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

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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 0.25–0.35 percentage points in response to a one-percentage-point increase in the policy rate, relative to a household with no debt. This is true among households with low or high levels of illiquid wealth, such as homeowners, who hold disproportionally little liquid wealth and display hand-to-mouth behavior when faced with increased interest expenses. 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 not only does monetary policy operate through this channel, but 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 do often 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, as we explain in detail in Section 3.4, 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

[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, for example, 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,

classify in our data as holders of ARMs are observationally similar along a variety of important dimensions to households holding FRMs.[5] In addition, we further reduce the selection concerns by conditioning on households that have already bought real estate and do not make a transaction. 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. This data source provides us with detailed information on all income, assets, and debt. The details of these data also 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, such as household spending, 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 impact varies between households depending on their debt contracts and balance sheets. In particular, we examine how monetary policy affects consumption choices for households with a large debt relative to households with less debt, and for households with ARMs relative to households with FRMs.

Our results lend strong support to the importance of the cash-flow channel of monetary policy. First, we find 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. Our 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 0.25 percentage points relative to a similar household with no debt. These estimates are consistent with the notion that hand-to-mouth consumers respond to changes in the policy rate when it affects their cash flow through changes in interest rate expenses, irrespective of whether the change was anticipated or not. Nevertheless, our empirical analysis faces a standard problem of 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. Our empirical specification separates out the aggregate effect of monetary policy on expenditure, estimating a differential response of more indebted and interest-rate-sensitive households. However, there may still be a concern that the central bank responds differentially to changing conditions of these groups, thus violating the assumptions that underlie our analysis. 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 re-

e.g., Campbell and Cocco (2003), Campbell and Cocco (2015) and Badarinza et al. (2018) for recent empirical evidence.

[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).

sponses 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 measure monetary policy shocks as the effect of a policy surprise on market interest rates at the time of the policy announcement. Using these shocks as instruments for changes in the policy rate, we find consumption responses that are about 50 percent larger than our non-instrumented estimates.

The policy rate and households' interest expenses do not necessarily change one to one. We therefore consider two other specifications. First, we estimate responses to the average aggregate interest rate faced by households. This results in considerably stronger effects. The estimates imply that a one-percentage-point increase in the household rate reduces the consumption spending of the average household by an additional 0.55 percentage points relative to those without any debt. Translating this estimate into a marginal propensity to consume (MPC) out of changes in disposable income, or cash flow, as a result of a change in interest rates implies an MPC of about 0.5. Second, we separate between the responses of households with ARMs and those with FRMs. Although our setting is one where a large share of households have at least a share of their debt with interest rates that adjust with changes in the short-term policy rate, there is considerable heterogeneity in the degree of interest-rate flexibility across households. As a result, the response for the average household will be muted, and the magnitude will be influenced by the shares of ARMs and FRMs in their loan portfolios. Using a proxy measure for the shares for each household, we find that the spending of households with all or a large share of their loans in FRMs does not respond to changes in the policy rate, whereas households with a low share respond strongly. These findings imply that our average estimates are, to a large degree, driven by a consumption response of relatively highly indebted households with ARMs.

We argue that our findings are consistent with widespread hand-to-mouth behavior and a high prevalence of relatively wealthy hand-to-mouth consumers. As further evidence supporting this notion, we see that in our sample 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; whereas 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 liquid assets. Combined with the high prevalence of ARMs, this increases the likelihood that changes in interest rates quickly pass through into changes in consumption expenditure.

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 for example 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. (2012) 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 framework, illustrating how the consumption behavior underlying the cash-

[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).

flow channel differs from the standard consumer theory behind the interest-rate channel. Section 3 then provides details on the data we use in our analysis and the background to our setting. Our empirical strategy is outlined in Section 4. Section 5 presents our empirical results. In Section 6, we exploit our data to study hand-to-mouth behavior and interest-rate sensitivity more in general by sorting households based on balance sheet characteristics. Section 7 concludes the paper. Some additional material and supplementary analyses 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 (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 balance. 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

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

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 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 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. 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 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 hold, 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 the extreme case, households with FRMs gain from higher inflation.

[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.

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 respond immediately, whereas HTM households with FRMs respond with a delay (i.e., only when the interest 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.

To summarize, we highlight three differences in behavior between optimizing and HTM households. 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. In addition, we note that the consumption of optimizing households with ARMs respond stronger than the consumption of households with FRMs.

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

[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).

and every listed stock or mutual fund it holds in its tax filings (see Calvet et al., 2007). The data 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

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 1 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 makes it clear 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 2 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 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 different 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 such a combination. 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 pay a penalty equal to the interest rate differential between FRMs and ARMs. 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

the reporting rule of 2000–2005 also on the latter period when imputing consumption.

[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.

fixation period. Banks therefore frequently recommend a combination of FRMs vs. ARMs as it lowers the risk 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 The 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 3 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

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

indebted group has less than 4 months of disposable income. These statistics relate to a growing 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 wealth HtM households in the population.

The bottom panels of Figure 3 display a cross-sectional variation in interest expenses relative to disposable income and consumption. Homeowners with a high DTI ratio spend on average 0.15 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 Framework

We now outline our empirical strategy. In Section 2, we have argued that the cash-flow channel is operational among HtM households that have a large share in ARMs. For these households, the magnitude of the consumption response is approximately proportional to the DTI ratio. Consistent with this, our main regression specification is:

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

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 $DTI_{i,t-2}$ is the household's DTI ratio, which we lag by one year so that it is predetermined with respect to $c_{i,t-1}$. We denote individual fixed effects by α_i. They capture any time-invariant cross-sectional

[16]Note that this specification relates household spending to an aggregate interest rate, Δr_t, with no subindex i. That is, 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 explore other specifications in the Online Appendix and provide further discussion in Section 5.3.

heterogeneity, such as in borrowing behavior or portfolio choice. Year fixed effects, denoted by δ_t, capture common macroeconomic effects and responses to aggregate shocks, including intertemporal responses to the consumption 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 effect of interest rate changes on consumption operating through the cash-flow channel is captured by β. It measures consumption responses to changes in the interest rate that vary systematically due to differences in DTI. If all households optimize, 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.[18,19]

We emphasize the implications of year and household fixed effects in our empirical model. The year fixed effects account for the overall aggregate effect of monetary policy on household spending. The household fixed effects account for time-invariant individual differences, including those in consumption growth. As a result, the coefficient β captures responses less the aggregate effect.

5 Results

5.1 Consumption responses to interest rate changes

Table 2 reports estimates of consumption responses to changes in aggregate interest rates, based on the regression equation (4). Panel A documents results for responses to the monetary policy (repo) interest rate. Column (1) reports a coefficient estimate of β of -0.26. The interpretation

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

[18] One caveat is that, given the data at hand, we are not able to observe if households adjust their amortization in response to interest-rate changes. Such a strategic response would be subsumed into the estimated cash-flow effect. For constrained households that consume all their disposable income, a decrease in the short interest rate implies increased consumption possibilities that could be highly valued. Therefore, we expect any strategic amortization adjustment to come from *less* constrained households, making the differential effect biased toward zero.

[19] As discussed in footnote 13, bank account deposits are reported only if certain criteria are met. Thus, one potential concern is that if households choose to save slightly more or less in response to interest rate changes, we would not observe this. However, if households save more in bank accounts in response to an increase in the monetary policy rate (and in bank deposit rates), and this is unobserved to us, it would overstate consumption. In turn, this would lead to a downward bias in the estimate of β (i.e., it would mute the cash-flow channel effect). 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 (i.e., the repo rate) gives a coefficient estimate of 0.62. Furthermore, there is a positive correlation between bank deposit rates and flows into bank account deposits.

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]

In Panel B of Table 2, we document results for consumption responses to the aggregate interest rate faced by households instead of the monetary policy rate. This rate is the average of interest rates across all loans to households and computed by Statistics Sweden. By focusing on responses to this interest rate, we ignore the first step in the transmission of monetary policy into households' interest payments.[22] Column (1) in Panel B reports a coefficient estimate of β of -0.62. This implies that a one-percentage-point increase in the lending rate reduces the consumption spending of the average household by an additional 0.55 percentage points relative to those without debt. As in Panel A, 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 Panels A and B indicates that responses to changes in the monetary policy rate are muted due to an incomplete transmission to household interest rates. This is expected since not all of the changes in the policy rate get transmitted into changes in household interest rates and expenses, partly due to interest-rate fixation.

[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. We construct five indicator variables for quantiles of the DTI distribution. In a regression, we interact these indicators with the change in the monetary policy rate. The estimated coefficients are negative for all five groups and strongest for the two upper quantiles. Results are available upon request.

[22] Figure 4 documents that the average interest rate on household debt closely follows the monetary policy rate. To further gauge the passthrough, 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.

These results 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 aggregate interest rate changes to household interest payments, the above estimates imply an MPC in the interval 0.22–0.52 out of a one-unit increase in interest expenses.[23]

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 does not separate that response from a potential heterogeneity in the consumption-to-income ratio that might be correlated with the size of the response. We investigate this possible concern in Tables A.5 and A.6 in the Appendix, finding relatively similar but somewhat stronger effects when adding this control.

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. While we seek to address this problem more generally below, we assess the robustness of our estimates presented in Table 2 by including income growth as an additional explanatory variable.[24] The results, documented in Tables A.5 and A.6 in the Appendix, show that adding this control raises the estimated effect for the average household. However, the results are almost unaffected in the sample of homeowners. This implies that the concern that potential effects of monetary policy on income may be spilling over to the effect of interest expenses is less important for responses of homeowners than renters, who may have a more cyclical income or employment status.

5.2 Monetary policy shocks and responses to unexpected interest rate changes

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 not. 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

[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. In Column (1), the average reduction in consumption to a one-percentage-point interest rate increase is in the interval $0.26 \times 0.01 \times 241$=0.63 to $0.62 \times 0.01 \times 241$=1.49 kSEK. This implies an MPC between 0.22 (0.63/2.84) and 0.52 (1.49/2.84).

[24]Including income growth could be considered as including a "bad control." It is therefore not included in our baseline specification.

households. To overcome this issue, we exploit monetary policy shocks that enable us to separate unanticipated changes in interest rates from those that are anticipated based on macroeconomic conditions.

To this end, we measure monetary policy shocks using an approach similar to what is used in recent literature studying monetary non-neutrality, including Gertler and Karadi (2015), Hanson and Stein (2015), and Nakamura and Steinsson (2018), building on insights from Kuttner (2001) and Gürkaynak et al. (2005). Using data at high frequency, this literature seeks to identify innovations in 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 both underdeveloped 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. Then, following examples from earlier work, such as Romer and Romer (2004) and Cloyne et al. (2019), we time-aggregate the monetary policy shocks to a yearly frequency by summing up these measures from all announcements in a year.[25]

Table 3 presents two-stage least squares estimates of equation (4) where changes in interest rates are instrumented with monetary policy shocks.[26] This isolates consumption responses to changes in interest rates that are unanticipated. Panel A documents results for responses to changes in the policy rate. 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. These results imply considerably stronger effects than those presented in Table 2, possibly indicating a bias toward zero. Panel B of Table 3 reports estimates of consumption responses to the average household interest rate, instrumented with monetary policy shocks. These estimates imply that consumption responds equally strongly to changes in policy rates that get passed through to lending rates to households, whether they are anticipated or unanticipated. All in all, these results are consistent with HtM behavior, as discussed in Section 2.

[25]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 optimizing households. However, as highlighted in Online Appendix B the latter are likely to be small.

[26]Figure A.11 in the Appendix documents how our measure of monetary policy shocks covaries with the monetary policy rate over our sample period, in particular during the period of interest rate increases. However, as expected, the magnitude of these unanticipated changes in interest rates is considerably smaller than the overall changes in interest rates.

5.3 Consumption responses of holders of ARMs

Our point of departure, and 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.

Since our data originate from tax records and do not include any contract details, we do not directly observe which households have mortgages with adjustable rates, 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 we first compute the implied household-specific interest rate using information on interest expenses and the amount 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 4 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. 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. Figure A.12 in the Appendix reports the cross-sectional distribution of these correlation coefficients. The median correlation is 0.61, consistent with a high prevalence of ARMs.[27]

[27] 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

Before studying differential responses by this measure of interest rate fixation, we compare the characteristics of households at the two sides of the spectrum. Table A.3 in the 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 vs. FRMs, respectively. We find that households with ARMs have higher income and consumption, but they also have more household members than those with FRMs. Households with ARMs have more debt as well as more illiquid assets, but there is no statistical difference in liquid assets. Importantly, 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.

To evaluate the differential consumption response of holders of ARMs vs. FRMs, we construct five indicator variables for quantiles of the correlation distribution, Interest Duration$_x$, where x =1 denotes the quantile with the lowest correlation and x =5 denotes the quantile with the highest correlation. The indicators reflect the duration of interest fixation in the household's loan portfolio. Then, we estimate an extended version of equation (4) where $\Delta r_t \times DTI_{i,t-2}$ is interacted with the quantile indicators. The results are presented in Table 4. For the two groups with the lowest correlation (Interest Duration$_1$, Interest Duration$_2$), the coefficients are not statistically significant, while the effects are negative and stronger for the three groups with the higher correlation (Interest Duration$_3$–Interest Duration$_5$). There is a statistically significant difference between each of the two top quantiles and the bottom two quantiles. When restricting the sample to homeowners, the results are similar, as found in our previous analysis, even though the coefficient estimates are less precise. For homeowners, the estimates are less precise, but there is a statistically significant difference between the second and the fourth quantiles (and between the first and fourth quantiles at the 10.1 percent level).

We compute "group effects" from these estimates. We multiply the coefficient of interest (for a given quantile x that is the coefficient on Interest Duration$_x \times \Delta r_t \times \text{DTI}_{i,t-2}$) by the average DTI ratio for that group and then add the coefficient for the simple interaction $\Delta r_t \times$Interest Duration$_X$.[28] For both the full sample and the sample of homeowners, there is a statistically significant difference in responses between the first and second quantiles and the third to fifth quantiles. This implies that the responses reported so far are driven not only by differential responses of more indebted households but also by those with a higher prevalence of debt with adjustable rates. Table 5 presents estimates where changes in the policy rate are instrumented with monetary policy shocks. The estimated effects are similar to those in Table 4 for the third to fifth quantiles, but somewhat more negative for the second quantile. This implies that the effects are homogenous among the second to fifth quantiles. However, in all specifications there is a statistically significant difference in the group response between the second quantile and the third to fifth quantiles,

differential responses would be muted. Another concern 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 some households have a negative correlation.

[28]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.

as well as between the first quantile and the fourth quantile.

To further evaluate the potential non-linearities in responses by interest rate flexibility, Table A.9 in the Appendix reports estimates based on the triple interaction $\text{Corr}_i \times \Delta r_t \times \text{DTI}_{i,t-2}$ (i.e., based on the continuous correlation measure). 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, where the results are somewhat stronger when restricting to homeowners. Table A.9 in the Appendix also presents results where the policy rate is instrumented with monetary policy shocks. They are of similar magnitudes.[29]

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 a 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 include details about neither 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.10 in the Appendix reports consumption responses to individual households' interest rates and interest expenses. Columns (1) and (2) report estimates of equation (4) where the interest rate is the household-specific interest rate rather than the policy rate. The coefficient estimate implies a similar but somewhat weaker response than what is reported in, e.g., Table 2. 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 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 results, which can be interpreted as the MPC out of a one-SEK increase in interest expenses, imply an MPC of about 0.16.

6 Hand-to-mouth behavior and interest-rate sensitivity

In previous sections we have documented how households with different DTI ratios adjust their consumption in response to changes in the monetary policy rate. In this section, we analyze other important characteristics associated with excess sensitivity of consumption. In particular, following Kaplan et al. (2014), a growing literature has emphasized that having low levels of liquid wealth is associated with HtM behavior.

To shed further light on how consumption responds to changes in the monetary policy rate, we group households according to three key characteristics relevant for interest-rate sensitivity

[29] As documented in Figure A.12 in the Appendix, some households have a negative correlation, which may result from changes in interest rates due to refinancing or loan repayment. When restricting the sample to households with a non-negative correlation, the coefficient estimates are broadly similar and, if anything, stronger than for the full sample.

and HtM behavior: the DTI ratio, the interest duration, and the ratio of liquid assets to income. We classify households depending on whether they are above or below median for each of these measures and form eight groups (2×2×2) to study heterogeneity in consumption responses.

Panel B of Table 6 reports summary statistics for the groups. Households with high DTI ratios have higher levels of disposable income on average than those with lower DTI ratios, have more household members, and have a household head that is slightly younger and more educated. Higher debt levels are also associated with higher levels of illiquid wealth, that is, higher real estate value. Looking within groups with same DTI and liquid assets to income status, households with ARMs vs. FRMs appear to be fairly similar along most dimensions.

Panel A of Table 6 reports estimates of consumption responses to changes in the monetary policy rate. The estimates are based on a single regression that is an extension of equation (4). The monetary policy rate is interacted with each of the eight group indicators ($\beta_1 \Delta r_t \times \text{Group}_1 + ... + \beta_8 \Delta r_t \times \text{Group}_8$). Groups 1 and 8 constitute the two extremes, and contrasting them provides the most interesting insight. A priori we expect group 1—households with high DTI ratio, ARMs, and low liquid assets to income—to exhibit the most negative consumption response to an interest rate increase. This is indeed the case. The coefficient estimate for this group is -0.67. At the other end of the spectrum, group 8—households with low DTI ratios, FRMs, and high liquid assets to income–is not expected to respond negatively in the same way. In line with this, we estimate a coefficient of 0.98 for this group. That is, the consumption response to higher interest rates is less negative (and possibly positive) for this group than for the average of the other groups. [30]

While the results show that the pattern is dominated by whether households have high or low DTI ratios, we see that this is necessary but not sufficient for observing a spending reduction in response to higher policy rates. For households with high DTI ratios but high levels of liquid assets, this response is muted, as they are more likely to be able to draw on their savings to finance increased 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 therefore muted as well. In sum, these results indicate that our main results reflect responses of households that have high levels of debt and an interest burden that is sensitive to changes in monetary policy but also do not have access to liquidity to smooth consumption in the short run.

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

[30] When using monetary policy shocks as instruments for changes in the monetary policy rate, this pattern is generally similar but the difference between groups 1 and 8 is more pronounced.

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 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. Specifically, we are unable to characterize the general equilibrium effect of the cash-flow channel on aggregate consumption in the economy. However, recent and contemporaneous research has highlighted the aggregate importance of the cash-flow channel (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.

References

AGARWAL, S., C. LIU, AND N. S. SOULELES (2007): "The Reaction of Consumer Spending and Debt to Tax Rebates – Evidence from Consumer Credit Data," *Journal of Political Economy*, 115, 986–1019.

AGARWAL, S. AND W. QIAN (2014): "Consumption and Debt Response to Unanticipated Income Shocks: Evidence from a Natural Experiment in Singapore," *American Economic Review*, 104, 4205–4230.

ATTANASIO, O. AND G. WEBER (2010): "Consumption and Saving: Models of Intertemporal Allocation and their Implications for Public Policy," *Journal of Economic Literature*, 48, 693–751.

AUCLERT, A. (2019): "Monetary Policy and the Redistribution Channel," *American Economic Review*, forthcoming.

BADARINZA, C., J. Y. CAMPBELL, AND T (2018): "What Calls to ARMs? International Evidence on Interest Rates and the Choice of Adjustable-Rate Mortgages," *Management Science*, 64, 2275–2288.

BERBEN, R. P., A. LOCARNO, J. MORGAN, AND J. VALLES (2004): "Cross-Country Differences in Monetary Policy Transmission," Working Paper 400, European Central Bank.

BERNANKE, B. AND M. GERTLER (1995): "Inside the Black Box: The Credit Channel of Monetary Policy Transmission," *Journal of Economic Perspectives*, 9, 27–48.

BERNANKE, B. S. (2015): "Monetary Policy and Inequality," .

BOIVIN, J., M. T. KILEY, AND F. S. MISHKIN (2011): *How Has the Monetary Policy Mechanism Evolved Over Time?*, vol. 3A of *Handbook of Monetary Economics*, Elsevier.

BROWNING, M. AND S. LETH-PETERSEN (2003): "Imputing Consumption from Income and Wealth Information," *The Economic Journal*, 113, 282–301.

BULLARD, J. (2014): "Income Inequality and Monetary Policy: A Framework with Answers to Three Questions," .

CALVET, L. E., J. Y. CAMPBELL, AND P. SODINI (2007): "Down or Out: Assessing the Welfare Costs of Household Investment Mistakes," *Journal of Political Economy*, 115, 707–747.

CALZA, A., T. MONACELLI, AND L. STRACCA (2013): "Housing Finance and Monetary Policy," *Journal of the European Economic Association*, 11, 101–122.

CAMPBELL, J. Y. AND J. F. COCCO (2003): "Household Risk Management and Optimal Mortgage Choice," *Quarterly Journal of Economics*, 118, 1449–1494.

——— (2015): "A Model of Mortgage Default," *Journal of Finance*, 70, 1495–1554.

CAMPBELL, J. Y. AND N. G. MANKIW (1990): "Permanent Income, Current Income, and Consumption," *Journal of Business and Economic Statistics*, 8, 265–279.

CARROLL, C. D. AND M. S. KIMBALL (1990): "On the Concavity of the Consumption Function," *Econometrica*, 64, 981–992.

CASIRAGHI, M., E. GAIOTTI, L. RODANO, AND A. SECCHI (2018): "A Reverse Robin Hood? The Distributional Implications of Non-Standard Monetary Policy for Italian Households," *Journal of International Money and Finance*, 85, 215 – 235.

CLOYNE, J., C. FERREIRA, AND P. SURICO (2019): "Monetary Policy when Households have Debt: New Evidence on the Transmission Mechanism," *Review of Economic Studies*, 0, 1–28.

DI MAGGIO, M., A. KERMANI, B. KEYS, T. PISKORSKI, R. RAMCHARAN, A. SERU, AND V. YAO. (2017): "Monetary Policy Pass-Through: Mortgage Rates, Household Consumption and Voluntary Deleveraging," *American Economic Review*, 107, 3550–3588.

DOEPKE, M. AND M. SCHNEIDER (2006): "Inflation and the Redistribution of Nominal Wealth," *Journal of Political Economy*, 114, 1069–1097.

EDIN, P.-A. AND P. FREDRIKSSON (2000): "LINDA - Longitudinal INdividual DAta for Sweden," Tech. Rep. No. 2000:19, Department of Economics, Uppsala University.

FINANSINSPEKTIONEN (2017): "FI-analys 9," .

GARRIGA, C., F. E. KYDLAND, AND R. SUSTEK (2017): "Mortgages and Monetary Policy," *The Review of Financial Studies*, 30, 3337–3375.

GERTLER, M. AND P. KARADI (2015): "Monetary Policy Surprises, Credit Costs, and Economic Activity," *American Economic Journal: Macroeconomics*, 7, 44–76.

GORNEMANN, N., K. KUESTER, AND M. NAKAJIMA (2012): "Monetary policy with heterogeneous agents," Tech. rep., FRB of Philadelphia Working Paper.

GREENWALD, D. L. (2018): "The Mortgage Credit Channel of Macroeconomic Transmission," Mimeo.

GÜRKAYNAK, R. S., B. SACK, AND E. T. SWANSONC (2005): "Do Actions Speak Louder Than Words? The Response of Asset Prices to Monetary Policy Actions and Statements," *International Journal of Central Banking*, 1, 55–93.

HANSON, S. G. AND J. C. STEIN (2015): "Monetary policy and long-term real rates," *Journal of Financial Economics*, 115, 429–448.

HOLMBERG, U., H. JANZÉN, L. OSCARIUS, P. VAN SANTEN, AND E. SPECTOR (2015): "An Analysis of the Fixation Period for Swedish Mortgages," Mimeo, Sveriges Riksbank.

HSIEH, C.-T. (2003): "Do Consumers React to Anticipated Income Changes? Evidence from the Alaska Permanent Fund," *American Economic Review*, 93, 397–405.

JAPPELLI, T. AND L. PISTAFERRI (2010): "The Consumption Response to Income Changes," *Annual Review of Economics*, 2, 479–506.

JAPPELLI, T. AND A. SCOGNAMIGLIO (2018): "Interest rate changes, mortgages, and consumption: evidence from Italy," *Economic Policy*, 33, 183–224.

JOHNSON, D. S., J. A. PARKER, AND N. S. SOULELES (2006): "Household Expenditure and the Income Tax Rebates of 2001," *American Economic Review*, 96, 1589–1610.

KAPLAN, G., G. VIOLANTE, AND J. WEIDNER (2014): "The Wealthy Hand-to-Mouth," *Brookings Papers on Economic Activity*.

KOIJEN, R., S. V. NIEUWERBURGH, AND R. VESTMAN (2015): "Judging the Quality of Survey Data by Comparison with "Truth" as Measured by Administrative Records: Evidence From Sweden," in *Improving the Measurement of Consumer Expenditures*, ed. by C. Carroll, T. Crossley, and J. Sabelhaus, University of Chicago Press, NBER Book Series Studies in Income and Wealth.

KUENG, L. (2018): "Excess Sensitivity of High-Income Consumers," *Quarterly Journal of Economics*, 133, 1693–1751.

KUTTNER, K. N. (2001): "Monetary policy surprises and interest rates: Evidence from the Fed funds futures market," *Journal of monetary economics*, 47, 523–544.

LA CAVA, G., H. HUGHSON, AND G. KAPLAN (2016): "The Household Cash Flow Channel of Monetary Policy," Research Discussion Paper 2016-12, Reserve Bank of Australia.

MERSCH, Y. (2014): "Monetary Policy and Economic Inequality," .

MISHKIN, F. S. (2007): "Housing and the Monetary Transmission Mechanism," Finance and Economics Discussion Series, Federal Reserve Board.

NAKAMURA, E. AND J. STEINSSON (2018): "High-frequency identification of monetary non-neutrality: the information effect," *The Quarterly Journal of Economics*, 133, 1283–1330.

PARKER, J. A., N. S. SOULELES, D. S. JOHNSON, AND R. MCCLELLAND (2013): "Consumer Spending and the Economic Stimulus Payments of 2008," *American Economic Review*, 103, 2530–2553.

ROMER, C. D. AND D. H. ROMER (2004): "A new measure of monetary shocks: Derivation and implications," *American Economic Review*, 94, 1055–1084.

SHAPIRO, M. D. AND J. SLEMROD (2003): "Consumer Response to Tax Rebates," *American Economic Review*, 93, 381–396.

——— (2009): "Did the 2008 Tax Rebates Stimulate Spending?" *American Economic Review Papers and Proceedings*, 99, 374–379.

SODINI, P., S. VAN NIEUWERBURGH, R. VESTMAN, AND U. VON LILIENFELD-TOAL (2017): "Identifying the Benefits from Home Ownership: A Swedish Experiment," Working Paper.

STEPHENS, M. (2008): "The Consumption Response to Predictable Changes in Discretionary Income: Evidence from the Repayment of Vehicle Loans," *The Review of Economics and Statistics*, 90, 241–252.

STERK, V. AND S. TENREYRO (2018): "The Transmission of Monetary Policy through Redistribution and Durable Purchases," *Journal of Monetary Economics*, 99, 124–137.

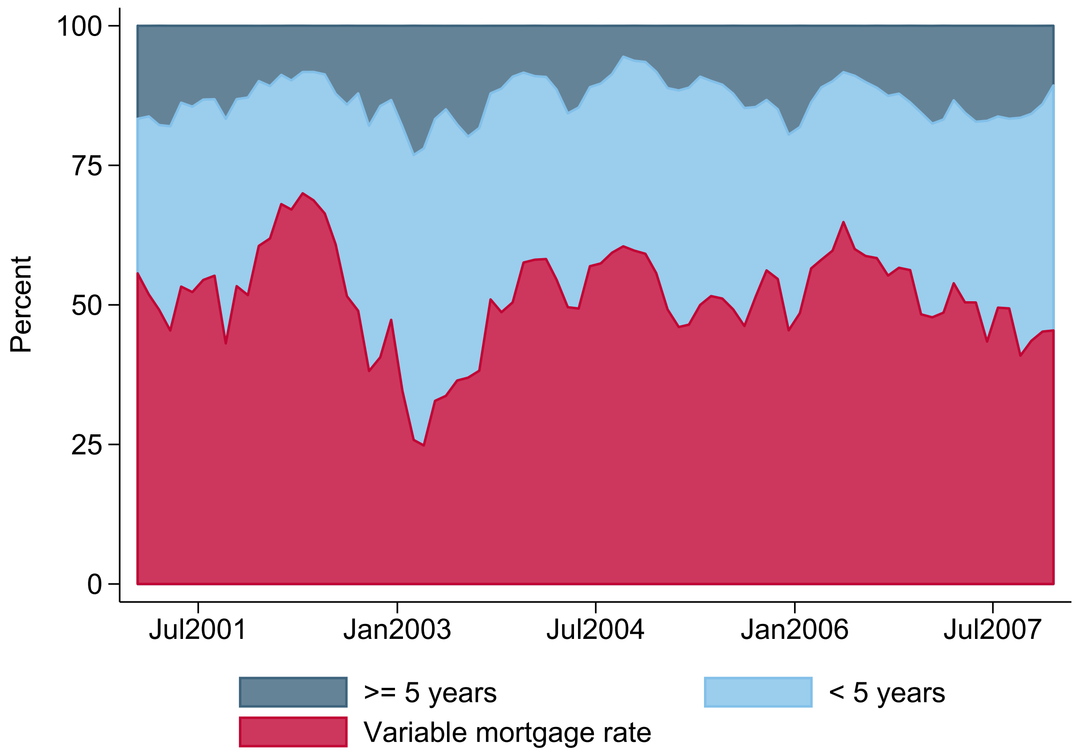
SVERIGES RIKSBANK (2012): "Monetary Policy Report," .

——— (2014): "Från ax till limpa: den svenska bolånemarknaden och dess roll i det finansiella systemet," .

——— (2015): “Financial Stability Report 2015:2,” .

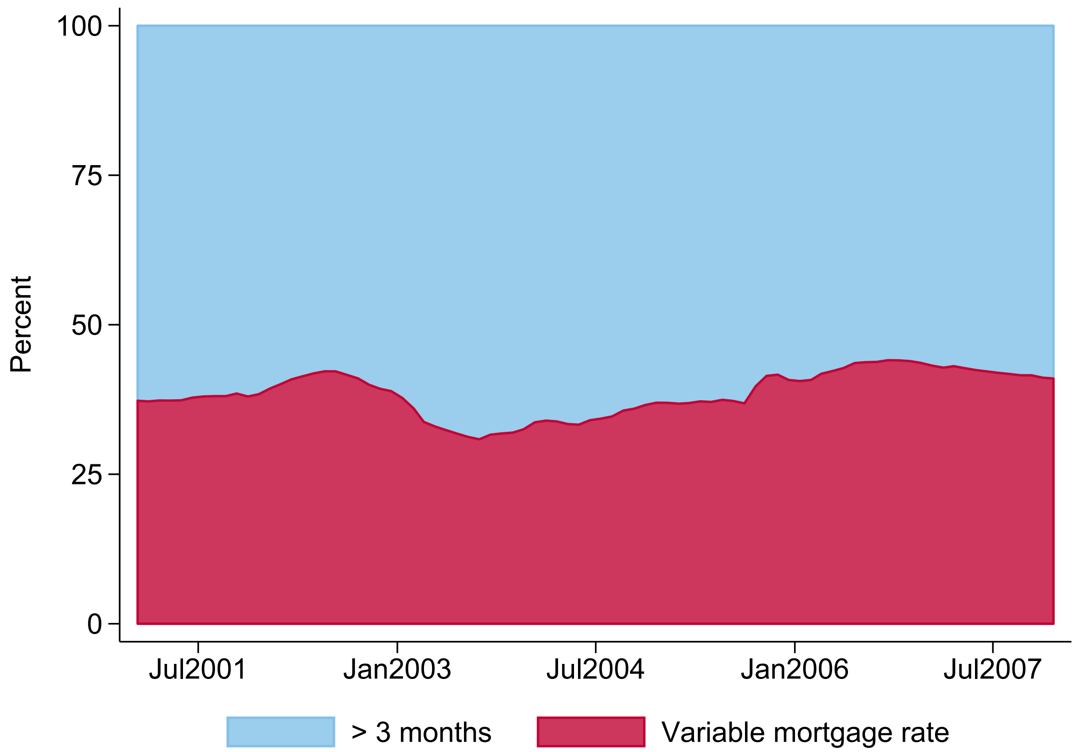
WONG, A. (2019): “Refinancing and the Transmission of Monetary Policy to Consumption,” Tech. rep., Princeton University.

Figure 1: Share of mortgage issuances by duration of interest rate fixation



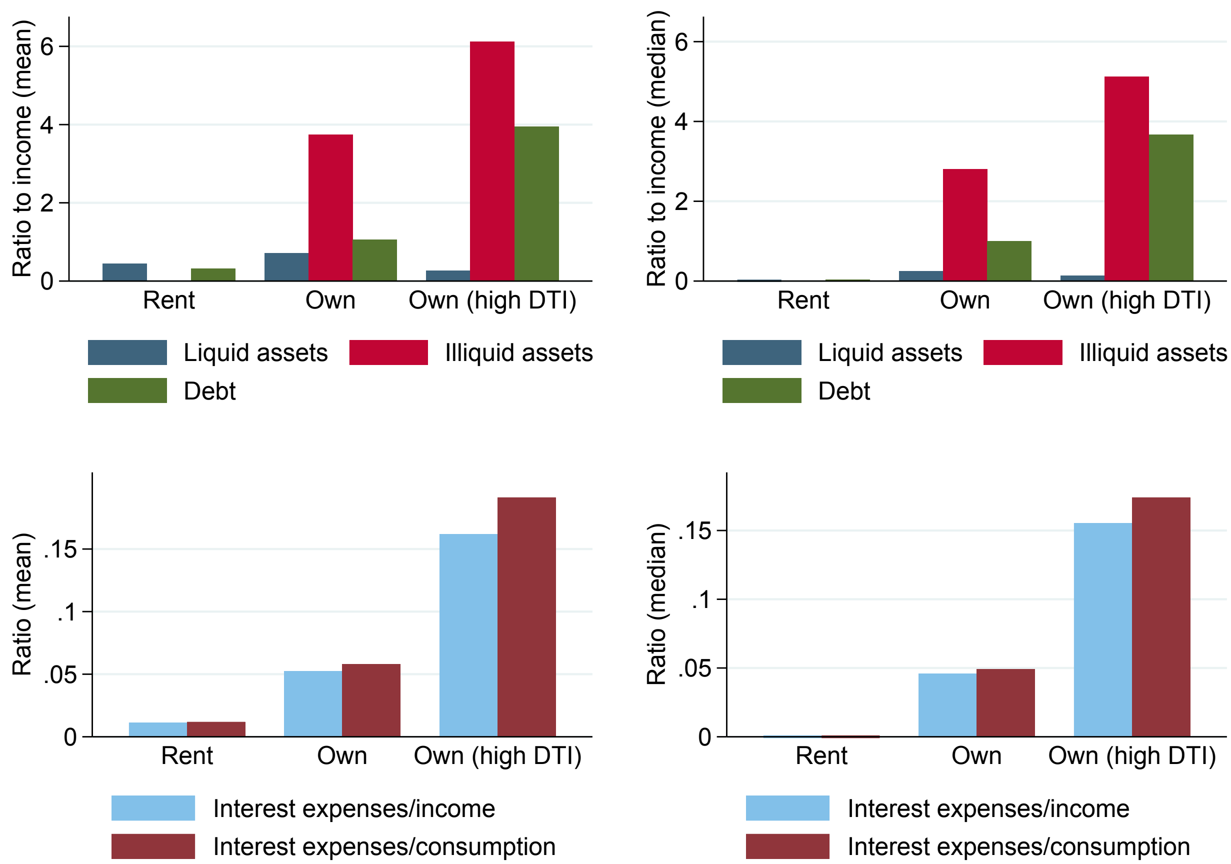
Notes: Variable mortgage rate is defined as 3 months or shorter. The data source is Figure A18 in Sveriges Riksbank (2012).

Figure 2: Shares of the mortgage stock by duration of interest rate fixation



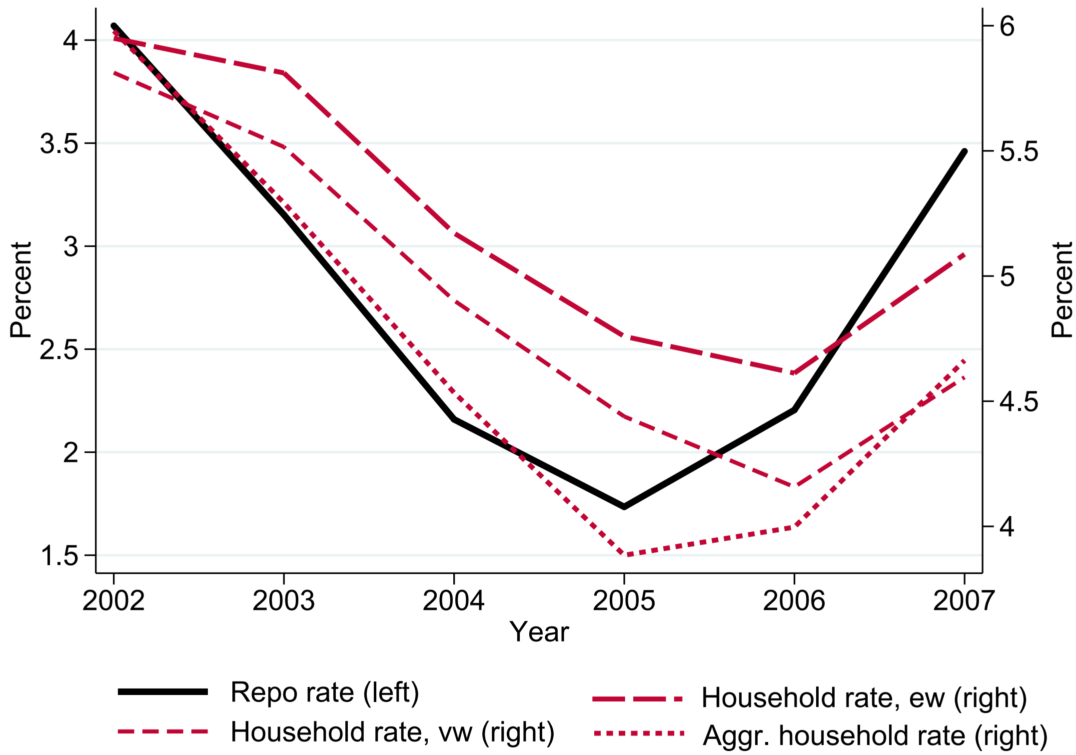
Notes: Variable mortgage rate is defined as 3 months or shorter. The data source is Figure A30 in Sveriges Riksbank (2015).

Figure 3: Assets, debt, and interest expenses



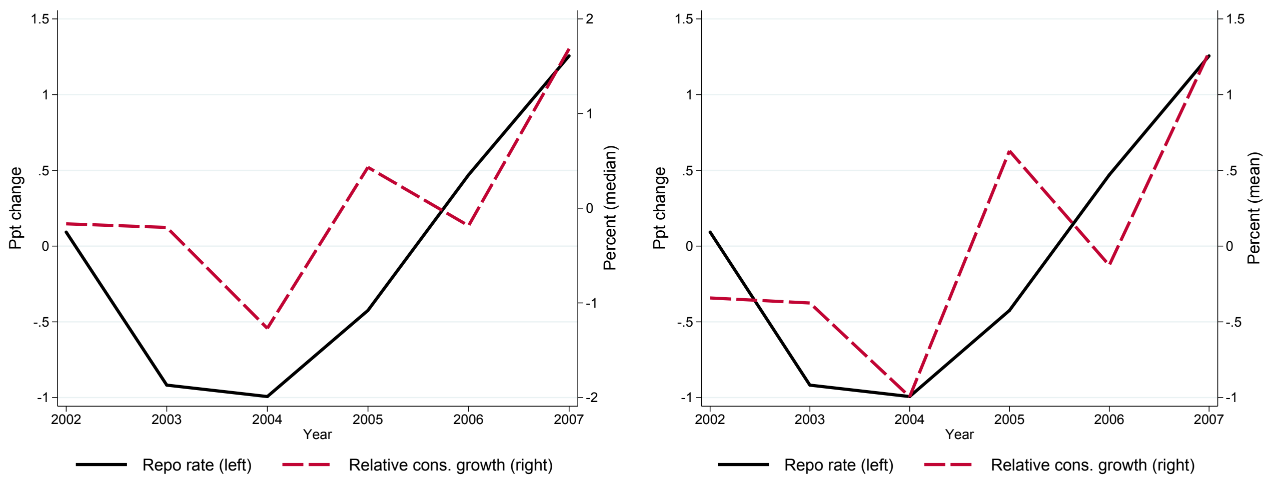
Notes: The figure displays renters' and homeowners' assets, debt, and interest expenses normalized by disposable income. The second and third category report homeowners with a debt-to-income ratio of less than 3 and equal or greater than 3, respectively. The last category is referred to as "high DTI" 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 4: The repo rate and household interest rates



Notes: The figure displays 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).

Figure 5: The repo rate and relative consumption growth



Notes: The left-hand panel depicts relative consumption growth measured as the median consumption growth among homeowners with a high debt-to-income ratio minus the median consumption growth of homeowners with a high debt-to-income ratio and an interest rate correlation above the median. The right-hand panel depicts the same difference evaluated at the mean.

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 Interest Rates

	(1)	(2)	(3)	(4)
	A. Monetary Policy Rate			
	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
	B. Aggregate Household Rate			
	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

Notes: In panel A, Δr is the year-on-year change in the monetary policy (repo) interest rate, set by the Central Bank's monetary policy committee. In panel B, 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 parenthesis.*** p<0.01, ** p<0.05, * p<0.1

Table 3: Consumption Responses to Changes in Interest Rates

Instrumented with Monetary Policy Shocks

	(1)	(2)	(3)	(4)
	A. Monetary Policy Rate			
	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
	B. Aggregate Household Rate			
	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: In panel A, Δr is the year-on-year change in the monetary policy (repo) interest rate, set by the Central Bank's monetary policy committee. In panel B, 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; 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 4: Consumption Responses to Interest Rate Changes by Interest Rate Flexibility Group

	(1)	(2)	(3)	(4)
	All Households		Homeowners	
Interest $\text{Duration}_1 \times \Delta r \times$ DTI	-0.102	-0.107	-0.034	-0.045
	(0.147)	(0.147)	(0.191)	(0.191)
Interest $\text{Duration}_2 \times \Delta r \times$ DTI	-0.072	-0.074	0.058	0.052
	(0.132)	(0.132)	(0.172)	(0.172)
Interest $\text{Duration}_3 \times \Delta r \times$ DTI	-0.381***	-0.384***	-0.306*	-0.312*
	(0.141)	(0.141)	(0.173)	(0.173)
Interest $\text{Duration}_4 \times \Delta r \times$ DTI	-0.438***	-0.439***	-0.440***	-0.446***
	(0.129)	(0.129)	(0.156)	(0.156)
Interest $\text{Duration}_5 \times \Delta r \times$ DTI	-0.440***	-0.448***	-0.279	-0.295*
	(0.145)	(0.144)	(0.170)	(0.170)
Interest $\text{Duration}_1 \times \Delta r$	0.626***	0.608***	0.615	0.565
	(0.205)	(0.205)	(0.373)	(0.373)
Interest $\text{Duration}_2 \times \Delta r$	0.626***	0.611***	0.665*	0.615*
	(0.225)	(0.225)	(0.366)	(0.366)
Interest $\text{Duration}_3 \times \Delta r$	0.520**	0.507**	0.516	0.465
	(0.249)	(0.249)	(0.372)	(0.372)
Interest $\text{Duration}_4 \times \Delta r$	0.272	0.262	0.457	0.418
	(0.245)	(0.245)	(0.365)	(0.365)
Interest $\text{Duration}_5 \times \Delta r$	0.421*	0.421*	0.192	0.169
	(0.237)	(0.237)	(0.358)	(0.358)
Liquid assets to income	No	Yes	No	Yes
Observations	265,675	265,675	153,997	153,997
Clusters (households)	64,158	64,158	37,547	37,547

Notes: Δrepo rate 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 Duration*$_X$ 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 to Interest Rate Changes by Interest Rate Flexibility Group

Instrumented with Monetary Policy Shocks

	(1)	(2)	(3)	(4)
	All Households		Homeowners	
Interest $\text{Duration}_1 \times \Delta r \times$ DTI	0.000	-0.004	-0.016	-0.020
	(0.193)	(0.193)	(0.250)	(0.250)
Interest $\text{Duration}_2 \times \Delta r \times$ DTI	-0.447***	-0.448***	-0.429*	-0.428*
	(0.168)	(0.168)	(0.221)	(0.221)
Interest $\text{Duration}_3 \times \Delta r \times$ DTI	-0.492***	-0.495***	-0.512**	-0.512**
	(0.176)	(0.176)	(0.215)	(0.215)
Interest $\text{Duration}_4 \times \Delta r \times$ DTI	-0.383**	-0.385**	-0.372*	-0.376*
	(0.174)	(0.174)	(0.212)	(0.212)
Interest $\text{Duration}_5 \times \Delta r \times$ DTI	-0.438**	-0.444**	-0.395*	-0.406*
	(0.194)	(0.193)	(0.228)	(0.228)
Interest $\text{Duration}_1 \times \Delta r$	-0.322	-0.312	-0.325	-0.331
	(0.271)	(0.271)	(0.494)	(0.494)
Interest $\text{Duration}_2 \times \Delta r$	0.391	0.405	0.371	0.371
	(0.296)	(0.296)	(0.489)	(0.489)
Interest $\text{Duration}_3 \times \Delta r$	-0.024	-0.009	-0.124	-0.124
	(0.323)	(0.323)	(0.488)	(0.488)
Interest $\text{Duration}_4 \times \Delta r$	-0.532	-0.508	-0.764	-0.740
	(0.329)	(0.329)	(0.497)	(0.497)
Interest $\text{Duration}_5 \times \Delta r$	-0.215	-0.189	-0.525	-0.494
	(0.320)	(0.320)	(0.489)	(0.490)
Liquid assets to income	No	Yes	No	Yes
Observations	265,675	265,675	153,997	153,997
Clusters (households)	64,158	64,158	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. Changes in interest rates are instrumented with monetary policy shocks; see main text for details. *Interest* $\textit{Duration}_X$ 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 6: Consumption Responses to Interest Rate Changes by Interest Rate Sensitivity Group

	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
Interest duration	ARM	ARM	FRM	FRM	ARM	ARM	FRM	FRM
Liquid assets to income	Low	High	Low	High	Low	High	Low	High
A. Consumption response								
$\text{Group}_X \times \Delta r$	-0.665***	-0.230	0.352*	-0.051	0.225	0.929***	0.690***	0.978***
	(0.201)	(0.207)	(0.195)	(0.226)	(0.228)	(0.305)	(0.192)	(0.283)
Observations (total)	265,675	265,675	265,675	265,675	265,675	265,675	265,675	265,675
Clusters (total households)	64,158	64,158	64,158	64,158	64,158	64,158	64,158	64,158
B. 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
< High school (share)	11.56	8.08	13.05	7.88	23.12	18.09	23.51	16.49
High school (share)	60.59	51.06	57.58	51.60	64.02	59.21	61.57	58.18
> High school (share)	27.85	40.86	29.38	40.52	12.86	22.71	14.92	25.32
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

Notes: Δrepo rate is the year-on-year change in the monetary policy (repo) interest rate, set by the Central Bank's monetary policy committee. Group_X refers to 8 indicator variables for group defined by DTI, interest duration and liquid assets 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 parenthesis.
*** p<0.01, ** p<0.05, * p<0.1. See Table 1 for further details on the summary statistics.

Online Appendix

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. This material is not intended for publication.

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:

$$c_t = y_t + r_t \cdot a_t \tag{6}$$

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

$$\log(c_t) = \log(y_t + r_t \cdot a_t). \tag{7}$$

We use a first-order Taylor approximation of the form $f(x) = f(x^*) + (x - x^*)f^{'}(x^*)$. The left-hand side in (7) is then approximated by:

$$\log(c_t) = \log(c^*) + (c_t - c^*)\frac{1}{c^*}, \tag{8}$$

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

$$\log(y_t + r_t \cdot a_t) = \log(y^* + r^* \cdot a^*) + [(y_t + r_t \cdot a_t) - (y^* + r^* \cdot a^*)]\frac{1}{y^* + r^* \cdot a^*}. \tag{9}$$

Now, use $y^* + r^* \cdot a^* = c^*$ to simplify (9):

$$\begin{aligned}
\log(y_t + r_t \cdot a_t) &= \log(c^*) + [(y_t + r_t \cdot a_t) - (y^* + r^* \cdot a^*)]\frac{1}{c^*} \\
&= \log(c^*) + \frac{y_t - y^*}{c^*} + \frac{(r_t - r^*)a^*}{c^*} \\
&= \log(c^*) + \frac{y^*}{c^*}\frac{y_t - y^*}{y^*} + \frac{y^*}{c^*}\frac{a^*}{y^*}(r_t - r^*) \\
&= \log(c^*) + \theta\frac{y_t - y^*}{y^*} + \theta\frac{a^*}{y^*}(r_t - r^*). \qquad (10)
\end{aligned}$$

Substitute (8) and (10) into (7) to obtain:

$$\frac{(c_t - c^*)}{c^*} = \theta \frac{y_t - y^*}{y^*} + \theta \frac{a^*}{y^*}(r_t - r^*). \tag{11}$$

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

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

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

$$P_1 (c_1 + h) + A_1 = P_1 w + D_1 + (1 + i_1) A_0, \tag{13}$$

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

$$P_t c_t + A_{t+1} = P_t w + (1 + i_t) A_t - i_t^D D_t - \gamma D_1 \tag{14}$$

and, finally, the constraint in the last period:

$$P_T c_T = P_T w + (1 + i_T) A_T - (1 + i_T) D_T + \alpha P_T h. \tag{15}$$

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:

$$1 + i_t = (1 + r) \cdot \frac{P_t}{P_{t-1}}, \tag{16}$$

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 $\left\{i_{\tau+j}, i^D_{\tau+j}, P_{\tau+j}\right\}_{j=0}^{\infty}$ to $\left\{\hat{i}_{\tau+j}, \hat{i}^D_{\tau+j}, \hat{P}_{\tau+j}\right\}_{j=0}^{\infty}$. 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 instantanously. The consumption function follows from the budget constraint (14):

$$c_t = w - i_t^D \frac{D_t}{P_t} - \gamma \frac{D_1}{P_t}. \tag{17}$$

For such a household, a shock in i_t (and hence i_t^D) is equivalent to a shock in 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, (16), 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.[31]

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 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).[32] If there is a positive relationship between

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

[32] 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

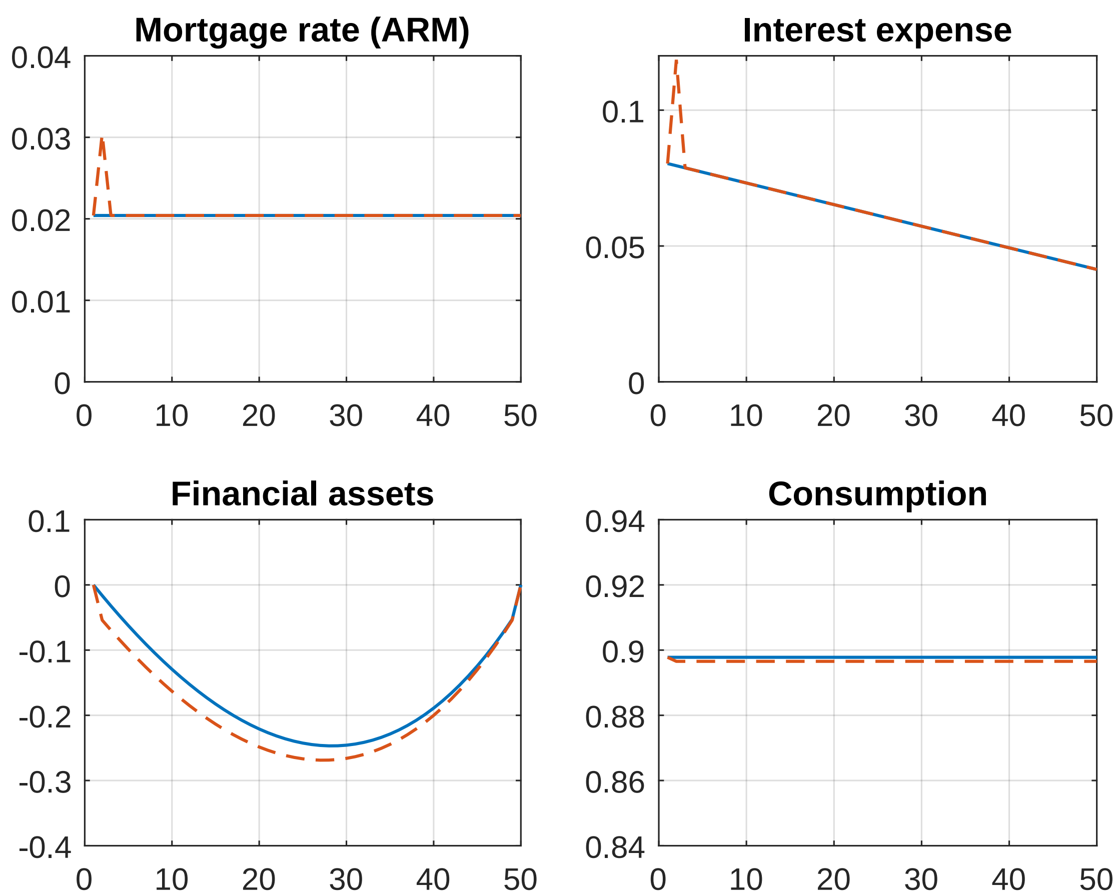
We first illustrate the model dynamics graphically in Figures A.1 to A.8. In these examples, the house value in time period 1 ($P_1 h$) is 4 and initial financial wealth (A_0) is 0. The interest rate is shocked (unexpectedly) in $t = 2$ by one percentage point. We consider both the case when the shock 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).[33]

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)



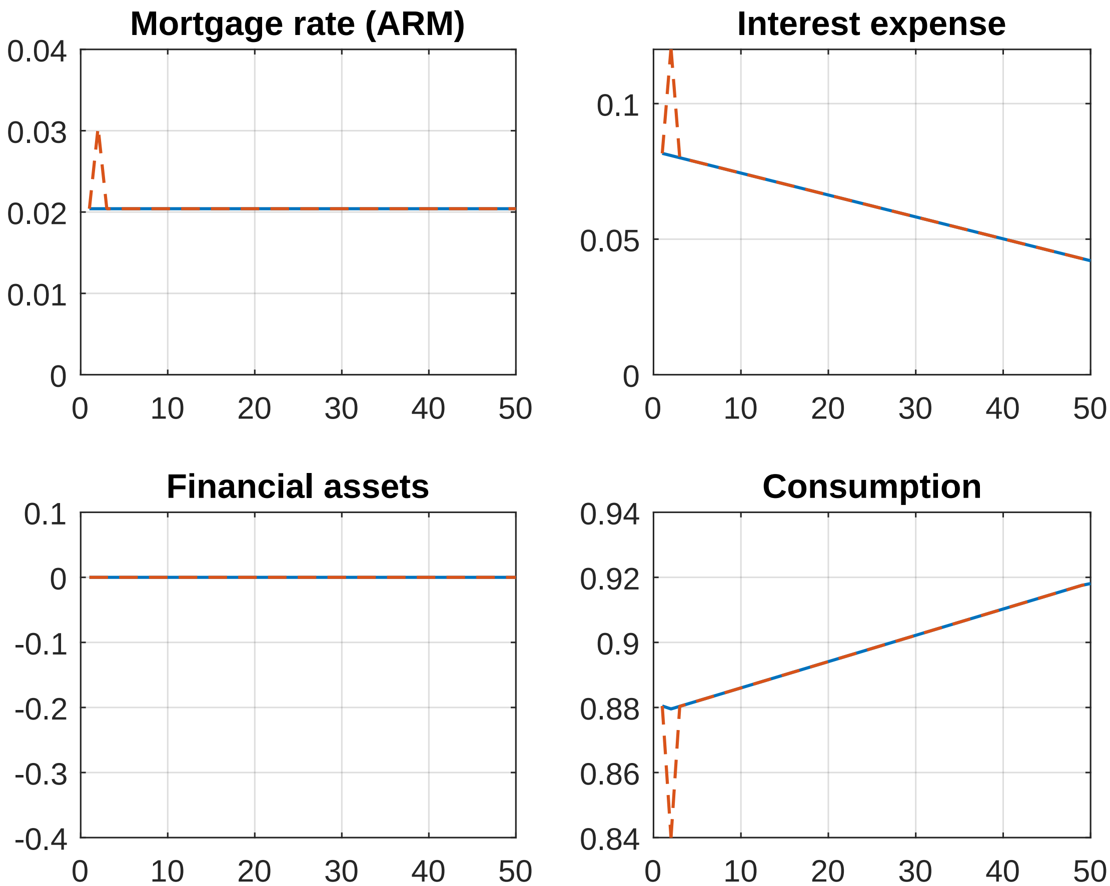
Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the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

[33]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.

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.

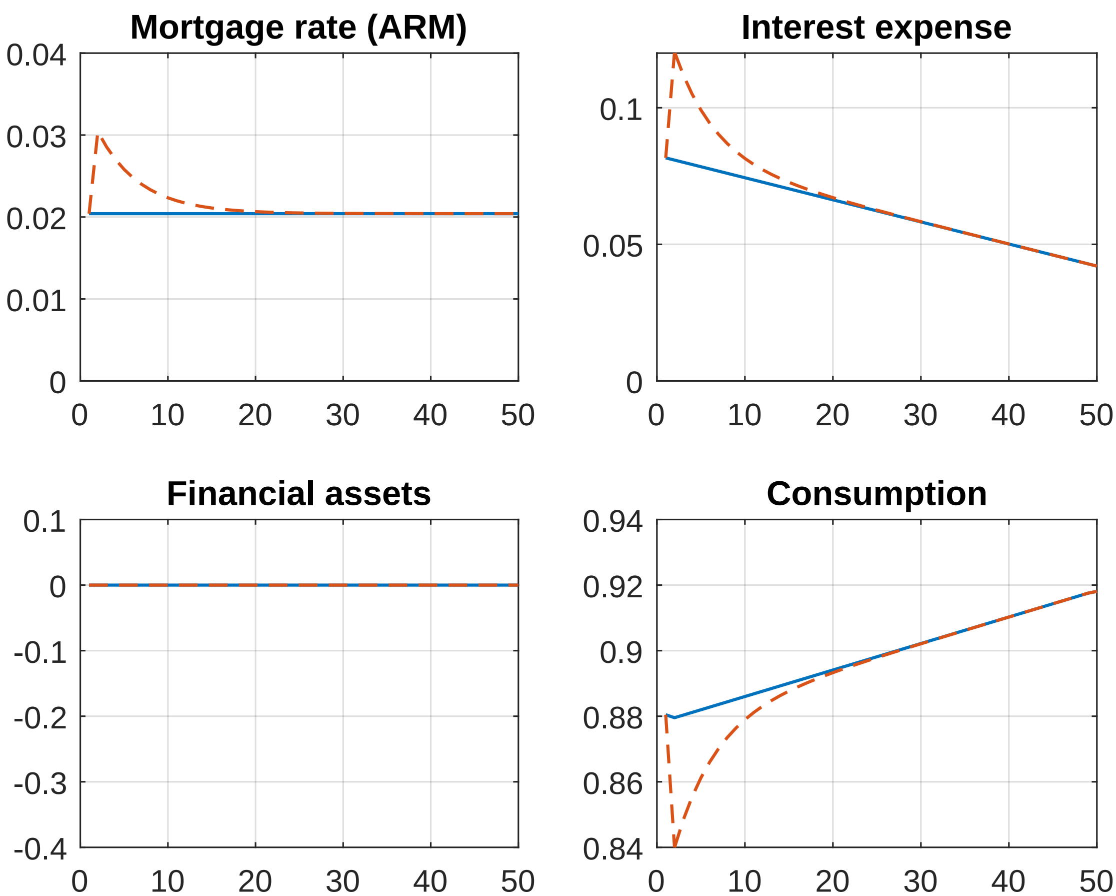
Figure A.6 shows the response of an HTM household with an FRM. The response is delayed until five years later and is then much smaller.

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 (16). 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.

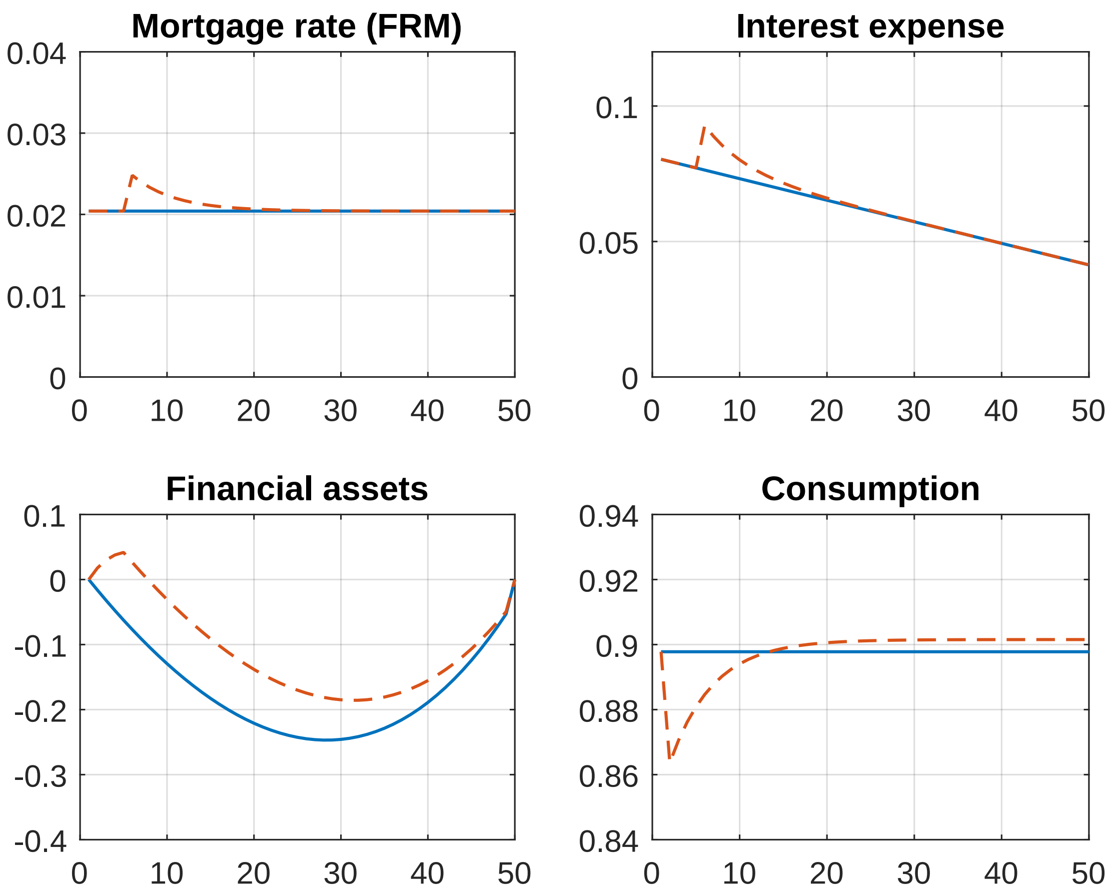
Figure A.7 displays the paths for an optimizing household with an ARM. Relative to the case

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



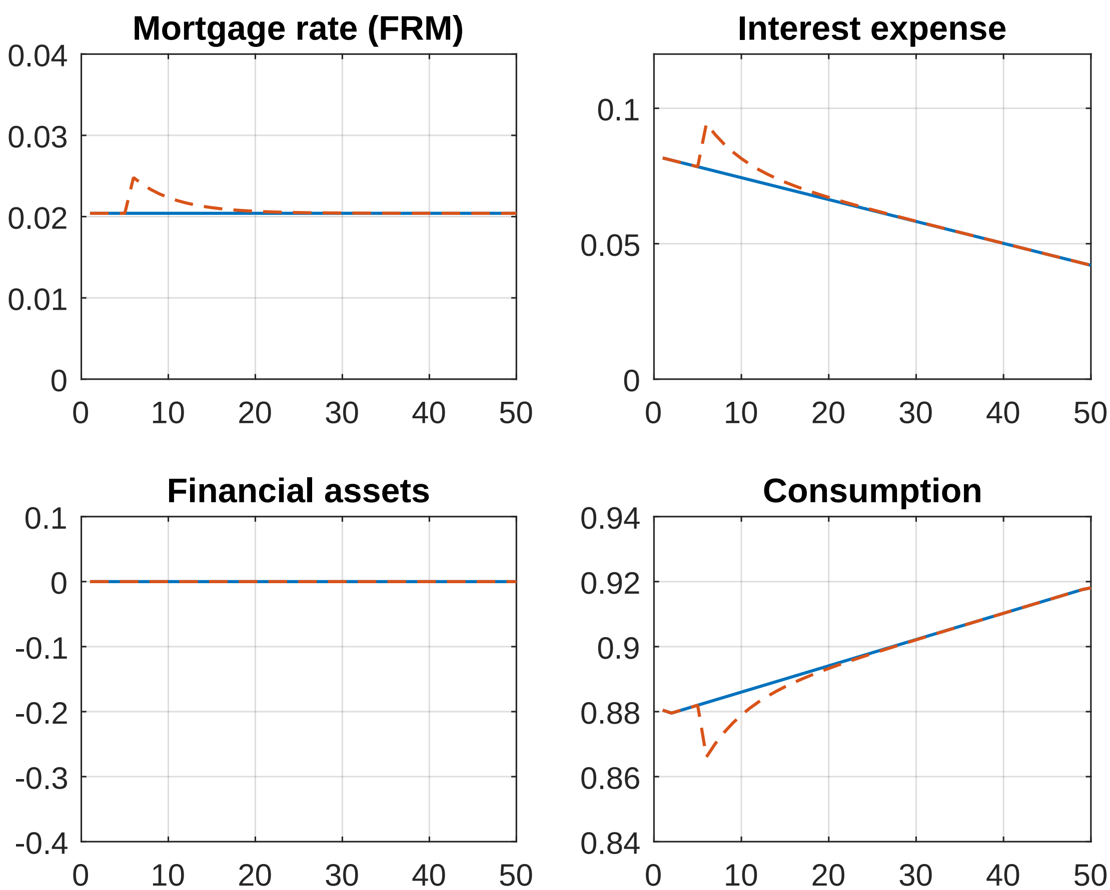
Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the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

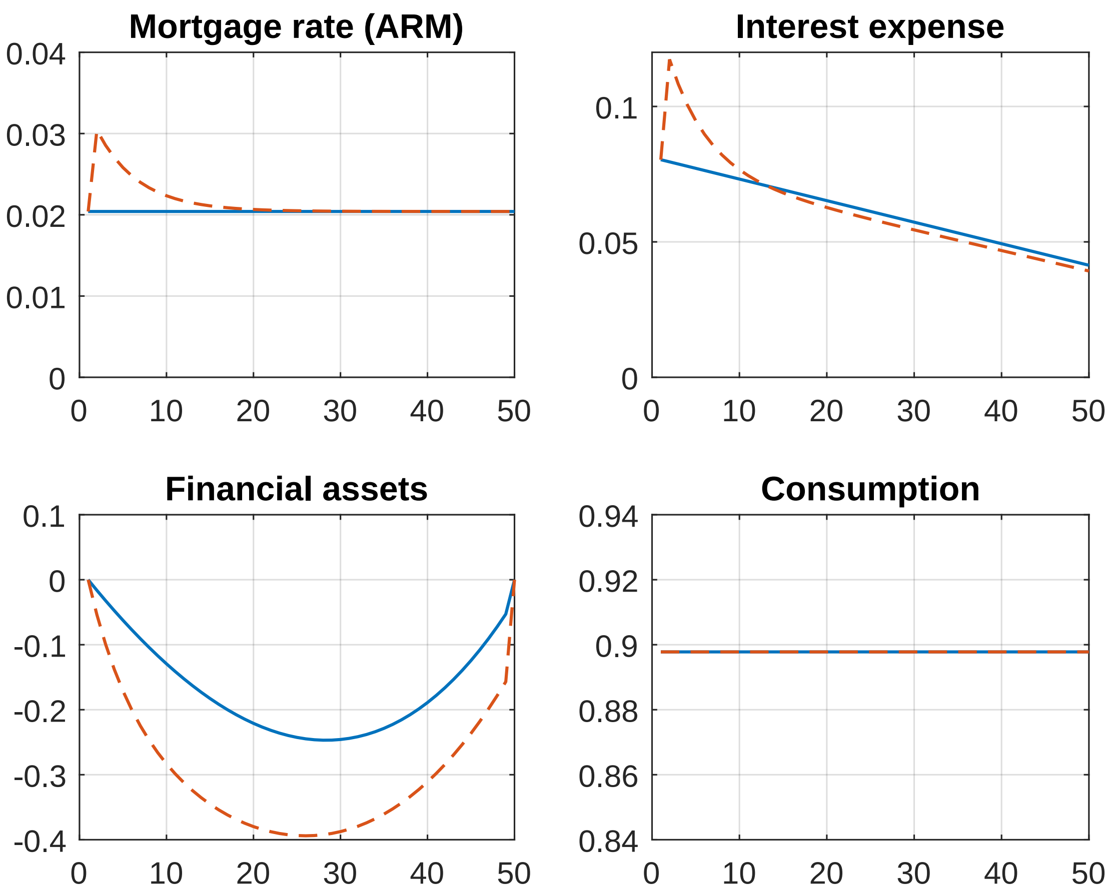
Figure A.6: Household response to a persistent interest rate shock (HTM, FRM)



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)



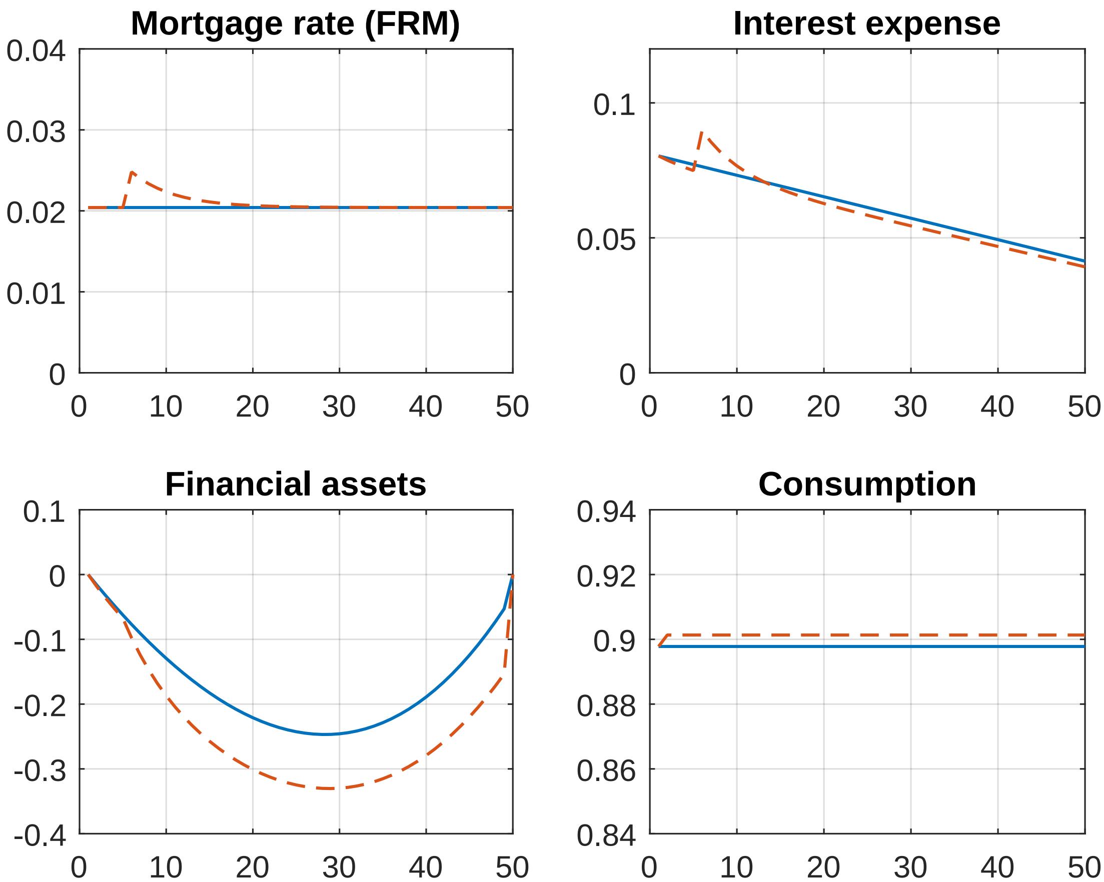
Note: All values are real. Real labor income is normalized to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the 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).[34] This motivates the following regression specification

$$\Delta \log c_{i,\tau} = \alpha_i + \beta DTI_{i,\tau-1} \times \Delta i_\tau + \gamma X_{i,\tau-1} + \varepsilon_{i,\tau}, \tag{18}$$

[34] 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 (12).

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 $X_{i,\tau-1}$.[35]

[35] 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.[36] 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 $\log \hat{c}_{i,t} - \log c_{i,t}$.

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

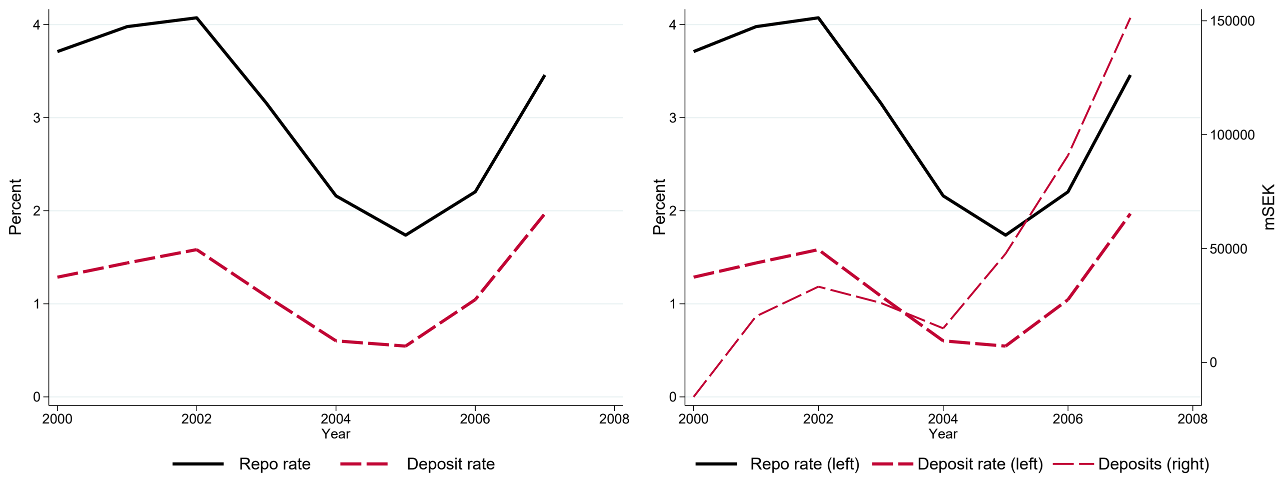
Table A.2: Regressions on simulated data (persistent shocks and mixes of types and mortgages)

	(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).

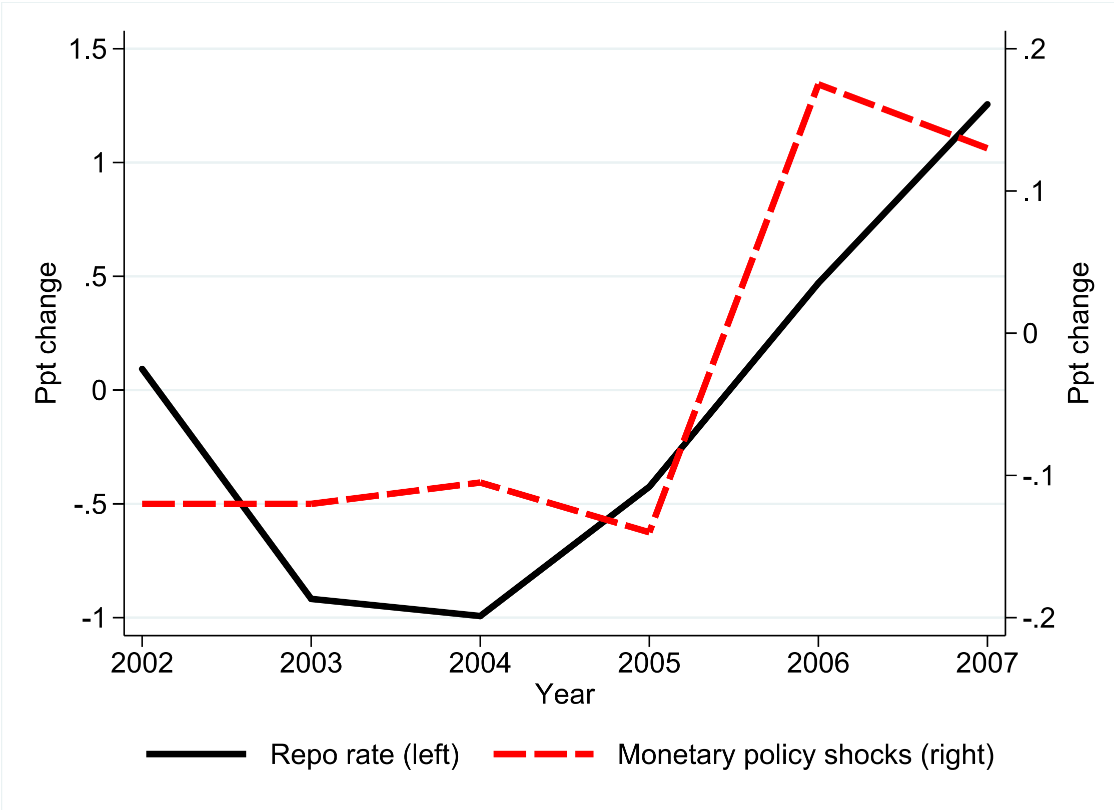
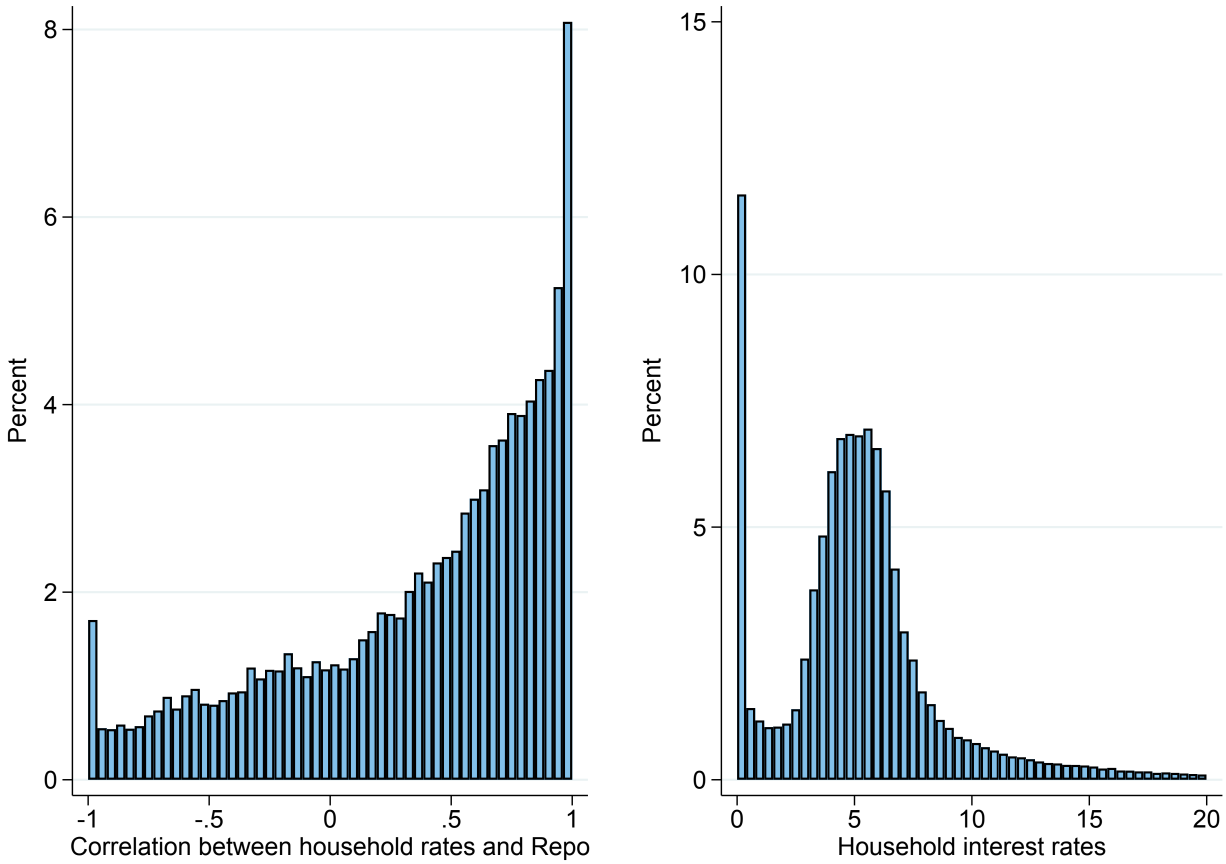


Figure A.11: Monetary policy shocks and changes in the monetary policy (repo) rate

Figure A.12: 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)
			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
			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)
			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
			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

Instrumented with Monetary Policy Shocks

	(1)	(2)	(3)	(4)	(5)
			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
			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; 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 parentheses.*** p<0.01, ** p<0.05, * p<0.1

Table A.8: Consumption Responses to Average Household Interest Rate

Instrumented with Monetary Policy Shocks

	(1)	(2)	(3)	(4)	(5)
			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
			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; 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 parentheses.*** p<0.01, ** p<0.05, * p<0.1

Table A.9: 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.10: 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