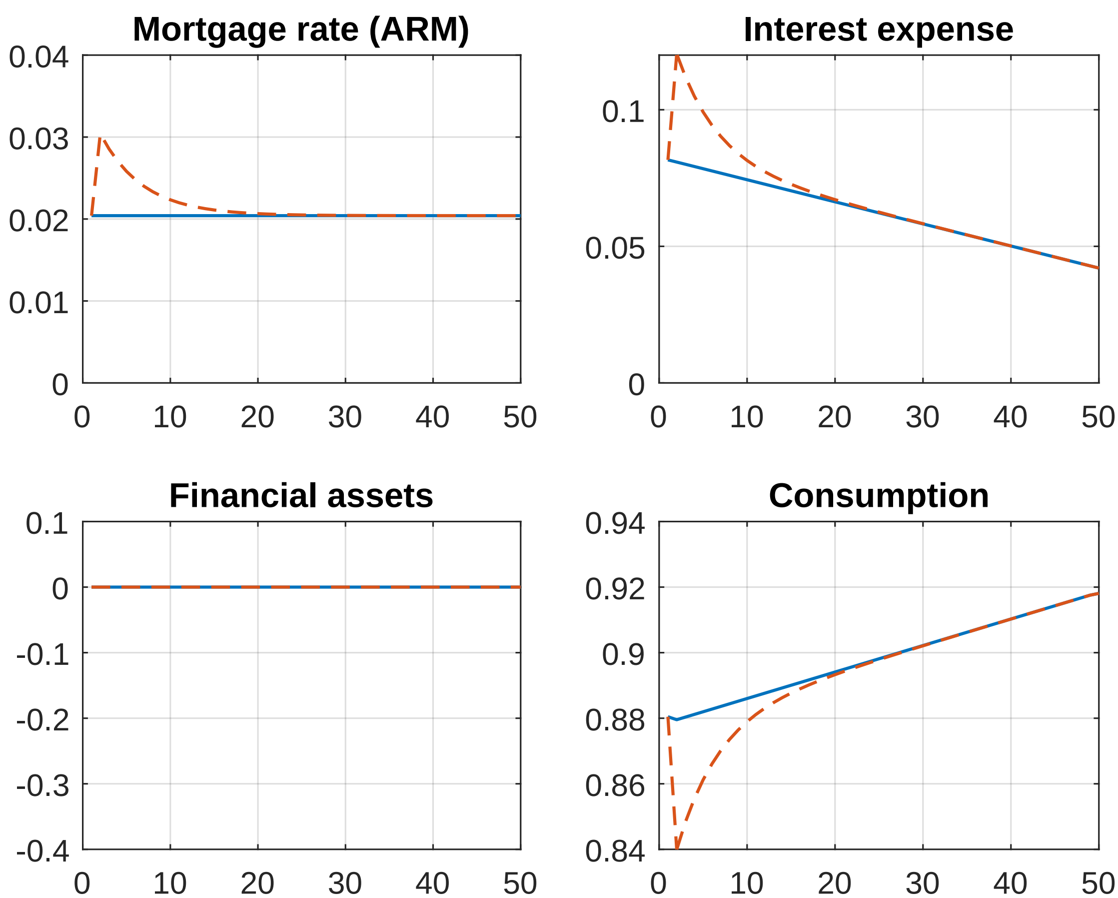
Figure A.6 shows the response of an HtM household with an FRM. The response is delayed until five years later and is then much smaller.

B.5.4 Persistent shocks to the interest rate and the inflation rate

We now consider the case in which, upon a persistent shock to the interest rate, the inflation rate moves in tandem through the Fisher equation (17). For both households with ARMs and those with FRMs, this implies that the negative effect of an increase in the interest rate to some extent is offset by a positive wealth effect, as its debt is worth less in real terms.

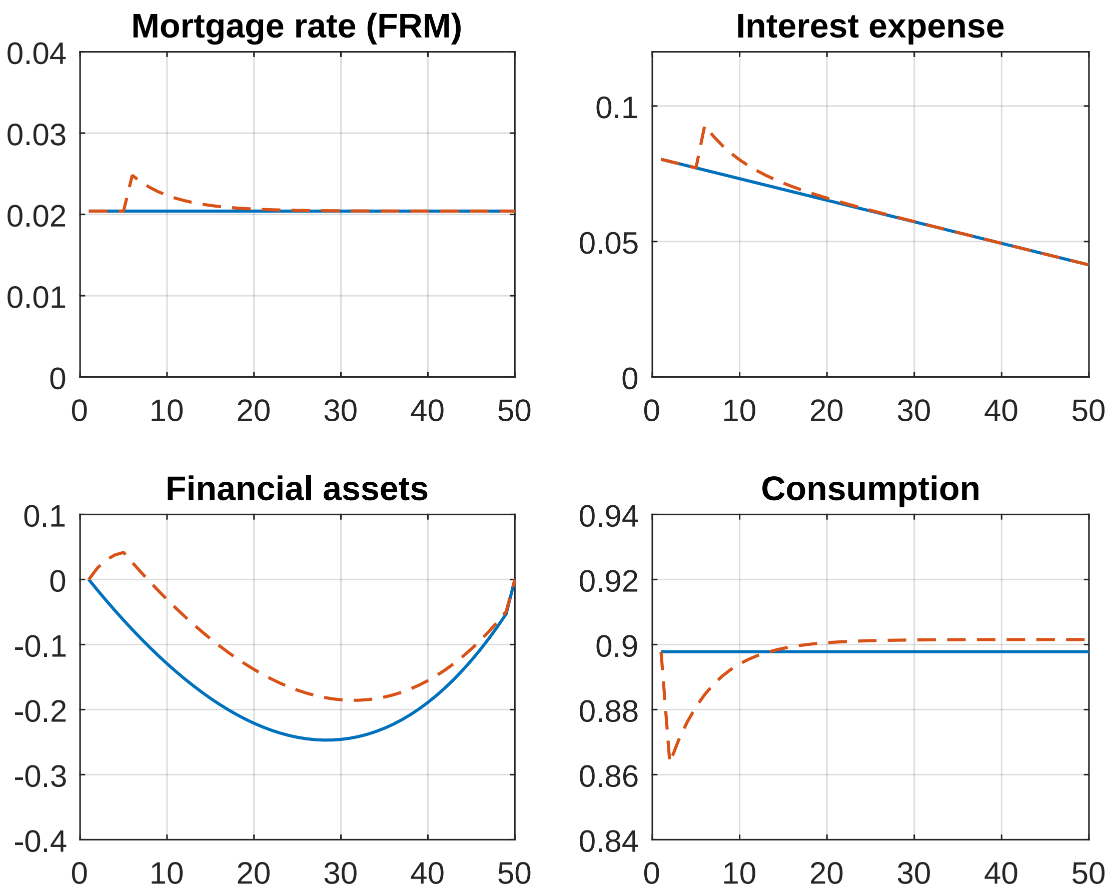
Figure A.7 displays the paths for an optimizing household with an ARM. Relative to the case

Figure A.4: Household response to a persistent interest rate shock (HtM, ARM)



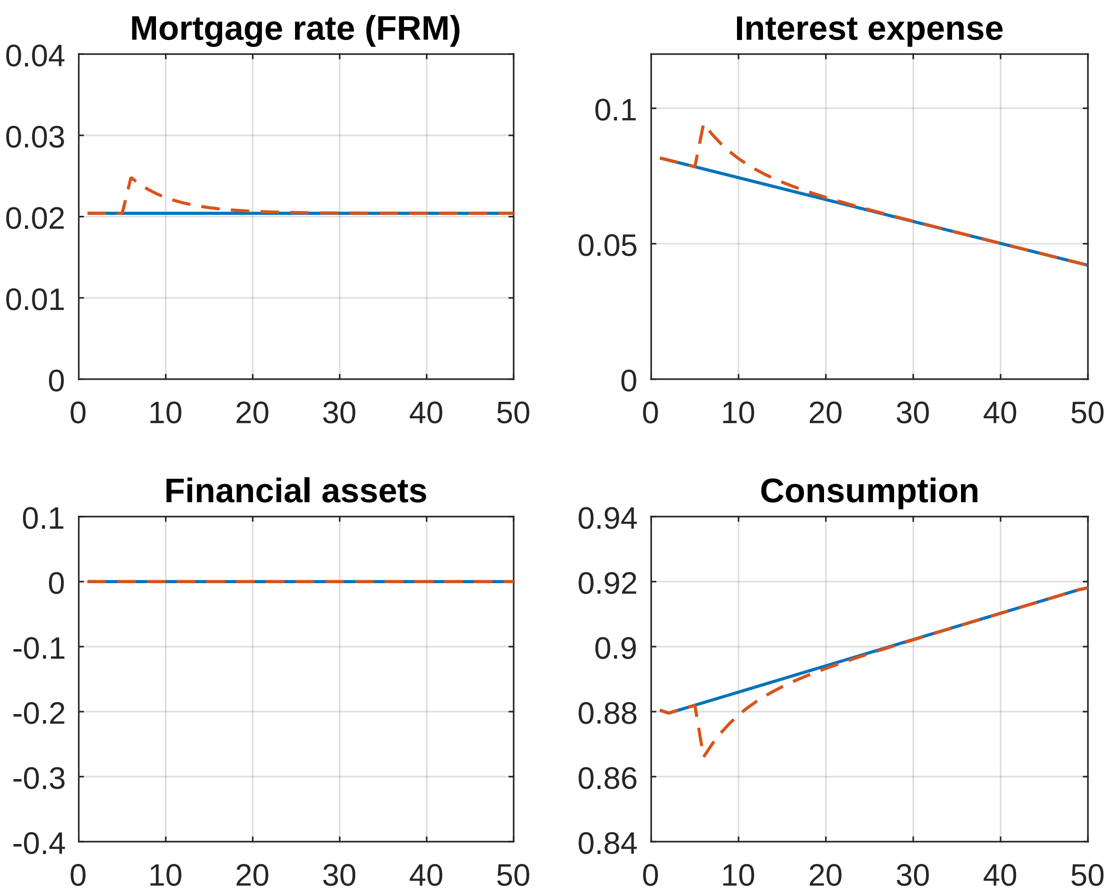
Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the ex post solution.

Figure A.5: Household response to a persistent interest rate shock (Optimizer, FRM)



Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the ex post solution.

Figure A.6: Household response to a persistent interest rate shock (HtM, FRM)



Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the ex post solution.

when the inflation rate does not move in tandem with the interest rate (as in Figure A.3), households respond much less. Essentially, the consumption response is similar to the response to a transitory shock since households are compensated through inflation.

Figure A.7: Household response to a persistent interest rate shock under the Fisher effect (Optimizer, ARM)

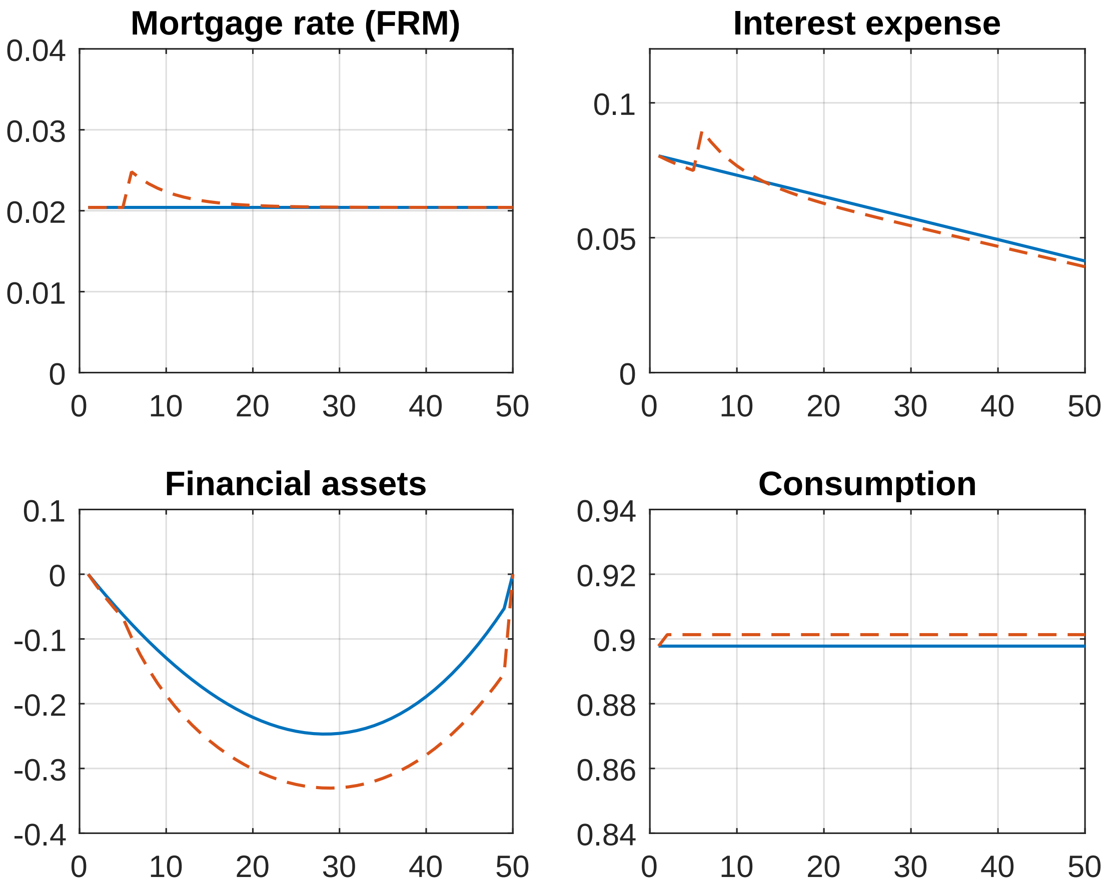
Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the ex post solution.

The same mechanism is present for households with FRMs. Figure A.8 shows the response of such a household. Consumption responds slightly positively due to the wealth effect, in contrast to the response in the absence of any inflation (Figure A.5).

B.6 Quantitative analysis

We now simulate households in the partial equilibrium economy and estimate the response to changes in the interest rate for different configurations. We populate the economy with households of different age (i.e., τ is between 2 and 49 when the shock hits). We also consider cross-sectional variation in house values. House values, $P_1 h$, is uniformly distributed on the interval

Figure A.8: Household response to a persistent interest rate shock under the Fisher effect (Optimizer, FRM)



Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the ex post solution.

$[0, 8]$.

B.6.1 Motivation for the regression specification

Figure A.9 displays the consumption response to a persistent shock to the interest rate of four household types with different house values. The house values are 2, 4, and 6 and imply that the DTI ratios early in life are approximately 2, 4, and 6, respectively. The figure illustrates that a feature of HtM households' response is that it is proportional to their DTI ratios (right panels), whereas optimizing households respond almost uniformly (left panels).[32] This motivates the following regression specification:

$$\Delta \log c_{i,\tau} = \alpha_i + \beta DTI_{i,\tau-1} \times \Delta i_\tau + \gamma X_{i,\tau-1} + \varepsilon_{i,\tau}, \tag{19}$$

[32] The figure does not display the role of age. For older households, the wealth effect is stronger, which implies a stronger response than for younger households.

Figure A.9: Consumption response of four households to a persistent interest rate shock

Note: Each panel depicts an optimizing household or a HtM household with either an ARM or an FRM. Real labor income is normalized to 1. The value of the house in $t = 1$ 1 is 2, 4, or 6, respectively. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The shock is persistent. At the time of the shock, households have a remaining life span of 48 years. The horizontal axes display the first ten time periods for expositional purposes. All values are real.

where $\Delta \log c_{i,\tau}$ is log consumption growth, α_i are household fixed effects that capture time-invariance cross-sectional heterogeneity. In our simulated data, the change in the nominal interest rate is Δi_τ and it is 0.01 for all households, and $X_{i,\tau-1}$ is a third-order polynomial in age (i.e., τ).

The covariate $DTI_{i,\tau-1} \times \Delta i_\tau$ captures responses of households that are hand-to-mouth. Figure A.9 shows that responses of such households increase linearly with debt. It is also consistent with the log-linearization leading to equation (13).

In our analysis on real data, we add year fixed effects (δ_t) that capture macroeconomic effects—including interest rate changes and aggregate shocks. Under the assumption of homogenous preferences, the year fixed effects capture the response of optimizing households, as long as the remaining life span is long relative to the persistence of the shock to the interest rate. To adjust for wealth effects due to life span, we include household age in $X_{i,\tau-1}$.[33]

[33]Note that in Figures A.1 to A.8, we compared $\hat{c}_{i,t}$ to $c_{i,t}$, that is, how consumption responds relative to the hypothetical consumption in the absence of an interest rate shock. In the real world we do not observe that hypothetical value but instead use $\log c_{i,t-1}$ in combination with household fixed effects as a proxy. The regression results are similar if

B.6.2 Regression estimates

Tables A.1 and A.2 show consumption responses in different configurations of the economy.[34] Table A.1 reports small responses for optimizing households with ARMs (columns (1)–(3)), whereas the combination of ARMs and HtM behavior implies responses of approximately -1 (column (4)). For optimizing households with FRMs, the response is moderate, at -0.118 (column (5)), and it is negligible among HtM households with FRMs (column (6)).

Table A.1: Regressions on simulated data

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{DTI}_i \times \Delta i$	-0.081	-1.282	-0.337	-1.282	-0.118	0.033
	(0.004)	(0.008)	(0.010)	(0.008)	(0.003)	(0.000)
Constant	-0.000	0.002	-0.029	0.002	-0.032	-0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.000)
Observations	423	423	423	423	423	423
R-squared	0.690	0.993	0.812	0.993	0.988	0.974
Persistent shock	No	No	Yes	Yes	Yes	Yes
Fisher effect ("$\Delta\pi = \Delta i$")	No	No	No	No	No	No
Share ARM	1.0	1.0	1.0	1.0	0.0	0.0
Share HtM	0.0	1.0	0.0	1.0	0.0	1.0

Notes: A fourth-order polynomial in age is included in all regressions. Robust standard errors.

Table A.2 reports estimates when the Fisher equation holds and for realistic mixes of household types and mortgages. Columns (1) to (4) report estimates when the Fisher equation holds. For optimizing households with ARMs, the response is zero because of the off-setting wealth effect (Column (1)). For HtM households with ARMs, the response is virtually identical to the case when inflation is unaffected (Column (2) of Table A.2 versus Column (4) of Table A.1). In this sense, a shock where nominal rates and inflation move in tandem imply even more different consumption responses for optimizing and hand-to-mouth households. For households with FRMs there is in this case a net positive effect, implying positive responses, in particular for optimizing households (Columns (3) and (4)).

Columns (5) and (6) of Table A.2 consider realistic mixes of the configurations (i.e., mixes of household and mortgage types). The responses in these configurations are of intermediate magnitude, meaning that they are much greater than for optimizing households with ARMs but smaller than the response for HtM households with ARMs. Notably, if inflation moves with the nominal interest rate it reduces the response by half but it is nevertheless sizable.

we base the regressions on $\log \hat{c}_{i,t} - \log c_{i,t}$.

[34] To exclude households that purchase or sell real estate, we only include households aged 3 to 49 in these regressions.

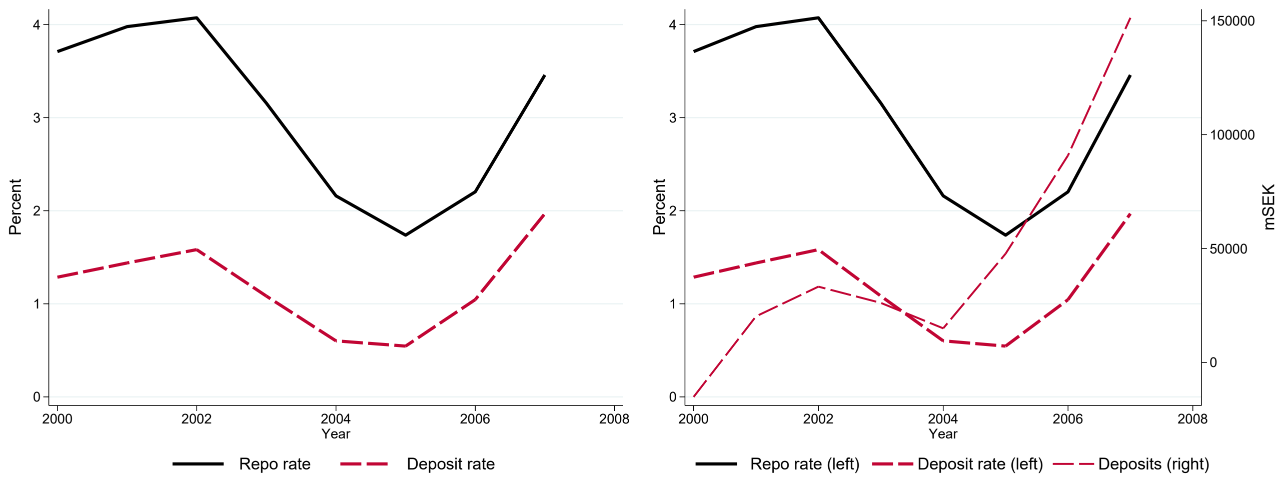
Table A.2: Regressions on simulated data (persistent shocks and mixes of types and mortgages)

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{DTI}_i \times \Delta i$	0.000	-1.224	0.206	0.073	-0.434	-0.210
	(0.000)	(0.007)	(0.009)	(0.001)	(0.027)	(0.029)
Constant	-0.000	0.001	-0.002	-0.001	-0.015	-0.001
	(0.000)	(0.001)	(0.001)	(0.000)	(0.005)	(0.005)
Observations	423	423	423	423	1692	1692
R-squared	0.010	0.993	0.741	0.988	0.210	0.057
Persistent shock	Yes	Yes	Yes	Yes	Yes	Yes
Fisher effect ("$\Delta\pi = \Delta i$")	Yes	Yes	Yes	Yes	No	Yes
Share ARM	1.0	1.0	0.0	0.0	0.5	0.5
Share HtM	0.0	1.0	0.0	1.0	0.5	0.5

Notes: A fourth-order polynomial in age is included in all regressions. Robust standard errors.

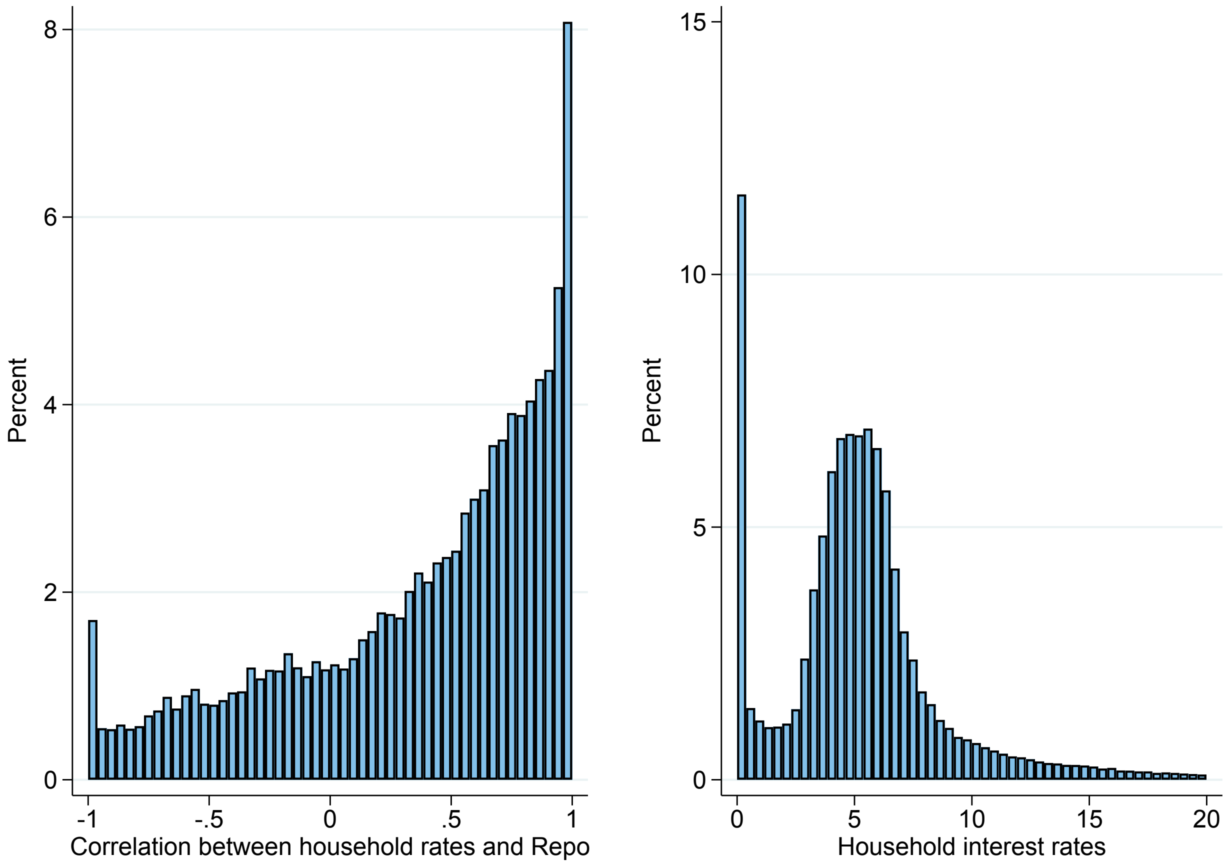
C Supplementary Figures

Figure A.10: The repo rate and deposits



Note: The left-hand panel displays the repo rate (i.e., the monetary policy rate) and the deposit rate paid by banks to households. Both interest rates are measured in terms of yearly averages. Deposits are classified as demand deposits—i.e., deposited funds can be withdrawn at any time. To measure the passthrough of monetary policy into deposit rates faced by households we regress changes in the deposit rate on changes in the repo rate (excluding a constant). This gives a coefficient estimate of 0.62. The right-hand panel plots the evolution of these two interest rates together with the transaction flows (the sum of flows in a year as measured in million SEK) into demand deposits. Regressing changes in the transaction flows on changes in the deposit rate also gives a positive and significant coefficient (with or without including a constant).

Figure A.11: Household interest rates and correlations with the repo rate



Note: The left-hand panel displays the cross-sectional distribution of correlations between the repo rate (i.e., the monetary policy rate) and the household interest rate. The right-hand panel displays the cross-sectional distribution of household interest rates.

D Supplementary Tables

Table A.3: Summary statistics and balance by mortgage type

	FRM	ARM	ARM – FRM
	(1)	(2)	(3)
Sociodemographics			
Disposable income	324	336	11.821***
	(140)	(147)	(1.588)
Disposable income a.e.	164	167	2.936***
	(56)	(59)	(0.620)
Age	50	50	0.090
	(13)	(13)	(0.153)
Household size	2.82	2.89	0.069***
	(1.48)	1.49	(0.017)
Consumption measure			
Consumption	301	314	12.787***
	(139)	(149)	(1.501)
Consumption a.e.	152	156	3.315***
	(58)	(61)	(0.582)
Balance sheet items			
Debt	500	556	55.576***
	(471)	(500)	(5.358)
Debt-to-income	1.46	1.57	0.115***
	(1.14)	1.16	(0.013)
Interest rate	5.38	5.04	-0.334***
	(2.40)	(1.89)	(0.020)
Interest share	7.37	7.47	0.001*
	(5.79)	(5.43)	(0.001)
Illiquid assets	1,120	1,220	99.430***
	(934)	(996)	(10.453)
Liquid assets	135	139	3.175
	(225)	(229)	(2.388)
Liquid assets-to-income	0.43	0.42	-0.003
	(0.74)	(0.71)	(0.008)
Loan-to-Value*	0.52	0.55	0.022***
	(0.002)	(0.002)	(0.005)
Unique households	15,695	15,857	31,552

Notes: Columns (1) and (2) report summary statistics by groups of homeowners with a different duration of debt, where High (Low) represents groups with a correlation of household interest rates with the repo rate (i.e., the monetary policy rate) below (above) the median among homeowners. Values are in 1,000 Swedish Krona or in percent (averages). Values in parentheses are (s.d.). Column (3) reports regression coefficients from single variable regressions on an indicator of having a highly variable interest rate. Standard errors, reported in parentheses below, are clustered at the household level. *) For the loan-to-value ratio, the mean for percentile 99 and below is reported. See Table 1 for further details.

Table A.4: Sample restrictions

	Type of restriction	Observations	Unique households	Age	Illiquid assets	Liquid assets
0.	Full sample (household heads)	2,434,359	412,568			
1.	Match with consumption data	1,890,190	394,504			
2.	Drop year 2000	1,591,265	329,001	47	816	236
3.	Excl. unstable households over time (includes dropping 2001)	1,066,434	255,014	49	872	248
4.	Excl. households who change official address or transact real estate	836,992	231,955	51	901	259
5.	Excl. self-employed	798,691	223,913	51	852	255
6.	Excl. households who hold derivatives	787,968	222,105	51	838	247
7.	Excl. households who hold securities with missing ISINs, or mutual funds or stocks with missing prices or returns	603,380	183,909	50	661	166
8.	Excl. households with missing disposable income in t, $t-1$ or $t-2$	603,314	183,890	50	661	166
9.	Excl. households with missing interest rate (unless debt is zero in t and $t-1$)	-	-			
10.	Excl. households with missing change in number of adults	-	-			
11.	Excl. households with missing DTI in $t-2$	566,897	177,792	52	701	177
12.	Excl. households that change housing tenure status	536,927	169,915	52	717	179
13.	Excl. households where the number of adults changes	524,935	167,280	52	708	179
14.	Excl. households where the household head is younger than 18	509,011	160,949	54	726	184
15.	Excl. households with negative consumption in t or $t-1$	485,982	156,982	54	713	167
16.	Excl. households with missing consumption growth	-	-			
17.	Excl. households with negative disposable income in t, $t-1$ or $t-2$	484,557	156,470	54	714	167
18.	Excl. lowest 1 percentile of disposable income in t, $t-1$ and $t-2$	474,957	153,096	54	724	169
19.	Excl. if the interest is higher than 20 percent for indebted households	461,922	151,409	54	740	172
20.	Excl. if consumption growth is higher/lower than +/- 50 percent	370,493	137,533	53	681	145
21.	Excl. if DTI in $t-2$ is negative or higher than 10	370,222	137,398	53	679	145
22.	Excl. households that are not in the sample at least 3 years	266,701	64,322	55	636	127
23.	Excl. indebted homeowners with no correlation measure	265,675	64,158	55	635	126
24.	For the balanced sample: required in sample for 2002-2007	67,425	11,253	55	635	126

Table A.5: Consumption responses to changes in the monetary policy rate

	(1)	(2)	(3)	(4)	(5)
		OLS: All Households			
$\Delta r \times$ DTI	-0.260***	-0.266***	-0.295***	-0.367***	-0.473***
	(0.058)	(0.058)	(0.055)	(0.056)	(0.053)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	0.88	0.88	0.88	0.88	0.88
Observations	265,675	265,675	265,675	265,675	265,675
Clusters (households)	64,158	64,158	64,158	64,158	64,158
		OLS: Homeowners			
$\Delta r \times$ DTI	-0.199***	-0.211***	-0.447***	-0.236***	-0.581***
	(0.075)	(0.075)	(0.073)	(0.074)	(0.072)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	1.27	1.27	1.27	1.27	1.27
Observations	153,997	153,997	153,997	153,997	153,997
Clusters (households)	37,547	37,547	37,547	37,547	37,547

Notes: Δr is the year-on-year change in the monetary policy (repo) interest rate, set by the Central Bank's monetary policy committee. DTI denotes the ratio of debt to income. All specifications include individual fixed effects, year fixed effects, and a set of controls containing a fourth polynomial in age, the number of children, change in number of children, as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60) and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parentheses.*** p<0.01, ** p<0.05, * p<0.1

Table A.6: Consumption responses to average household interest rate

	(1)	(2)	(3)	(4)	(5)
			OLS: All Households		
$\Delta r \times$ DTI	-0.622***	-0.631***	-0.837***	-0.741***	-1.076***
	(0.087)	(0.087)	(0.084)	(0.085)	(0.080)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	0.88	0.88	0.88	0.88	0.88
Observations	265,675	265,675	265,675	265,675	265,675
Clusters (households)	64,158	64,158	64,158	64,158	64,158
			OLS: Homeowners		
$\Delta r \times$ DTI	-0.594***	-0.616***	-1.177***	-0.624***	-1.370***
	(0.114)	(0.114)	(0.112)	(0.112)	(0.111)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	1.27	1.27	1.27	1.27	1.27
Observations	153,997	153,997	153,997	153,997	153,997
Clusters (households)	37,547	37,547	37,547	37,547	37,547

Notes: Δr is the year-on-year change in the average household interest rate computed by Statistics Sweden based on all loans to households. DTI denotes the ratio of debt to income. All specifications include individual fixed effects, year fixed effects, and a set of controls containing a fourth polynomial in age, the number of children, change in number of children, as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60), and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parentheses.*** p<0.01, ** p<0.05, * p<0.1

Table A.7: Consumption responses to changes in the monetary policy rate

	(1)	(2)	(3)	(4)	(5)
			IV: All Households		
$\Delta r \times$ DTI	-0.400***	-0.400***	-0.716***	-0.461***	-0.853***
	(0.078)	(0.078)	(0.074)	(0.076)	(0.070)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	0.88	0.88	0.88	0.88	0.88
Observations	265,642	265,642	265,642	265,642	265,642
Clusters (households)	64,125	64,125	64,125	64,125	64,125
			IV: Homeowners		
$\Delta r \times$ DTI	-0.413***	-0.415***	-1.035***	-0.403***	-1.093***
	(0.103)	(0.103)	(0.098)	(0.101)	(0.096)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	1.27	1.27	1.27	1.27	1.27
Observations	153,964	153,964	153,964	153,964	153,964
Clusters (households)	37,514	37,514	37,514	37,514	37,514

Notes: Δr is the year-on-year change in the monetary policy (repo) interest rate, set by the Central Bank's monetary policy committee. DTI denotes the ratio of debt to income. Changes in interest rates are instrumented with monetary policy shocks. All specifications include individual fixed effects, year fixed effects, and a set of controls containing a fourth polynomial in age, the number of children, change in number of children as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60), and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parentheses.*** p<0.01, ** p<0.05, * p<0.1

Table A.8: Consumption responses to average household interest rate

	(1)	(2)	(3)	(4)	(5)
			IV: All Households		
$\Delta r \times$ DTI	-0.529***	-0.528***	-1.001***	-0.611***	-1.186***
	(0.111)	(0.111)	(0.106)	(0.108)	(0.100)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	0.88	0.88	0.88	0.88	0.88
Observations	265,642	265,642	265,642	265,642	265,642
Clusters (households)	64,125	64,125	64,125	64,125	64,125
			IV: Homeowners		
$\Delta r \times$ DTI	-0.538***	-0.539***	-1.452***	-0.521***	-1.524***
	(0.146)	(0.146)	(0.140)	(0.144)	(0.137)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	1.27	1.27	1.27	1.27	1.27
Observations	153,964	153,964	153,964	153,964	153,964
Clusters (households)	37,514	37,514	37,514	37,514	37,514

Notes: Δr is the year-on-year change in the average household interest rate computed by Statistics Sweden based on all loans to households. DTI denotes the ratio of debt to income. Changes in interest rates are instrumented with monetary policy shocks. All specifications include individual fixed effects, year fixed effects, and a set of controls containing a fourth polynomial in age, the number of children, change in number of children, as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60), and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parentheses.*** p<0.01, ** p<0.05, * p<0.1

Table A.9: Consumption responses to interest rate changes by interest-rate fixation

Homeowners

	(1)	(2)	(3)	(4)
	OLS		IV	
Interest fixation$_1$ $\times$ Δr $\times$ DTI	-0.034	-0.045	-0.016	-0.020
	(0.191)	(0.191)	(0.250)	(0.250)
Interest fixation$_2$ $\times$ Δr $\times$ DTI	0.058	0.052	-0.429*	-0.428*
	(0.172)	(0.172)	(0.221)	(0.221)
Interest fixation$_3$ $\times$ Δr $\times$ DTI	-0.306*	-0.312*	-0.512**	-0.512**
	(0.173)	(0.173)	(0.215)	(0.215)
Interest fixation$_4$ $\times$ Δr $\times$ DTI	-0.440***	-0.446***	-0.372*	-0.376*
	(0.156)	(0.156)	(0.212)	(0.212)
Interest fixation$_5$ $\times$ Δr $\times$ DTI	-0.279	-0.295*	-0.395*	-0.406*
	(0.170)	(0.170)	(0.228)	(0.228)
Interest fixation$_1$ $\times$ Δr	0.615	0.565	-0.325	-0.331
	(0.373)	(0.373)	(0.494)	(0.494)
Interest fixation$_2$ $\times$ Δr	0.665*	0.615*	0.371	0.371
	(0.366)	(0.366)	(0.489)	(0.489)
Interest fixation$_3$ $\times$ Δr	0.516	0.465	-0.124	-0.124
	(0.372)	(0.372)	(0.488)	(0.488)
Interest fixation$_4$ $\times$ Δr	0.457	0.418	-0.764	-0.740
	(0.365)	(0.365)	(0.497)	(0.497)
Interest fixation$_5$ $\times$ Δr	0.192	0.169	-0.525	-0.494
	(0.358)	(0.358)	(0.489)	(0.490)
Liquid assets-to-income	No	Yes	No	Yes
Observations	153,997	153,997	153,997	153,997
Clusters (households)	37,547	37,547	37,547	37,547

Notes: This table presents results from the same regression estimation as reported in Table 4 in the main text, restricted to the sample of homeowners. Δr is the year-on-year change in the monetary policy (repo) interest rate, set by the Central Bank's monetary policy committee. *DTI* denotes the ratio of debt-to-income. *Interest fixation$_q$* refer to 5 indicator variables for quantiles of the distribution of correlation coefficients between the household-specific interest rate and the monetary policy rate; see main text for details. All specifications include individual fixed effects, year fixed effects and a set of controls containing a fourth polynomial in age, the number of children, change in number of children as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60) and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parenthesis.*** p<0.01, ** p<0.05, * p<0.1

Table A.10: Consumption responses to interest rate changes by interest-rate correlation

	(1)	(2)	(3)	(4)
	OLS			
	All Households		Homeowners	
Corr × Δr × DTI	-0.478***	-0.468***	-0.499***	-0.490***
	(0.093)	(0.093)	(0.102)	(0.102)
Δr × DTI	-0.098	-0.109	0.002	-0.017
	(0.076)	(0.076)	(0.094)	(0.094)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	1.19	1.19	1.52	1.52
Observations	192,242	192,242	129,406	129,406
Clusters (households)	46,801	46,801	31,552	31,552
	IV			
	All Households		Homeowners	
Corr × Δr × DTI	-0.413***	-0.404***	-0.485***	-0.473***
	(0.124)	(0.123)	(0.135)	(0.135)
Δr × DTI	-0.158	-0.167*	-0.107	-0.116
	(0.099)	(0.099)	(0.125)	(0.124)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	1.19	1.19	1.52	1.52
Observations	192,242	192,242	129,406	129,406
Clusters (households)	46,801	46,801	31,552	31,552

Notes: Δr is the year-on-year change in the monetary policy (repo) interest rate, set by the Central Bank's monetary policy committee. DTI denotes the ratio of debt to income. In the bottom panel, changes in interest rates are instrumented with monetary policy shocks. All specifications include individual fixed effects, year fixed effects, and a set of controls containing a fourth polynomial in age, the number of children, change in number of children, as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60), and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parentheses.*** p<0.01, ** p<0.05, * p<0.1

Table A.11: Consumption responses to individual interest rates and expenses

	(1)	(2)	(3)	(4)
Dependent variable:	$\Delta \log c_{i,t}$		$\Delta c_{i,t}$	
$\Delta r_i \times$ DTI	-0.181***	-0.180***	–	–
	(0.044)	(0.044)	–	–
Δinterest expenses$_i$	–	–	-0.165***	-0.164***
	–	–	(0.057)	(0.057)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	1.40	1.40	1.40	1.40
Observations	168,994	168,994	168,994	168,994
Clusters (households)	46,041	46,041	46,041	46,041

Notes: Δr_i is the year-on-year change in the average household-specific interest rate, computed according to equation (5). Δinterest expenses$_i$ is the year-on-year change in households total interest expenses. We exclude the top and bottom 5 percent in terms of changes in debt (extreme values are likely associated with debt repayment etc.). DTI denotes the ratio of debt to income. All specifications include individual fixed effects, year fixed effects, and a set of controls containing a fourth polynomial in age, the number of children, change in number of children, as well as interactions between change in the monetary policy interest rate and *young* (dummy for < 40), *old* (dummy for ≥ 60), and *children* (dummy for having children). Robust standard errors, clustered at the household level, are in parentheses.*** p<0.01, ** p<0.05, * p<0.1