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

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Abstract

We examine the cash-flow channel of monetary policy, i.e. the effect of monetary policy on spending when households hold debt linked to short-term rates such as adjustable rate mortgages (ARMs). Using registry-based data on Swedish households, we estimate substantial heterogeneity in consumption responses to a change in monetary policy through the cash-flow channel. Our findings imply that monetary policy has a stronger effect on real economic activity when households are highly indebted and have ARMs. For homeowners with a debt-to-income ratio of around 3 and ARMs, the estimated response is equivalent to a marginal propensity to consume of 0.5.

JEL classification: D14, E21, E52, G11
Keywords: Monetary policy, consumption, household debt, variable interest rates, adjustable rate mortgages

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1 Introduction

A fundamental question in macroeconomics is how the transmission of monetary policy to the real economy works. In standard macroeconomic models the primary transmission mechanism is the interest rate channel - affecting intertemporal substitution. However, many researchers, e.g. Bernanke & Gertler (1995), have found that changes in monetary policy have more powerful effects on the real economy than predicted by the interest rate channel. This observation suggests that there are other important transmission mechanisms at work. Among channels that have been discussed in the literature are the wealth channel (Ando & Modigliani, 1963) and the credit channel (Bernanke & Gertler, 1989).

In modern economies, where a large share of households hold debt, monetary policy can also have a direct effect on household spending via its effects on households' cash flows and disposable income. Households are then unequally affected by monetary policy depending on their balance sheet positions. In this paper we empirically study the relevance of this mechanism. More specifically we examine if monetary policy affects household consumption through its direct effect on disposable income for households that hold loans with a variable interest, i.e. through a *cash-flow channel*.[1] The intuition behind this channel is that a tightening of monetary policy raises interest rate expenses for households with adjustable mortgage rates and therefore has a negative impact on disposable income of such households. If the household is forward-looking and has 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 reason unable or unwilling to increase its debt in response to temporarily lower disposable income, monetary policy will affect consumption also through the cash-flow channel.

The importance and effectiveness of the cash-flow channel depends on a number of factors such as the distribution of wealth and debt across households, the marginal propensity to consume out of disposable income across borrowers and savers, and how elastic market interest rates are to changes in monetary policy. In particular, institutional details in the mortgage market matter. If the market is dominated by fixed-rate mortgages (FRMs), as in the United States, Germany, and France, one would expect the cash-flow channel to be muted. But in economies where most mortgages have an adjustable rate (ARMs), as in the United Kingdom, Spain, and Sweden, the cash-flow channel may be more important for the transmission of monetary policy. However, to date there is limited evidence on how households are influenced through this channel. In particular, what is lacking is empirical evidence from high quality micro data – on households' balance sheets as well as measures of income and consumption – in a setting where variable rates are common.

In this paper we investigate the heterogeneity in the consumption response to a monetary policy induced change in the short-term rate. We study these effects using Swedish household data. For several reasons, Sweden is the perfect lab for this analysis. First, ARMs is a standard,

[1] This terminology has previously been used by for example Cloyne *et al.* (2016) whereas Berben *et al.* (2004) and Di Maggio *et al.* (2014) refer to the same channel as the "income channel".

non-exotic, product. Throughout our sample period, ARMs as a share of the aggregate value of outstanding mortgages varied between 30 and 40 percent on average, and indebted Swedish homeowners in general hold at least a share of their mortgages in adjustable interest rates (Holmberg *et al.* , 2015). Furthermore, in our setting, the households' choice between ARMs and FRMs does not correlated with observable characteristics, suggesting that it is unlikely that our results are driven by selection into different type of loan portfolios depending on characteristics or spending behavior.[2] One indication of this is that households that we identify as having variable rates in our sample have observable characteristics very similar to households identified as having fixed rates.[3] A second reason to focus on Sweden is data availability. A common challenge in previous studies on the impact of monetary policy on consumption is the lack of data sets that feature both a high quality measure of consumption and data on households' wealth and balance sheets. We overcome this problem by using administrative panel data based on tax reports, which allows us to impute a measure of consumption, as in Koijen *et al.* (2015), as well as providing us with detailed information on all earnings, income, assets and debt positions.

A typical identification problem when trying to estimate the impact of monetary policy is that changes in monetary policy are endogenous to the economic development. It is therefore difficult to identify the causality from monetary policy to economic outcomes. Such problems are mitigated with the household-level data that we use. All households are affected by the same monetary policy, but the impact varies from household to household because they have different balance sheets and financial contracts, i.e. there is variation in the exposure to the cash-flow channel. In particular, we examine how monetary policy affects consumption choices for households with large debt positions, measured as debt-to-income ratios, and how it affects homeowners with ARMs relative to homeowners with FRMs. We are thus able to study how households that are more likely to be credit constrained and have a higher degree of variability in their mortgage interest rates respond to interest rate changes induced by monetary policy. We show that these households can be seen as an empirical mirror image of the theoretical concept of wealthy hand-to-mouth households, as they have relatively high levels of illiquid wealth but hold little liquid wealth, strengthening our hypothesis that the consumption response will be stronger for the households that we classify to be interest sensitive.

Our empirical strategy focuses on heterogeneity in consumption responses, net of a common

[2] A possible concern is otherwise that households may select into adjustable vs. fixed interest rates based on household-specific characteristics that are correlated with macroeconomic developments. Campbell & Cocco (2003) study the selection between ARMs and FRMs in a life-cycle model with risky labor income and borrowing constraints. Their results suggest that households with a large mortgage, risky labor income, high risk aversion, a high cost of default, and a low probability of moving are less likely to prefer an ARM. Further, Campbell & Cocco (2015) show, in an incomplete markets model, that ARMs have a higher default rate than FRMs when interest rates increase. Badarinza *et al.* (2017) study the determinants of within- and cross-country variation in the ARM share. They find evidence suggesting that households consider both current interest costs, consistent with borrowing constraints, as well as life-time cost minimization.

[3] Moreover, a recent study on Swedish households by Holmberg *et al.* (2015) does not find that the default probability correlates with the choice of interest-rate fixation.

aggregate effect. Our main finding is that consumption among the most indebted homeowners responds substantially more than among less indebted households. Comparing a homeowner who owes three times her disposable income instead of an otherwise identical homeowner who owes two times her income, the former responds by reducing consumption by 0.43 percent more for a one-percentage point increase in the monetary policy rate. Moreover, the effect coming from the cash-flow channel is entirely concentrated among highly indebted homeowners who hold ARMs. Among highly indebted holders of ARMs, the MPC out of changes in interest expenses is estimated to approximately 0.5 (again, net of the common aggregate response). I.e., among this group of homeowners – which represents about one sixth of all homeowners – half of the monetary policy induced change in interest expenses is absorbed by household consumption. Further analysis provides support for both the role of binding borrowing constraints as well as outright hand-to-mouth behavior. One the one hand, little liquid financial assets and a high loan-to-value ratio exacerbates the cash-flow channel. On the other hand, we find that expected changes to the monetary policy rate have a stronger differential impact than unexpected changes which is consistent with outright hand-to-mouth behavior.

Our paper contributes to several strands of literature, of which Cloyne *et al.* (2016) is most similar to us. They study the response of expenditure and income to monetary policy in the UK and the US.[4] In 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.* (2016) we are able to study responses across the distribution of debt positions even among households with the same housing tenure status, and thus shed further light on the mechanisms at work.

Another closely related strand of the literature uses quasi-experiments to deduce effects of changes to the mortgage rate. Di Maggio *et al.* (2014) study consumption and deleveraging decisions of households prior to, and following, a change in their monthly interest payments. They study data for the subsample of US households with non-agency mortgages which have interest rates that remain fixed for 5 years but are then automatically adjusted. Differences in the timing of these adjustments allow for difference-in-difference estimation. The authors find strong responses in consumption to a change in interest expenses. At the reset date, monthly interest payments drop by about a half, causing a substantial increase in car purchases, the authors' main measure of consumption. In addition, they find that a share of the increase in disposable income generated by lower expenses is devoted to saving through deleveraging on the mortgage. Applying a similar identification strategy, Keys *et al.* (2014) study proprietary loan data and estimate the balance sheet effects of a change in interest payments following the reset date. They find that a reduction in mortgage payments causes a decrease in defaults, a drop in credit card debt, and an increase in new auto debt, indicating an increase in durable consumption.[5] Unlike these studies

[4] As in Sweden, ARMs make up a large share of mortgages in the UK, whereas FRMs are more prevalent in the US.

[5] These two papers have since been combined into Di Maggio *et al.* (2017).

we use a comprehensive expense-based measure of consumption to study responses of a representative sample of the Swedish population. Since changes to the monetary policy rate are partly predictable and partly unpredictable, we are able to disentangle the two. Our instrumental variables estimates based on monetary policy shocks indicate that predictable changes are at least as important for the heterogeneity in response as unpredictable ones. 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 argue that households that hold debt (or assets) with variable rates will be more sensitive to such changes. Furthermore, they compare the responses of borrowers and savers. Compared to their study we add a dimension by looking at responses across the debt-to-income distribution. Furthermore, the panel data we use contains detailed balance sheet information in each year in our sample, and enables us to include all interest bearing debt in our classification of mortgage types.

We also contribute to the general literature studying the transmission mechanisms of monetary policy (see e.g. Bernanke & Gertler, 1995; Kashyap & Stein, 2000) and, in particular, to the literature on the relation between household debt and the transmission mechanisms of monetary policy. 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 higher prevalence of ARMs. Rubio (2011) builds a New Keynesian model with a housing market and collateral-constrained households, extending the framework in Iacoviello (2005) by allowing for both adjustable and fixed rate mortgages. Monetary policy has a stronger effect when a larger share of mortgages have adjustable rates. However, in general equilibrium the partial equilibrium effects are muted by a redistribution between borrowers and savers as well as by labor supply responses. In a recent paper, Garriga *et al.* (2015) view mortgages with contract frictions that prevent interest rates to adjust instantly as a nominal rigidity which they incorporate into a general equilibrium model as the only source of nominal friction. The authors find that monetary policy shocks have larger real effects under ARMs than FRMs since not only does an increase in the nominal interest rate reduce consumption growth through a reduction in new borrowing but also by increasing (real) mortgage payments. Another recent contribution is Greenwald (2016), who shows that inclusion of a payment-to-income constraint in a DSGE model generates substantial aggregate effects to interest rate changes. Recently, Hedlund *et al.* (2016) study the interaction between monetary policy, house prices and consumption responses in a rich quantitative model.

Closely related is also the literature that studies whether sensitivity of household spending to changes in income is related to mortgage debt or house prices. Mian *et al.* (2013) study household consumption response to large negative shocks to household wealth, finding that households with different levels of wealth have a different marginal propensity to consume out of a dollar lost. Baker (2017) finds that the consumption elasticity of income is significantly higher in households with high debt. This relation is not causal, however, since level of liquid assets and access to credit drive most of the heterogeneity in consumption responses to an income shocks and debt by itself plays a minor role, indicating that it is important to consider exposure. Using Danish

administrative data, Andersen *et al.* (2016) study if household leverage prior to the financial crisis amplified the reduction in household spending during the crisis. They find a negative correlation between pre-crisis debt growth and consumption growth during the crisis but no relation between high debt at the time of the crisis and a spending decline over the course of the crisis.[6] In contrast, rather than considering the role of debt per se, we use indebtedness to assess households' exposure to interest rates changes.

The long period with 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). By estimating disaggregated household reactions to monetary policy, our paper contributes to the recent literature that analyzes this distributional impact. In previous theoretical work, Garriga *et al.* (2015) find that monetary policy shocks redistribute income from homeowners to capital owners under ARMs, but vice versa under FRMs. Auclert (2017) develops a model to evaluate the redistributional effect of monetary policy on consumption. He finds that unhedged interest rate exposure is an important channel in household's response to monetary policy, highlighting the importance of considering interest sensitivity.[7]

Lastly, our study is related to a series of papers studying household consumption responses to shocks to unearned income and fiscal stimulus programs. For example, Shapiro & Slemrod (2003), Johnson *et al.* (2006), Agarwal *et al.* (2007), Shapiro & Slemrod (2009), and Parker *et al.* (2013) study the effect of 2001 and 2008 economic stimulus payments in the US on consumer spending.[8] 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, e.g. have low liquid assets or a low credit card limits. These papers study consumption responses to a positive shock to disposable income as a result of fiscal policy programs. One way to view our paper is as a monetary policy analogue to the fiscal policy programs studied in this literature.

The remainder of this paper proceeds as follows. In Section 2 we use consumer theory to derive testable implications for the empirical framework. Section 3 provides details on the data set we use and our measure of consumption, and presents general summary statistics and empirical motivation. The empirical strategy is discussed in Section 4. We present our main findings in Section 5 and Section 6 concludes.

2 Theoretical motivation

We relate our empirical strategy to basic theories of intertemporal consumption choice.

[6] The paper by Andersen *et al.* (2016) is relevant for our study also because they use a similar data set and, as we, impute consumption from changes in households' balance sheets.

[7] For recent empirical studies on the redistribution channel of monetary policy, see, e.g., Sterk & Tenreyro (2015) and Casiraghi *et al.* (2016).

[8] For studies on the consumption responses to other sources of shocks to disposable income, see, e.g. Stephens (2008), Kueng (2016), Hsieh (2003) and Agarwal & Qian (2014).

2.1 Consumption theory in relation to monetary policy

To motivate our empirical framework we briefly consider models of consumer behavior. A natural starting point for studying consumption and savings decisions are the life cycle/permanent income models. In these types of models consumers have concave preferences which induces a consumption smoothing motive. Another implication of these models is that unconstrained households that are forward-looking and maximize expected utility only reacts to unanticipated income changes. In the most extreme setup, where markets are complete and allow households to fully insure against idiosyncratic risks, the consumption growth rate will be identical for all households. To see this, note that in this setting the first-order conditions for household optimization reduce to

$$\Delta \log c_{i,t} = \lambda_t \tag{1}$$

where $\Delta \log c_{i,t}$ is the difference in log consumption and λ_t captures anticipated and unanticipated macroeconomic developments that are common to all households.[9] A somewhat more general specification that does not rely on full insurance between households would also imply that household reactions are homogeneous across households in response to interest-rate changes that are either anticipated or temporary.

According to these theories, a change in monetary policy will be captured by the term λ_t and therefore have an identical impact on consumption growth for all households. But it is well-established that there is little empirical support for a strict interpretation of the life cycle and permanent income theories. For example, it has been found that consumption, in violation of these theories, often responds to predictable household-specific income changes. One suggested remedy to explain such behavior is to introduce borrowing constraints. Carroll & Kimball (1990) is an early theoretical contribution showing that the average marginal propensity to consume increases in the presence of borrowing constraints and uncertainty. Campbell & Mankiw (1990) introduce "rule-of-thumb" consumers as another potential explanation for the excess sensitivity of consumption.

If binding borrowing constraints or hand-to-mouth behavior due to other factors are prevalent in the economy, interest-rate changes will affect consumption growth more for some households than others. To motivate an empirical specification that allows for such *cash-flow effects* – i.e, an effect where for some households changes in disposable income feed directly into changes in consumption – we next present a simple model that considers different kinds of mortgages.

2.2 A simple model with ARMs and hand-to-mouth consumers

In order to illustrate the interaction between the presence of ARMs and hand-to-mouth households we set up a simple model. Consider a household with net financial assets a_t, where “net" indicates the value of financial assets exposed to the short-term interest rate minus the balance of

[9] Although not explicitly captured in this specification, preference shifters, such as age or household composition, may then still generate variation in consumption growth between households.

the household's ARM. Notice that for the typical mortgage holder gross financial assets is small relative to the value of the mortgage. For such households (the majority of ARM holders) a_t is essentially equal to the negative of the mortgage principal. Being aware of the fact that some ARM holders are financially rich we will nonetheless refer to the negative of $\frac{a_t}{y_t}$ as the debt-to-income ratio. The intertemporal budget constraint reads $c_t + a_{t+1} = y_t + a_t(1 + r_t)$ where y_t is labor income.[10] We begin with a characterization of hand-to-mouth behavior and then contrast this to optimizing households' behavior.

By definition, hand-to-mouth (HTM) households maintain net financial assets constant. Hence consumption obeys

$$c_t = y_t + r_t \cdot a_t. \tag{2}$$

In other words, if measured as a marginal propensity to consume, the response of a hand-to-mouth household of a change to the short-term interest rate is equal to one. Such a response may be irrational but it also occurs if the household is borrowing constrained. To obtain a measure of the elasticity in the response, we write equation (2) as a log-linear approximation

$$\Delta \log c_t \approx \theta \cdot \Delta \log y_t + \theta \cdot \frac{a}{y} \cdot \Delta r_t \tag{3}$$

where θ is the inverse of the household's (steady state) consumption to income ratio and $\frac{a}{y}$ the (steady state) debt-to-income ratio.[11] If households hold no or little financial assets that respond to short-term interest rate changes, this equation shows that the percentage consumption response to interest-rate changes is proportional to the household's debt-to-income ratio. For example, in response to an interest-rate increase, a HTM household with a net assets-to-income ratio of 3 will reduce consumption (in percentage terms) by twice as much as a HTM household with a debt-to-income ratio of 1.5. Note also that the response of HTM households does not depend on when information about the interest-rate change arrives. Their consumption responds when their cash-flow changes, irrespective of if the changes was anticipated or not. In Section 5.2 we use this insight in an instrumental variable regression with monetary policy shocks to shed light on HTM behavior.

In contrast to HTM households optimizing households obey the Euler equation, given by (1). If optimizing households' preferences are captured by a CRRA utility function with an elasticity of intertemporal substitution equal to σ, the response, measured as an elasticity, is:

$$\Delta \log c_t \approx \sigma \cdot \Delta r_t. \tag{4}$$

This implies that the optimizer's response to an unanticipated temporary interest rate change, measured as an elasticity, is independent of the debt-to-income ratio. If the response is measured as a marginal propensity to consume it is decreasing in the debt-to-income ratio. This simple framework suggests that if ARMs is a common type of mortgage contract the implications for

[10] For ease of notation household subscripts i are suppressed.

[11] Appendix A.1 provides a derivation of the approximation.

consumption response is very different for the two types of behavior. In contrast to HTM households, optimizing households respond to new information about the future interest rate.[12]

In contrast to the simple models of behavior given by (3)-(4), households who hold FRMs do not respond to changes in the short-term interest rate unless they have substantial financial assets which are exposed to the change.[13]

3 Data and Summary Statistics

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 for the Swedish population, covering a random sample of 300,000 households and their members. Since in Sweden, as in other Scandinavian countries, each tax payer 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 which meant that taxpayers were required to provide the tax authority with comprehensive information on all taxable wealth, in addition to information on earnings and income. The tax registers therefore include information about all taxable income and transfers, tax payments, liabilities and taxable wealth, including value of real estate (i.e., houses, apartments and cabins), cash holdings on bank accounts, bonds, stocks, and mutual funds.[14]

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

[12]To be precise, the consumption of HTM households responds when their cash-flows change, irrespective of if the changes were anticipated or not. For optimizing households, a temporary one-period increase in r_{t+1} implies a decrease in c_t (if y>0 this holds regardless of the value of the EIS, σ). The timing of the response of HTM and optimizing households is simultaneous if the interest fixation period is short (a few months). Appendix A.2 explores the effects on consumption of optimizing households under different assumptions about when they learn about the interest rate change and shows that it matters little in our empirical approach. Appendix A.4 discusses how one can think of an FRM in the context of our simple model.

[13]Our model is admittedly stylized and ignores effects of monetary policy on e.g. labor income and house prices, and more generally a common aggregate effect. Our purpose is to illustrate the differential effect for households with little or much debt and the differential response between ARM and FRM holders. This is consistent with our empirical analysis.

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

variables.

The unit of analysis is the household, meaning that individual data has been aggregated to the level of the household 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 Sampling restrictions

We restrict the sample in four ways. First, we restrict the households in our sample to be represented by a household head which is 18 years or older. Second, since changes in the family structure, such as divorces, may affect our consumption measure, we exclude observations for unstable households, i.e. when the household head is not the same as in the previous period. Third, we exclude observations for those years when households buy or sell residential housing. The reason for this restriction is that we have an imperfect measure of the value of the real estate, and changes in this variable – which is undoubtedly the largest component in households' asset portfolios – might bias our consumption measure. Fourth, we restrict our attention to households that remain in our panel for 3 or more years. The main reason for this restriction is, as we explain further in Section 4, to be able to compute the correlation between each household's interest rate and the monetary policy rate. This correlation is then used as our measure of fixed and adjustable rate mortgages.

We exclude outliers in our sample in four ways. First, we exclude observations when our consumption measure is negative. Negative consumption is likely to reflect some measurement issues that we are unable to account for in the consumption imputation process. Second, we exclude the bottom 3rd percentile in the income distribution. Third, we exclude the top 3rd percentile of the distribution of household specific interest rates. Fourth, we exclude the bottom and top 5th percentiles of the distribution of consumption growth rates. These restrictions leave us with a sample of around 50,000 households on average per year, of which about 30,000 per year are homeowners. The latter group is of our focus in the empirical analysis since those holding mortgages have interest expenses that may be affected by monetary policy. Finally, in our empirical analysis we use predetermined debt-to-income values. We restrict the sample to include households with information on debt-to-income lagged by two years.

3.3 Imputing consumption

We use this detailed data set to impute a measure of consumption expenses based on the approach in Koijen *et al.* (2015).[15] This is a vital part of our exercise since the main outcome of interest is spending.

[15] Browning & Leth-Petersen (2003) was the first to impute consumption expenses from Danish registry-based data.

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

$$c_{i,t} = y_{i,t} + \Delta d_{i,t} - r^d_{i,t} d_{i,t-1} - \Delta a_{i,t} + r^a_{i,t} a_{i,t-1} \tag{5}$$

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 previous period. This is possible since all terms on the right-hand side of equation (5) are observable in our data. Mapping equation (5) into the detailed structure of our data gives the identity

$$c_{i,t} = y_{i,t} + \Delta d_{i,t} - r^d_{i,t} d_{i,t-1} - \Delta b_{i,t} - \Delta v_{i,t} - \Delta h_{i,t} - \Delta \psi_{i,t} - \omega_{i,t} \tag{6}$$

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 active re-balancing of mutual funds, stocks, and bonds, Δh is the change in housing wealth (due to buying/selling), $\Delta \psi$ are changes in capital insurance accounts, and ω are contributions to private pension savings.

Equation (6) is identical to the imputation method of Koijen *et al.* (2015), who show that the correlation between the imputed measure and a survey-based measure of consumption exceeds 0.5 at the household level.[16]

3.4 Imputing mortgage type

Our proposed transmission channel for monetary policy relies on a high prevalence of adjustable rate mortgages (ARMs). Figure 1 shows the division of fixed-rate periods of new mortgages in Sweden during the relevant period. ARMs are defined as mortgages with a fixed-rate period of three months or shorter. It is clear that a nontrivial share, approximately fifty percent, of new mortgages had adjustable rates during the period. Figure 2 reports the division of fixed-rate periods in the stock of outstanding mortgages. The value-weighted share of ARMs increases from 30 to 40 percent during the time period. Taken together, these aggregate statistics suggest that the cash-flow channel may be an important transmission mechanism.

We now turn to the measurement of household-specific interest rates in our microdata set. We do not observe debt contract details in our data. However, we observe both interest payments and

[16] Relative to Koijen *et al.* (2015), one refinement has been made which concerns bank accounts. Bank account deposits are only reported 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 only reported if the balance on the account exceeded SEK 10,000. Overall, the new rule implies an improvement in accuracy. However, to avoid over-stating savings between 2005 and 2006 we artificially implement the reporting rule of 2000-2005 also on the latter period when imputing consumption.

balance on the loans every year. For each household we therefore define the interest rate $r^d_{i,t}$ as total interest expenses divided by total debt in the same period,

$$r^d_{i,t} = \frac{\text{interest payment}_{i,t}}{\text{debt}_{i,t}} \tag{7}$$

The left panel of Figure 3 illustrates how the value-weighted household interest rate moves with the repo rate. The U-shaped pattern of both rates highlights the prevalence of ARMs, with the average household interest rate sligthly lagging the policy rate. However, we cannot directly observe in our data set if a household has a fixed or adjustable rate mortgage. Instead, we first calculate the correlation between household-specific interest rates, $r^d_{i,t}$, and the repo rate, r_t[17] as

$$corr_i = \text{corr}\left(r_t, r^d_{i,t}\right). \tag{8}$$

Figure 4 shows the density of the household interest rate (left panel) and the correlation measure in our sample (right panel). We see that there is substantial variation both in the household-specific interest rate and in its correlation with the repo rate. We then classify indebted homeowners as having a high variability of their interest rates ("ARM") or low variability ("FRM") depending on if the correlation of their interest payments with the repo rate is above or below the median correlation, which equals 0.55. Households with missing correlations are assigned to be FRM holders. In the empirical analysis we then use changes to the repo rate together with this classification of mortgage type rather than individual interest rates directly. This is to avoid any bias from unobserved events to the household that may affect both interest rates and consumption growth. Using this definition, the fraction of homeowners with ARMs in our sample is 39%, corresponding well with the average number that we see in Figure 2, and the average correlation among homeowners with ARMs equals 0.85 whereas it is 0.15 among homeowners with FRMs. The right panel of Figure 3 provides a graphical documentation of there being a strong effect of our classification. We see that the (value-weighted) interest rate for households with ARMs co-moves strongly with the repo rate year-by-year, while the interest rate for households with FRMs is much less sensitive to monetary policy. Going forward, mortgage debt and total debt are used synonymously in discussions that focus on homeowners.[18]

3.5 Summary statistics

We report summary statistics for the main variables in our data set. An important part of our analysis is to identify groups of households that (i) are likely or unlikely to be credit constrained, and (ii) have interest expenses that are either sensitive or insensitive to changes to changes in monetary policy. Therefore, we split the sample along two dimensions and present summary statistics

[17] The low numbers of observations used to calculate household correlations can raise concerns about measurement error. A misclassification would, however, result in attenuation bias as the differential responses would be muted.

[18] The motivation for this treatment is that mortgage debt in most cases will constitute the vast majority of total debt.

by groups. First, we split the sample by debt-to-income (DTI) ratios, our primary measure of (in)ability to smooth changes to interest expenses. Second, we split the sample by mortgage type.

Figure 5 provides motivation for why it is sensible to hypothesize that homeowners with higher DTI are more sensitive to interest rate changes than less indebted homeowners. The figure displays the cross-sectional variation in assets, debt, and interest expenses among homeowners. The cross-section of homeowners is split into four groups of debt-to-income: homeowners with no debt, and in addition three equally large groups sorted into low, medium and high debt-to-income. The top panels show liquid assets, illiquid assets, and debt. Whereas illiquid assets are relatively evenly distributed among the four groups (the mean varies between 1.88 for the "No debt" category to 5.1 for the high category), both liquid assets and debt are more unevenly distributed. The least indebted homeowners ("No debt") have on average liquid assets equal to 1.37 years of disposable income. In contrast, the most indebted group ("High DTI") has on average liquid assets equal to 0.29 years of disposable income and a debt-to-income ratio of 3.04. Strikingly, the median liquid assets position in the most indebted group amounts to only 0.13 years (one and a half month) of disposable income. In sum, there is a strong negative correlation between illiquid and liquid assets and between debt and liquid assets. The bottom panels of Figure 5 display cross-sectional variation in interest expenses relative to disposable income and consumption. Homeowners in the high DTI category spend on average 0.14 years of 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 liquid assets within one year, unless they adjust their income and/or consumption. Kaplan *et al.* (2014) show the importance of considering the varying liquidity of household assets. They emphasize the significant share of "wealthy-hand-to-mouth" households. These households are wealthy in terms of illiquid wealth but hold very little liquid wealth. Importantly, these wealthy households have a large propensity to consume out of changes in transitory income and do not react strongly to news about future income changes. In this light the pattern we observe in the raw data strengthens our hypothesis of the sensitivity of indebted households to changes in interest expenses. To summarize, the figure documents that although high DTI households are wealthy in terms of illiquid wealth they hold low levels of liquid assets and have high interest expenses relative to their income. When faced with increased expenses, such as after an increase in their mortgage interest rate, these households may face a difficulty in retaining their level of consumption unless being able to access additional credit. If credit constrained, these households are likely to have to reduce their level of consumption when faced with increased expenses. In the Appendix we report the analogous figure for an even split of homeowners into quintiles of debt-to-income (Figure 7).

Table 1 reports further summary statistics for the full sample (column 1), and for three groups of homeowners (column 3-5). Column 2 reports statistics for renters as a reference. First we consider all homeowners (column 3) and then two groups that are based on level of indebtedness. More specifically, indebted homeowners have been split into three equally large groups based on DTI. The top third of the distribution we call high DTI (column 4) and, the bottom two thirds are combined with homeowners that hold no debt into the low/medium category (column 5). Going

forward, this is our main group classification of homeowners. We report all monetary values in Swedish kronor (SEK).[19] On average, homeowners with high debt have favorable characteristics compared to the average homeowners. They have higher disposable income (SEK 366,000 vs SEK 311,000), are younger (46 years vs 54), and have more household members (3.2 household members vs 2.6). They are also better educated. 43 percent have more than high school education compared to 32 percent among all homeowners. These differences also spill over to consumption. Highly indebted homeowners consume SEK 342,000 whereas homeowners on average consume SEK 295,000. Most of the difference is driven by household size – once scaled by adult equivalents the difference is only SEK 1,000. Highly indebted homeowners have twice as much debt as the average homeowner (SEK 1,031,000 vs SEK 466,000). The difference in debt-to-income is of about the same magnitude. Highly indebted homeowners have a lower interest rate (4.6 percent vs. 5.0 percent) but a higher interest share out of disposable income (12.8 percent vs. 6.2 percent). The correlation between the household interest and the repo rate is about the same as for the average homeowners (0.52 vs 0.48). The greater debt is matched by a greater position in illiquid assets (i.e., real estate). Highly indebted homeowners have a on average illiquid assets worth SEK 1.7 million whereas the average homeowner has SEK 1.1 million. Notably, highly indebted homeowners fair worse in terms of liquid assets (SEK 110,000 vs SEK 196,000), liquid assets to income (0.29 vs 0.71) and loan-to-value (0.81 vs. 0.49).

In Table 2 we report summary statistics for homeowners with ARMs and FRMs. The sample is remarkably balanced along this dimension. The two groups have similar wealth (both financial assets and real estate), income, and consumption. They also have similar LTV ratios. Homeowners with an ARM have slightly more debt and a slightly higher DTI ratio but overall these differences are small. The third column reports the coefficient estimates from single-variable regressions of each characteristic on an indicator of having an ARM. While the coefficients are statistically significant apart from a few exceptions, the magnitudes of the coefficients are small in an economic sense. To summarize, the differences in characteristics across the two groups are small.

4 Empirical Framework

Our empirical strategy builds on the insights from the theory presented in Section 2.2. In particular, it is motivated by the interaction between hand-to-mouth behavior and ARMs as given by equation (3). This cash-flow effect of monetary policy is likely to be detectable for households with ARMs and/or high DTI. In order to test this hypothesis, we begin by estimating the following regression equation on homeowners:

$$\Delta \log c_{i,t} = \beta_0 + \beta_1 DTI_{i,t-2} + \beta_2 \Delta r_t \times DTI_{i,t-2} + \beta_3 \mathbf{X}_{i,t} + \delta_t + \phi_i + \varepsilon_{i,t} \tag{9}$$

[19] During our sample period the average exchange rate to the U.S. dollar was about 8 SEK/USD.

where Δr_t is the change in the repo rate and $DTI_{i,t-2}$ is the household's DTI ratio. We lag the DTI ratio by one year so that it is predetermined with respect to $c_{i,t-1}$.[20]

The coefficient β_1 captures systematic variation in consumption growth due to differences in DTI, δ_t are year fixed effects and capture common effects of aggregate shocks, including intertemporal responses to consumption of optimizing households. We include household fixed effects, ϕ_i, to capture any time-invariant cross-sectional heterogeneity (in particular any unobserved differences between ARM and FRM holders) as well as a set of controls, $\mathbf{X}_{i,t}$, which consists of factors influencing preferences for consumption. We include in this vector a fourth order polynomial in age, education, household size and the change in household size.

The coefficient of main interest is β_2. It captures the differential effect of monetary policy as a consequence of different debt-to-income ratios among households, measured relative to the effect of monetary policy on a homeowner with no debt (i.e., net of the common aggregate effect). If all households obey (4) its true value would be zero or close to zero. If all households obey (3) its true value would be equal to the average income to consumption ratio (θ). In sum, the regression specification given by (9) is intended to capture the theoretical implications from Section 2.2.[21]

It is important to further emphasize the implications of including year and household fixed effects in our empirical model. This accounts for the overall aggregate effect of monetary policy on household spending as well as systematic individual differences in consumption growth. In other words, the coefficient β_2 captures responses less the aggregate effect. Our specification thus allows us to make inference about heterogeneous responses to monetary policy rather than the aggregate effect *per se*.[22] Appendix A.3 provides regression estimates from our simple model presented in Section 2.2 for a realistic calibration with finite time horizon and a realistic DTI distribution in order to further illustrate the relationship to the specification given by equation (9).

We then extend (9) to include an interaction term for mortgage type:

$$\begin{aligned}\Delta \log c_{i,t} = \gamma_0 + \gamma_1 DTI_{i,t-2} + \gamma_2 \Delta r_t \times DTI_{i,t-2} + \gamma_3 \Delta r_t \times DTI_{i,t-2} \times ARM_i \\ + \gamma_4 DTI_{i,t-2} \times ARM_i + \gamma_5 \mathbf{X}_{i,t} + \delta_t + \phi_i + \varepsilon_{i,t}\end{aligned} \tag{10}$$

where ARM_i is a dummy variable that takes on a value of one if the household is classified as a holder of an ARM and otherwise zero. γ_2 measures the impact on consumption growth for a holder of an FRM relative to a homeowner with no debt. In this specification, the coefficient γ_3 is of main interest. It measures the differential impact on consumption growth between holders FRMs and holders of ARMs. Again, γ_2 and γ_3 are net of a common aggregate effect.

[20] The lagged value also resembles the use of a steady state value in the log-linear approximation given by equation (3).

[21] 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 absorbed into the estimated cash flow effect. For constrained households who consume all their disposable income, a decrease in the short interest rate implies increased consumption possibilities which could be highly valued. We therefore expect any strategic amortization adjustment to come from *less* constrained households, making the differential effect biased towards zero.

[22] Note that throughout our analysis, we prefer to use the change in the repo rate, Δr_t, rather than the change in the household-specific rate. This avoids any bias that would arise if unobserved idiosyncratic events (e.g., negative news about future income) affect both the household's consumption path and the household's credit worthiness.

By estimating equation (9) and (10) on households with different DTI ratio (i.e., "low/medium", or "high"), we attempt to capture differences in sensitivity to interest changes across the DTI distribution. We also estimate equation (9) on selected sub samples where we expect that the cash-flow effect is particularly strong, either because of binding borrowing constraints (detected by little financial assets in combination with a high loan-to-value) or because of likely abundance of hand-to-mouth behavior (detected by low income or low age).

5 Results

This section presents and discusses our main empirical findings. Table 3 reports estimates based on regression equation (9). The estimate in column (1), a coefficient β_2 of -0.013, indicates a statistically significant heterogeneity in consumption responses to monetary policy changes across the DTI distribution. However, in an economic sense the heterogeneity is small. For a homeowner with a high DTI ratio (3.3 on average), a one percentage point increase in the repo rate implies that consumption growth drops by a mere 0.043 percent (3.3×0.013) more than among homeowner without any debt. In contrast, a similar calculation for a homeowner with medium or low DTI ratio (0.75 on average), implies a drop of 0.01 percent (0.75×0.013) in consumption growth in response to a one percentage point increase in the repo rate. These estimates indicate very moderate differences. Viewed in isolation they do not speak in favor of a strong cash-flow effect.

In order to allow for a non-linear relationship between repo rate changes and indebtedness on consumption, columns (2) and (3) separately focus on high and medium/low DTI households, respectively.[23] An important finding from comparing these two specifications is that the role that household indebtedness plays in shaping consumption responses is very different over the different parts of the cross-sectional DTI distribution. Among highly indebted homeowners, monetary policy has a quite different effect on consumption depending on their level of debt relative to income. Compare two identical homeowners in the high-DTI group who differ only so that one of them has additional debt worth one year of disposable income – say, e.g., that one homeowner has a DTI ratio of 3 and the other a ratio of 4. A one-percentage point increase in the repo rate leads to an additional decrease in consumption growth by 1.44 percent among the latter household. The impact of a change in the repo rate depends on the outstanding DTI ratio among low and medium DTI homeowners too (column 3). Each additional unit of debt-to-income (say a comparison between a ratio of 0.5 and 1.5) implies an incremental positive response to consumption growth by 0.93 percent if the repo rate increases by one percentage point. These results indicate that the small negative response reported in column (1) masks a non-linear relationship.

Column (4) to (6) of Table 3 report estimates based on the extended specification described by equation (10). Comparing column (4) to (1) we see that the initial specification masks substantial

[23] Note that when we estimate separate regressions for sub-groups of homeowners, and include year fixed effects in those regressions, it is not so straightforward to interpret the differential effect relative the effect for a household with no debt. This is because the year fixed effects are allowed to be different in the different regressions. This is evident from equation (1) and (4).

heterogeneity between ARM and FRM holders. In the event of a one-percentage point increase of the repo rate, the average FRM holder (with a DTI ratio of 1.6) responds by increasing consumption by 1.7 percent (1.6×1.055) more than a homeowner with no debt. The average ARM holder (with a DTI ratio of 1.9), however, responds by decreasing consumption by 0.03 percent ($1.9 \times (1.055 - 1.071)$).[24] Among highly indebted households (column 5) we measure even greater variation in the response. For FRM holders, we measure a positive response of 1.72 percent (evaluated at the mean DTI ratio of 3.10). For ARM holders, we measure a negative response of -1.95 percent (given a mean DTI ratio of 3.48). Assuming an immediate one-to-one response between the repo rate and the rate on ARMs, a net MPC (i.e., net of some average aggregate effect) can be calculated for ARM holders based on conversion of the estimated semi-elasticities. Using the fact that ARM holders consume 95 percent of disposable income (see Table 1) we calculate an MPC out of changes in interest expenses induced by monetary policy of roughly 0.5.[25] In other words, this implies that half of the cash-flow effect of monetary policy is absorbed through adjustment of consumption for highly indebted ARM holders.

For low and medium indebted homeowners, we find variation in the response too. For the FRM households, the response to an interest rate is similar as before, roughly a 2 percent increase in relative consumption growth following a one percentage point interest increase, while the negative effect on households with ARMs is smaller than among more indebted households, translating to an MPC of about 0.2. We are inclined to believe that this heterogeneity in response makes the cash-flow channel highly relevant if ARMs are commonly held. That is, in an economy where the prevalence of ARMs is high, monetary policy will have a stronger effect – other things equal – operating through this channel.

In order to graphically illustrate the relative effect for different groups of homeowners, we plot the difference in consumption growth in Figure 6. The figure also plots the corresponding change in the repo rate. The path for the repo rate displays a distinct U-shape during 2002–2007. In the left panel we plot the median consumption growth of all homeowners minus the median consumption growth of homeowners that belong to the high DTI group during the same time period. There is a strong positive correlation between this metric and the repo rate, indicating that as the repo rate increases the consumption of highly indebted homeowners falls behind. In the right panel we further narrow our focus to display the importance of mortgage contracts in channelling this effect. This panel plots the median consumption growth of homeowners that belong the high DTI group minus median consumption growth of homeowners in the high DTI group that also hold ARMs. Compared to the left panel, the positive correlation is even starker. Among homeowners that hold a lot of debt in the form of ARMs consumption falls behind that of other highly indebted households as the repo rate increases.

[24] Recall that these responses are net of a common aggregate response – see discussion in Section 4.

[25] We approximate the MPC as the coefficient(s) of interest multiplied with the DTI ratio and the ratio of consumption relative to income. Throughout we use a consumption to income ratio of 95 percent.

5.1 Analysis of sub groups – the role of borrowing constraints versus outright HTM behavior

The cash-flow channel will affect interest sensitive households more than other households. If households are exposed to variable interest expenses, consumption behavior according to equation (3) can arise either because of binding borrowing constraints or outright hand-to-mouth behavior. Table 4 breaks down our sample further to shed light on this distinction. We consider the effect of monetary policy on consumption responses among different sub-groups of homeowners that are likely to be more or less able to accommodate a tightening of monetary policy. As a reference, column (1) repeats the analysis on the high DTI group in Table 3. Columns (2)-(7) then impose further restrictions on the sample. First we consider the effect of – in addition to high DTI – low liquid assets. Low liquid assets is defined as a share of liquid assets relative to disposable income below the median. Restricting the sample in this way does not affect the estimated consumption response relative to that of the high DTI group in its entirety. Column (3) restricts the sample to those with a high LTV ratio. These households are expected to have limited access to additional credit. We define having a high LTV ratio as being in the group of households with the top third highest LTV ratios across homeowners, which equals a value of 0.67 or higher. For this sample we estimate a semi-elasticity of -2.55 which is greater than among the high DTI group in its entirety. The combined effect of high DTI, low liquid assets, and a high LTV ratio is even stronger (column 4). At an estimated semi-elasticity of -3.74, the effect within this subgroup is more than twice as large as for the group of high-indebted households at large. These estimates are strong evidence in favor of the view that our main effects are driven by sub-groups of homeowners that are borrowing constrained, rather than by very wide-spread outright hand-to-mouth behavior. As we restrict the sample to low income households (defined as having a disposable income below the median; column 5) or to young households (defined as being 40 years old or younger; column 6) the effect is weaker. One reason for this finding could be that younger households have a longer time horizon to smooth temporary shocks (see Appendix A.2). It could also be because younger households have a lower share of committed expenses.

Overall, we view these findings as pointing towards the role of borrowing constraints in combination with large exposure to ARMs. To emphasize this point we relax the sample restriction on high DTI homeowners in column 7 but maintain the restriction on low liquid assets and low income, i.e. we focus on a sub-sample in which hand-to-mouth behavior is believed to be common. For this group there is no statistically significant differential response along the DTI ratio. Again, this provides an indication that the effect in the full sample is a manifest of some households' exposure to fluctuating interest expenses in conjunction with binding borrowing constraints (which manifests itself as hand-to-mouth behavior).

5.2 Instrumental Variables Estimates of Consumption Responses

As argued in our theoretical motivation, households may display different responses to expected and unexpected changes to the repo rate. If households are forward-looking but constrained

from borrowing they respond only to unexpected changes whereas if households display hand-to-mouth behavior they respond equally to expected and unexpected changes. In order to investigate whether households respond differently to unexpected changes we instrument the repo rate changes with monetary policy shocks. We calculate monetary policy shocks similarly to Gertler & Karadi (2015). They use high frequency identification of monetary policy shocks. This approach is developed to identify exogenous innovations in monetary policy that are due entirely to policy shifts, i.e. innovations that are unrelated to the macroeconomic development. With such an instrument, we address the simultaneity problem which would arise if monetary policy reacts to a macroeconomic development that may have a differential impact on the household groups of our analysis.

To identify this innovation, we use a tight window around the time of a monetary policy announcement to isolate the effect of policy surprise on market interest rates. In Sweden, the monetary policy decision is announced the day after the meeting in which the policy rate, the repo rate, is determined. We use the change in the Treasury bill rate on the day of the announcement, and assume that the movement in the rate that day is driven by the innovation in monetary policy.[26] More precisely, we construct the monetary policy shock as the difference between the interest rate at the end of the day of the policy announcement and the day before the announcement:

$$MPS_d = {i_d}^{1M} - i_{d-1}^{1M}$$

where i_d^{1M} is the interest rate on the 1-month Swedish Treasury bill and d is the day of a monetary policy announcement. Typically there are six meetings per year. We time aggregate the monetary policy shocks to an annual measure by summing them year-by-year. As demonstrated in Figure 8, the measured monetary policy shocks this way covaries with the repo rate over our sample period, in particular during the period of interest rate increases, but the magnitude of these innovations is considerably smaller than the repo rate changes themselves.

Using standard instrumental variables method, we estimate (9) and (10). The results are presented in Table 5. Compared to the results presented earlier, e.g. in Table 3, these results estimate the differential effect of an unexpected change in the repo rate, while before the estimates captured the overall differential effect of interest rate changes. Comparing the results to Table 3, we find effects that are much smaller in magnitude – in particular for the high DTI group – but the results are qualitatively similar for the first specification. Among high DTI households there is a negative effect of increases in the repo rate whereas among low and medium DTI households the effect is positive (column 1 to 3). When contrasting the holders of ARMs and FRMs, there is wedge similar as before, although the magnitude of the response, in particular for holders of ARMs, is now smaller (column 4 to 6). We conclude that unexpected changes to the repo rate have a smaller differential impact on levered versus unlevered homeowners, suggesting presence of some hand-to-mouth behavior.

[26] In contrast to Gertler & Karadi (2015), we do not have access to futures instruments for the entire time period of our study.

6 Conclusion

This paper studies a transmission mechanism of monetary policy that operates through interest rate changes on households' debt. The effect on households' spending is heterogeneous and depends on whether the household has debt with variable interest rates, in particular adjustable rate mortgages (ARMs). We study this channel for monetary policy using an administrative panel data set for a large representative sample of Swedish households. The data set contains both detailed information about the balance sheet of households and their consumption. Most Swedish households hold some share of their overall debt in loans with variable interest rates. Importantly, ARMs is a standard, non-exotic, form of mortgage contract in Sweden.

We estimate a small negative response of consumption growth to increases in the policy rate (i.e., the repo rate) for levered homeowners. There is however substantial heterogeneity in effects at different parts of the debt-to-income distribution and the negative effect is attributed to homeowners with the greatest debt-to-income ratio. Highly indebted homeowners respond more negatively to repo rate increases the higher their debt-to-income ratio is. Furthermore, we find that holders of fixed rate and adjustable-rate mortgages respond differently. Our results suggest that the negative effect of repo rate increases is entirely concentrated among highly leveraged homeowners who hold ARMs. For those, half of the cash-flow effect induced by repo rate changes is absorbed by changes to consumption expenditure. We also consider other sub-groups which are likely to be constrained and find that households respond particularly strongly if they have little financial assets and a high loan-to-value in addition to a high debt-to-income. This is evidence in favour of borrowing constraints contributing to the cash-flow channel. We do however find that even predicted changes to the repo rate have an effect, pointing to a role for outright hand-to-mouth behavior.

Our results have important implications for the role of monetary policy. They indicate that in economic environments where households are highly indebted, face restricted access to credit, and hold loans with interest rates that respond directly to variations in short interest rates, monetary policy is very potent. Monetary policy will have a stronger effect on real economic activity than in other environments since households will respond to monetary policy-induced interest rate changes by a larger magnitude than predicted by conventional estimates of the intertemporal elasticity of substitution.

It is in order to emphasize the limitations of our study and the interpretability of our results. Our focus is only on the cash-flow effect of changes in interest rates, but not on the effect 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 its policy rates. Specifically, we are unable to characterize the general equilibrium effect of the cash-flow channel on aggregate consumption in the economy. Another channel that we have abstracted from, but believe to be important, is that monetary policy may have heterogeneous effects on household consumption by affecting the distribution of wealth in the economy. Studying such implications remains as interesting but challenging tasks for future research.

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Table 1: Summary statistics

	All	Renters	Homeowners	High DTI	Low/Medium DTI
	(1)	(2)	(3)	(4)	(5)
Sociodemographics					
Disposable income	262	187	311	366	291
	(148)	(94)	(155)	(154)	(151)
Disposable income a.e.	152	134	163	169	161
	(57)	(47)	(60)	(60)	(59)
Age	55	56	54	46	57
	(17.1)	(19.1)	(15.5)	(11.1)	(15.8)
Household size	2.3	1.8	2.6	3.2	2.4
	(1.5)	(1.4)	(1.5)	(1.5)	(1.4)
Education					
< High school (share)	17.50	24.60	13.48	6.20	16.58
High school (share)	53.09	50.94	54.31	50.50	55.94
> High school (share)	29.41	24.46	32.21	43.30	27.48
Consumption measure					
Consumption	253	187	295	342	278
	(148)	(99)	(158)	(168)	(151)
Consumption a.e.	147	135	155	156	155
	(61)	(53)	(65)	(67)	(64)
Balance sheet items					
Debt	311	74	466	1,031	260
	(450)	(152)	(509)	(563)	(280)
Debt-to-income	1.2	0.90	1.4	3.3	0.74
	(107)	(170)	(14.7)	(28.3)	(1.3)
Interest rate	5.0	5.1	5.0	4.6	5.2
	(3.3)	(4.9)	(2.1)	(1.3)	(2.3)
Correlation measure	0.38	0.13	0.48	0.52	0.46
	(0.54)	(0.58)	(0.48)	(0.46)	(0.49)
Interest share	4.2	1.2	6.2	12.8	3.8
	(5.4)	(2.8)	(5.9)	(5.5)	(3.7)
Illiquid assets	705	0	1,166	1,706	968
	(949)	(0)	(976)	(1,102)	(843)
Liquid assets	150	81	196	110	227
	(292)	(216)	(324)	(179)	(358)
Liquid assets-to-income	0.62	0.48	0.71	0.29	0.87
	(2.4)	(3.2)	(1.8)	(1.7)	(1.8)
Loan-to-Value (-p99)	0.49	-	0.49	0.81	0.38
	(0.44)	-	(0.44)	(0.37)	(0.41)
Observations	257,921	102,033	155,888	41,720	114,168

Notes: High DTI and Low/Medium DTI represent groups separated based on homeowners' Debt-to-Income (DTI). High DTI represents the top third of the DTI distribution for homeowners with positive debt. The Low/Medium DTI group includes the bottom two thirds and homeowners without debt. The split is based on DTI lagged by two years, and we display average predetermined DTI. 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 refers to the household head.

Table 2: Summary statistics and balance by mortgage type

	FRM	ARM	ARM – FRM
	(1)	(2)	(3)
Sociodemographics			
Disposable income	336	348	12.102***
	(148)	(152)	(1.433)
Disposable income a.e.	168	171	2.193***
	(59)	(61)	(0.553)
Age	50	50	0.044
	(12.9)	(12.8)	(0.130)
Household size	2.8	2.9	0.086***
	(1.5)	(1.5)	(0.015)
Education			
< High school (share)	11.64	10.09	-
High school (share)	55.72	54.85	-
> High school (share)	32.64	35.06	-
Consumption measure			
Consumption	315	330	15.607***
	(153)	(160)	(1.401)
Consumption a.e.	157	161	3.790***
	(63)	(66)	(0.536)
Balance sheet items			
Debt	532	607	75.238***
	(498)	(514)	(4.782)
Debt-to-income	1.6	1.9	0.282***
	(5.4)	(22.9)	(0.095)
Interest rate	5.3	4.7	-0.548***
	(2.4)	(1.7)	(0.017)
Correlation measure	0.15	0.85	0.694***
	(0.45)	(0.10)	(0.003)
Interest share	7.4	7.6	0.002***
	(5.8)	(5.5)	(0.001)
Illiquid assets	1,201	1,310	110.036***
	(970)	(1,022)	(9.336)
Liquid assets	152	159	6.934***
	(248)	(262)	(2.281)
Liquid assets-to-income	0.40	0.42	0.022***
	(0.79)	(1.53)	(0.009)
Loan-to-Value (-p99)	0.59	0.62	0.031***
	(0.42)	(0.41)	(0.004)
Observations	67,258	60,804	186,840

Notes: Columns (1) and (2) report summary statistics by groups with different duration of debt, where High (Low) represents groups with a correlation of household interest rates with the repo rate below (above) the median among home owners. Values are in 1,000 Swedish Krona or in percent (averages). Values in parenthesis 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 parenthesis below, are clustered at the household level. See table 1 for further details.

Table 3: Consumption Responses to Changes in Interest Rates

By Debt-to-Income and ARM/FRM

	All	High DTI	Medium and Low DTI	All	High DTI	Medium and Low DTI
	(1)	(2)	(3)	(4)	(5)	(6)
$DTI_{t-2} \times \Delta r_t$	-0.013**	-0.435***	1.260***	1.055***	0.555**	2.450***
	(0.006)	(0.140)	(0.398)	(0.119)	(0.259)	(0.458)
$DTI_{t-2} \times \Delta r_t \times ARM$	–	–	–	-1.071***	-1.114***	-2.644***
	–	–	–	(0.119)	(0.158)	(0.260)
DTI_{t-2}	0.000***	0.002***	0.113***	0.019***	0.010***	0.108**
	(0.000)	(0.001)	(0.038)	(0.006)	(0.002)	(0.045)
$DTI_{t-2} \times ARM$	–	–	–	-0.019***	-0.007**	0.025
	–	–	–	(0.006)	(0.003)	(0.058)
Mean DTI	1.40	3.29	0.74	–	–	–
Mean DTI - ARM	–	–	–	1.90	3.48	1.04
Mean DTI - FRM	–	–	–	1.60	3.10	0.94
Average Response	-0.02	-1.44	0.93			
Average Response - ARM	–	–	–	-0.03	-1.95	-0.20
Average Response- FRM	–	–	–	1.70	1.72	2.30
Observations	155,888	41,720	114,168	128,062	41,720	86,342

Notes: Sample is restricted to homeowners. All specifications include year fixed effect, household fixed effects, a fourth polynomial in age, household size, and growth in household size. DTI denotes the ratio of debt-to-income. Δr_t is the year-on-year change in the repo (monetary policy) interest rate, set by the Central Bank's monetary policy committee. ARM is an indicator for having ones own interest rates that correlate strongly with the repo rate (above median correlation). Standard errors in parenthesis are clustered at the household level.

*, ** and *** denotes significance at the 10 percent, 5 percent and 1 percent level, respectively.

Table 4: Consumption Responses to Changes in Interest Rates

Analysis of Sub-Groups of High DTI Households

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$DTI_{t-2} \times \Delta r_t$	-0.435***	-0.427**	-0.765**	-1.102***	-0.329**	-0.191	-0.243
	(0.140)	(0.205)	(0.307)	(0.389)	(0.151)	(0.514)	(0.193)
DTI_{t-2}	0.002***	0.002**	0.004**	0.005***	0.002**	0.082***	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.013)	(0.001)
High DTI	✓	✓	✓	✓	✓	✓	
Low liquid assets		✓		✓			✓
High LTV			✓	✓			
Low income					✓		✓
Age $\leq$40						✓	
Mean DTI	3.29	3.46	3.33	3.39	3.97	3.29	4.34
Average Response	-1.43	-1.48	-2.55	-3.74	-1.31	-0.63	-1.05
Observations	41,720	22,450	25,969	15,888	15,184	15,489	8,638

Notes: Sample is restricted to homeowners. Low liquid assets is defined as having a liquid assets to income ratio that is below the median (0.17). High LTV is defined as having an LTV in the in the highest third of all households (above 0.66). Low income is defined as having a disposable income below median (below SEK 283,000). All specifications include year fixed effect, household fixed effects, a fourth-order polynomial in age, household size, and growth in household size. Standard errors in parenthesis are clustered at the household level. *, ** and *** denotes significance at the 10 percent, 5 percent and 1 percent level, respectively.

Table 5: IV Estimates of Consumption Responses to Changes in Interest Rates

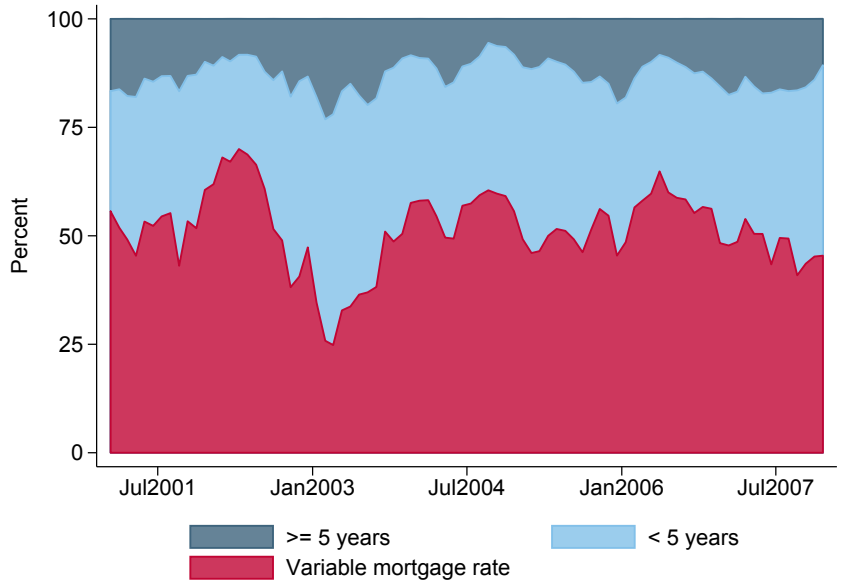
By Debt-to-Income and ARM/FRM

	All	High DTI	Medium and Low DTI	All	High DTI	Medium and Low DTI
	(1)	(2)	(3)	(4)	(5)	(6)
$DTI_{t-2} \times \Delta r_t$	-0.027**	-0.017***	0.269***	0.079	0.164	0.859***
	(0.012)	(0.004)	(0.099)	(0.080)	(0.144)	(0.213)
$DTI_{t-2} \times \Delta r_t \times ARM$	–	–	–	-0.107	-0.183	-1.884***
	–	–	–	(0.081)	(0.143)	(0.211)
DTI_{t-2}	0.000***	0.000***	0.004***	-0.000	-0.002	0.003
	(0.000)	(0.000)	(0.001)	(0.001)	(0.002)	(0.002)
$DTI_{t-2} \times ARM$	–	–	–	0.001	0.002	-0.011***
	–	–	–	(0.001)	(0.002)	(0.003)
Mean DTI	1.40	3.29	0.74	–	–	–
Mean DTI - ARM	–	–	–	1.90	3.48	1.04
Mean DTI - FRM	–	–	–	1.60	3.10	0.94
Average Response	-0.04	-0.06	0.20	–	–	–
Average Response - ARM	–	–	–	-0.05	-0.07	-1.07
Average Response- FRM	–	–	–	0.15	0.51	0.81
Observations	155,888	41,720	114,168	128,062	41,720	86,342

Notes: Sample is restricted to homeowners. All specifications include year fixed effect, household fixed effects, a fourth polynomial in age, household size, and growth in household size. DTI denotes the ratio of debt-to-income. Δr_t is the year-on-year change in the repo rate, instrumented by monetary policy shocks. ARM is an indicator for having ones own interest rates that correlate strongly with the repo rate (above median correlation). Standard errors in parenthesis are clustered at the household level.

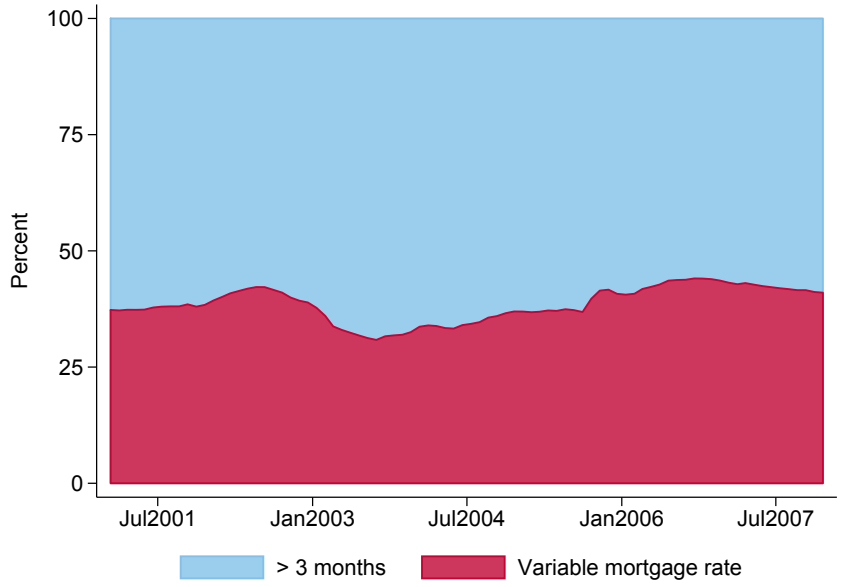
*, ** and *** denotes significance at the 10 percent, 5 percent and 1 percent level, respectively.

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



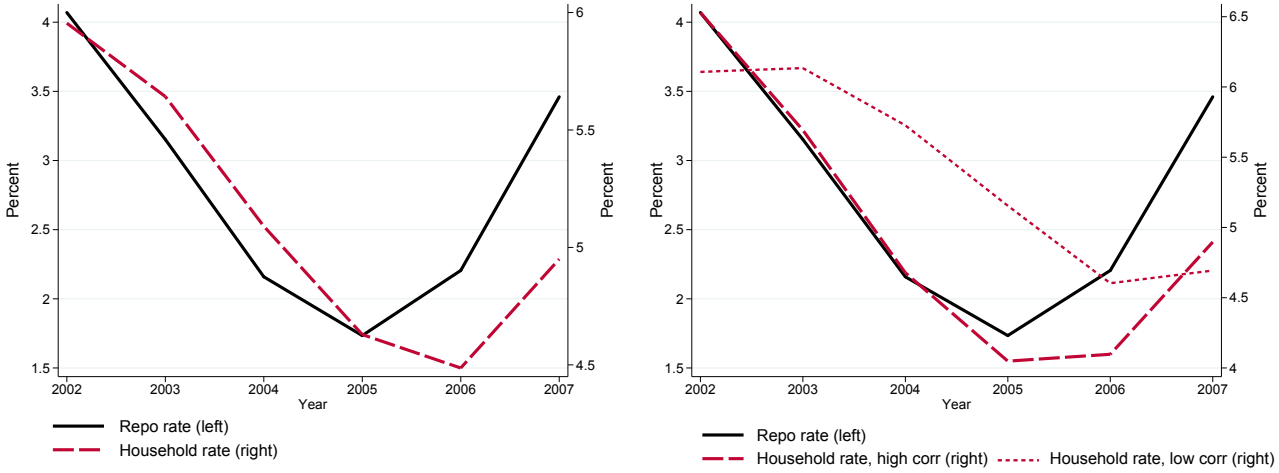
Note: Variable mortgage rate is defined as 3 months or shorter. The data source is Figure A18 in Riksbanken (2012).

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



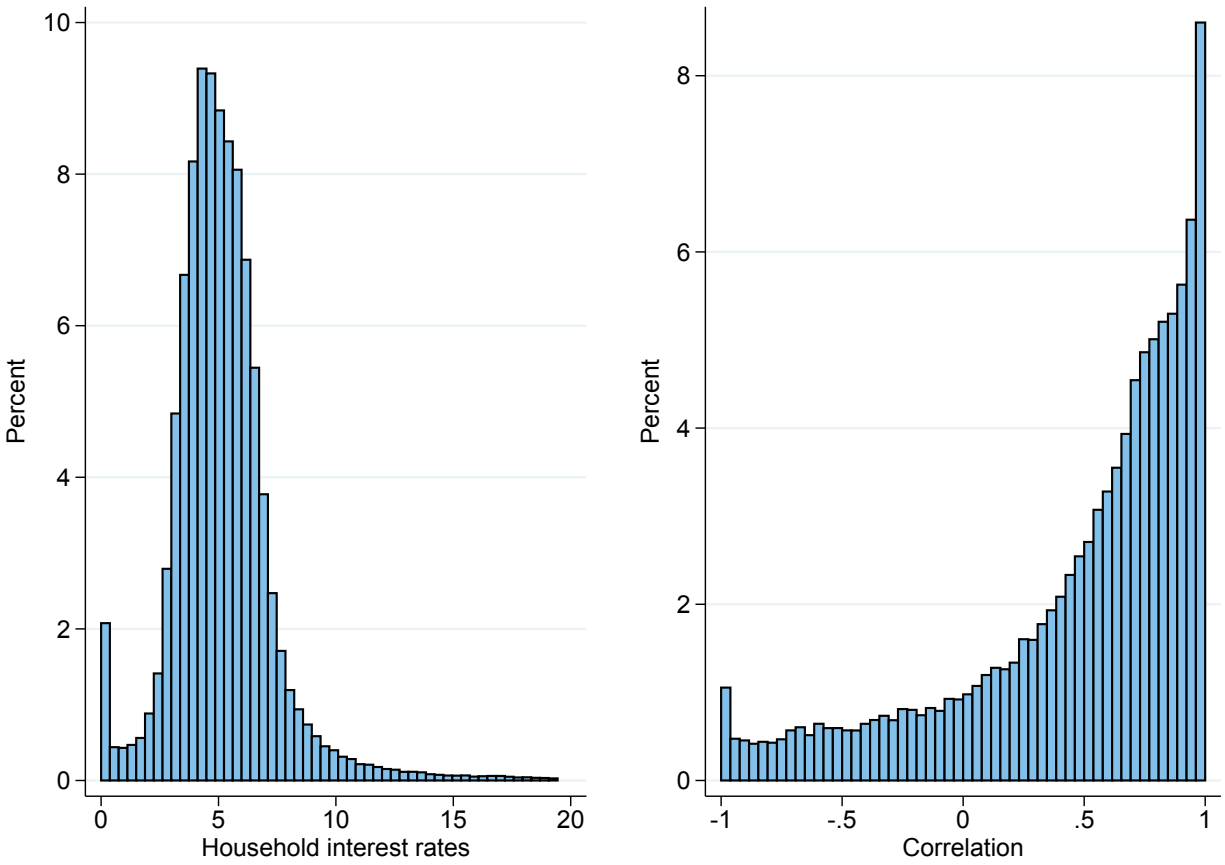
Note: Variable mortgage rate is defined as 3 months or shorter. The data source is Figure A30 in Riksbanken (2015).

Figure 3: The repo rate and household interest rates



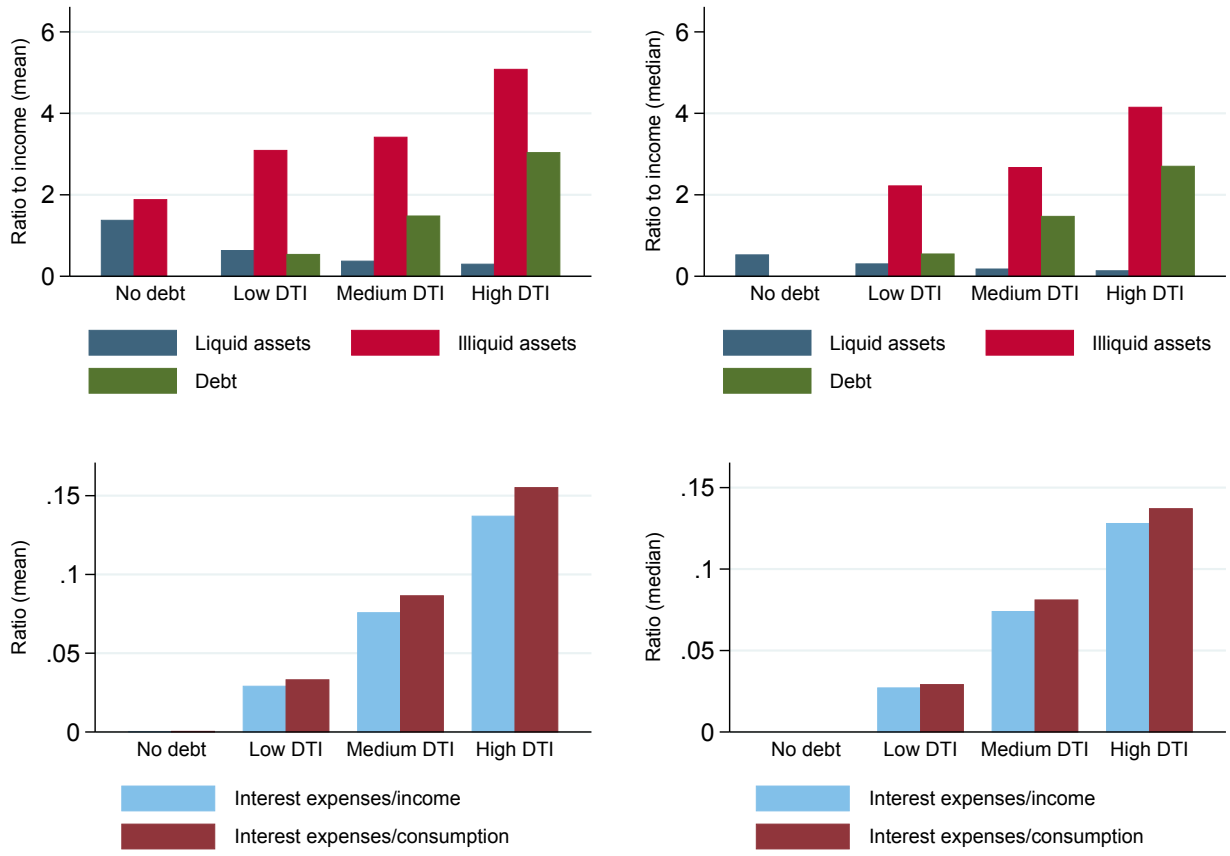
Note: The left panel displays the repo rate and the average household interest rate. The right panel displays the repo rate, and the average household interest rate separated into households with a low correlation (dotted line) and high correlation (dashed line).

Figure 4: Household interest rates and correlations with the repo rate



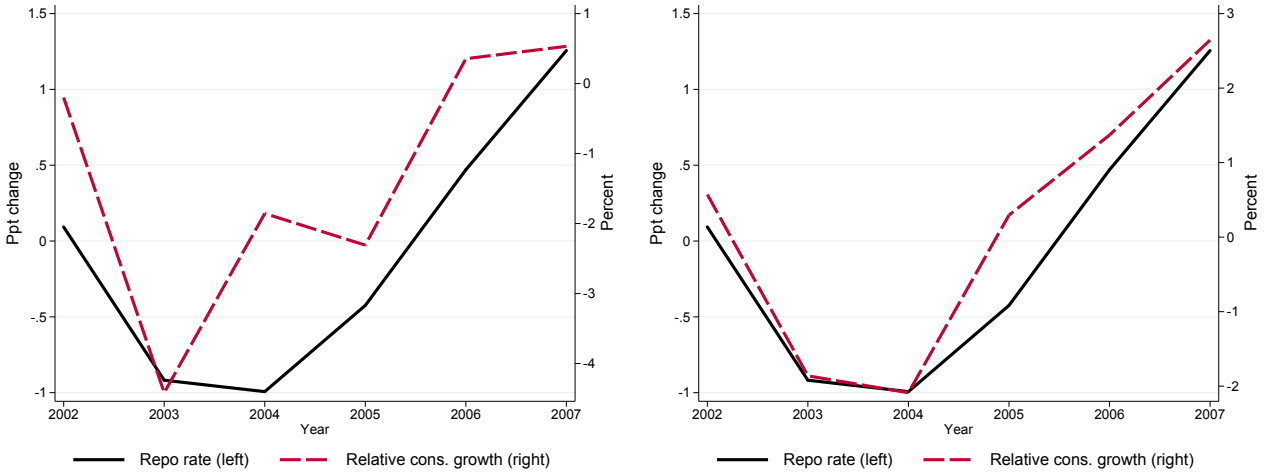
Note: The left panel displays the cross-sectional distribution of correlations between the repo rate and the household interest rate. The right panel displays the cross-sectional distribution of household interest rates.

Figure 5: Homeowners' assets, debt, and interest expenses



Note: The figure displays home owners' assets, debt, and interest expenses normalized by disposable income across four groups of the debt-to-income distribution. Homeowners are sorted into "No Debt" and in addition, into three equally large categories. The cut-off points for the three equally large groups are debt-to-income ratios of 1.03 and 1.97. The left panels display means and the right panels display medians within each group.

Figure 6: The repo rate and relative consumption growth



Note: The left panel depicts relative consumption growth measured as the median consumption growth among all homeowners minus the median consumption growth of homeowners with a high debt-to-income ratio who hold an ARM. The right panel depicts relative consumption growth measured as the median consumption growth of homeowners with high debt-to-income ratio minus the median consumption growth of homeowners with high debt-to-income ratio who hold an ARM.

A Details on the model

A.1 Derivation of the log-linear expression for hand-to-mouth behavior

Starting from equation (2) we want to approximate:

$$\log(c_t) = \log(y_t + r_t \cdot a_t). \tag{11}$$

We use a first-order Taylor approximation of the form $f(x) = f(x^*) + (x - x^*)f'(x^*)$. The left-hand side in (11) is then approximated by

$$\log(c_t) = \log(c^*) + (c_t - c^*)\frac{1}{c^*} \tag{12}$$

while the right-hand side is approximated by

$$\log(y_t + r_t \cdot a_t) = \log(y^* + r^* \cdot a^*) + [(y_t + r_t \cdot a_t) - (y^* + r^* \cdot a^*)]\frac{1}{y^* + r^* \cdot a^*} \tag{13}$$

Now, use $y^* + r^* \cdot a^* = c^*$ to simplify (13):

$$\begin{aligned}
\log(y_t + r_t \cdot a_t) &= \log(c^*) + [(y_t + r_t \cdot a_t) - (y^* + r^* \cdot a^*)]\frac{1}{c^*} \\
&= \log(c^*) + \frac{y_t - y^*}{c^*} + \frac{(r_t - r^*)a^*}{c^*} \\
&= \log(c^*) + \frac{y^*}{c^*}\frac{y_t - y^*}{y^*} + \frac{y^*}{c^*}\frac{a^*}{y^*}(r_t - r^*) \\
&= \log(c^*) + \theta\frac{y_t - y^*}{y^*} + \theta\frac{a^*}{y^*}(r_t - r^*)
\end{aligned} \tag{14}$$

Substitute (12) and (14) into (11) to obtain:

$$\frac{(c_t - c^*)}{c^*} = \theta\frac{y_t - y^*}{y^*} + \theta\frac{a^*}{y^*}(r_t - r^*). \tag{15}$$

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

$$\Delta\log(c_t) = \theta\Delta\log(y_t) + \theta\frac{a^*}{y^*}\Delta r_t. \tag{16}$$

A.2 Optimizing households – Alternative timing assumptions

The optimizing household's problem is as follows. We ignore uncertainty in returns and labor income and consider only the effects of unanticipated shocks to the short-term interest rate. Optimizing households solve

$$\max \mathrm{E}_0 \sum_{t=0}^{T^i-1} \beta^t u\left(c_t^i\right) \tag{17}$$

subject to the budget constraint

$$\sum_{t=0}^{T^i-1} R_t^{-1}\left(c_t^i - y_t^i\right) = \left(1+r_0\right) a_0^i \tag{18}$$

where $R_0 = 1$ and $R_t = \left(1+r_t\right) R_{t-1}$ for $t \geq 1$, and where β denotes the discount factor and the utility function is $u\left(c\right) = c^{1-\frac{1}{\sigma}} / \left(1-\frac{1}{\sigma}\right)$

The solution to this problem is characterized by the Euler equation which determines consumption growth

$$\frac{c_{t+1}^i}{c_t^i} = \left[\beta\left(1+r_{t+1}\right)\right]^\sigma \tag{19}$$

and

$$c_0^i = \frac{Y^i + \left(1+r_0\right) a_0^i}{\sum_{t=0}^{T^i-1} R_t^{\sigma-1} \beta^{\sigma t}} \tag{20}$$

which determines the level of consumption. Y^i is the present value of the household's income stream. The Euler equation demonstrates that the percentage consumption response to anticipated interest rate movements is identical for all optimizing households in the economy. There is however some heterogeneity in response to unanticipated interest-rate changes when households have different levels of wealth and/or remaining life-spans.

We refer to the solution given by (19) and (20) for a given constant interest rate as the steady state. Below we analyze scenarios when a household has chosen c_0 in steady state and then learns in the beginning of period 1 that either r_2 has changed or that r_1 has changed. In the first case, the household chooses c_1 so that the relation between c_1 and c_2 remains consistent with the Euler equation. The level of c_1 (and consumption in periods thereafter) in relation to the initial steady-state consumption (c_0) is however also affected – exactly how depends on the household's initial (net) wealth. In the second case, all forward-looking interest rates are unaffected. The household therefore does not want to reoptimize the slope of its consumption path. But the surprise in return on savings between period 0 and 1 has consequences for the household?s available resources in the beginning of period 1. This wealth or cash-flow effect thus affects the relation between c_0 and all future consumption levels.

A.2.1 Timing assumption 1: new information about the future interest rate

We first explore the assumption that the household has chosen c_0 according to (20), but that it in the beginning of period $t = 1$ learns that the interest rate will be $\widetilde{r}_2$ instead of the anticipated r_2. The household will then reoptimize in the beginning of period $t = 1$, resulting in

$$\Delta \log c_1^i \approx \alpha + \gamma^i \left(\widetilde{r}_2 - r_2\right) \tag{21}$$

where $\Delta \log c_1^i$ denotes the deviation in c_1 away from steady state, α is a term common to all household, and where

$$\gamma^i \approx -\frac{T^i - 2}{T^i - 1}\left(\frac{T^i}{T^i + a^i/y^i} + \sigma - 1\right), \tag{22}$$

and where the last approximation builds on the assumption that there is little discounting, that the interest rate is close to zero, and that the household has a flat income profile. In this forward-looking scenario, there are three effects that determine the response: a substitution effect, an income effect, and a cash-flow effect. Notice that apart from accounting for a finite horizon, equation (21) is essentially equal to the negative of equation (4). The difference in sign appears because equation (4) considers changes to $\log(c_2) - \log(c_1)$ in response to a change in r_2.

A.2.2 Timing assumption 2: new information about the realized interest rate

We also explore the assumption that the household has chosen c_0 according to (20), but that the interest rate turns out to be $\hat{r}_1$ instead of the anticipated r_1. The household will then reoptimize in the beginning of period $t = 1$, resulting in

$$\Delta \log c_1^i \approx \alpha + \delta^i \frac{a^i}{y^i} (\hat{r}_1 - r_1) \tag{23}$$

where α is, again, a term common to all households. The individual-specific factor δ in this expression can be approximated as

$$\delta^i \approx \frac{1}{T^i + a^i/y^i} \tag{24}$$

if there is little discounting, the interest rate is close to zero, and if the household has a flat income profile over the life cycle. The fact that future interest rates remain at steady state shuts down the substitution effect. Nonetheless, the response of typical optimizers is an order of magnitude smaller than for hand-to-mouth households (provided that $T^i \gg |a^i/y^i|$).

A.3 Quantitative analysis

We report model estimates based on a simple model simulation. We set $\beta = 0.98$, $y = 1$, and let T be distributed uniformly between 10 and 50 years. Debt-to-income (the negative of $\frac{a}{y}$, is uniformly distributed between 0 and 5. The experiment is that the interest rate increases for one period from 0.02 to 0.03.

We estimate the regression:

$$\Delta \log c_i = \beta_0 + \beta_1 DTI_i \times \Delta r + \varepsilon_i \tag{25}$$

where subscript $t = 1$ has been omitted. Column (1) to (3) of Table 6 report estimates for optimizers that behave as in Section A.2.1. The EIS (σ) varies between 0.5 (column 1), 1.0 (column 2), and 1.5 (column 3). This parameter determines the common response of all households, and is identified by the intercept in each regression. The estimate on $\Delta r \times DTI_i$ indicates that the percentage response in consumption growth is amplified by 0.071 for each unit of additional debt-to-income.

The mean response is estimated to be -0.179 percent. Whether optimizers can adjust period-0 consumption (column 1 to 3), or not (column 4) does not matter much for the response. Column 5 focuses on a sample of households that display hand-to-mouth behavior as given by equation

(2). The estimate in this sample is 16 times larger than the estimate of column (2). The response is essentially proportional to the debt-to-income ratio. Finally, column (6) reports estimates if optimizers and hand-to-mouth households are mixed 50-50, simply by combining the samples of column 2 and 5. At -0.607 the estimate in the combined sample is equal to the average of the two estimates. The mean response is -1.53 percent and the response amplitude varies by 0.607 percent for each unit of debt-to-income.

Table 6: Model Estimates for ARM Holders

	(1)	(2)	(3)	(4)	(5)	(6)
$DTI_i \times \Delta r$	-0.071***	-0.071***	-0.071***	-0.076***	-1.143***	-0.607***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.012)
Constant	-0.005***	-0.009***	-0.014***	-0.0004***	0.0013***	-0.0065***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	2,100	2,100	2,100	2,100	2,100	4,200
R-squared	0.536	0.580	0.622	0.457	0.999	0.450
Share of optimizers	1.0	1.0	1.0	1.0	0.0	0.5
Share of HTMs	0.0	0.0	0.0	0.0	1.0	0.5
EIS of optimizers (σ)	0.5	1.0	1.5	1.0	—	1.0
Flexible current consumption	✓	✓	✓			✓
Mean DTI	2.525	2.525	2.525	2.525	2.525	2.525
Average Response	-0.179	-0.179	-0.179	-0.192	-2.886	-1.533

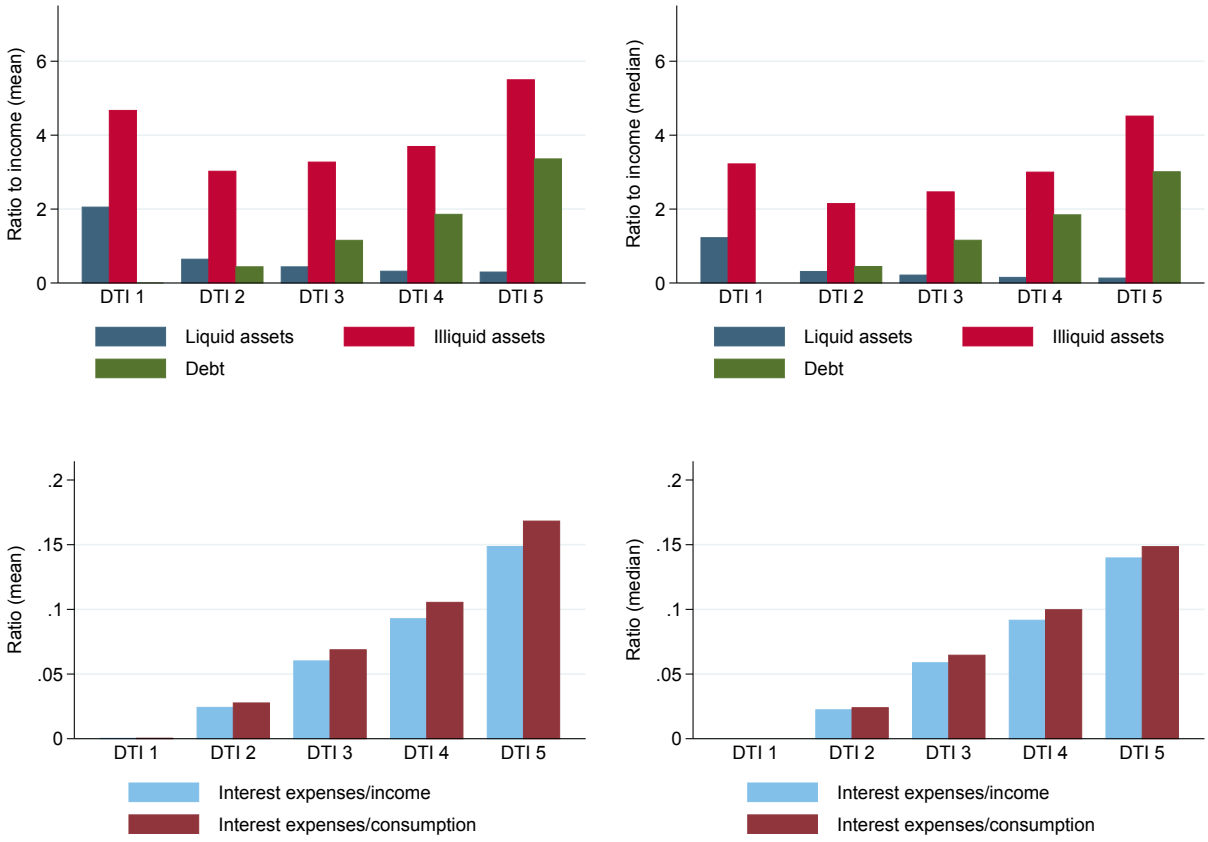
Notes: The sample is based on a parameterization where $y = 1$, $\beta = 0.98$, households whose heads are aged between 30 and 70 years (T uniformly distributed between 10 and 50), and debt-to-income uniformly distributed between 0 and 5 (DTI_i is the negative of $\frac{a_i}{y_i}$). The experiment involves a one-year increase in the interest rate from 0.02 to 0.03. Flexible current consumption denotes whether optimizers follow equation (23), in which case it is fixed, or equation (21), in which case it is flexible. *, ** and *** denotes significance at the 10 percent, 5 percent and 1 percent level, respectively.

A.4 Extension of model to FRMs

It is straightforward to extend the simple model to include an FRM. The most simple form of FRM would involve a non-amortizing mortgage with a fixed interest rate (i.e., independent of the experiment above) that is paid back in full at time T. In the setting above, the response of a household that holds such a mortgage to a temporary one-period change to the short-term interest rate would be miniscule.

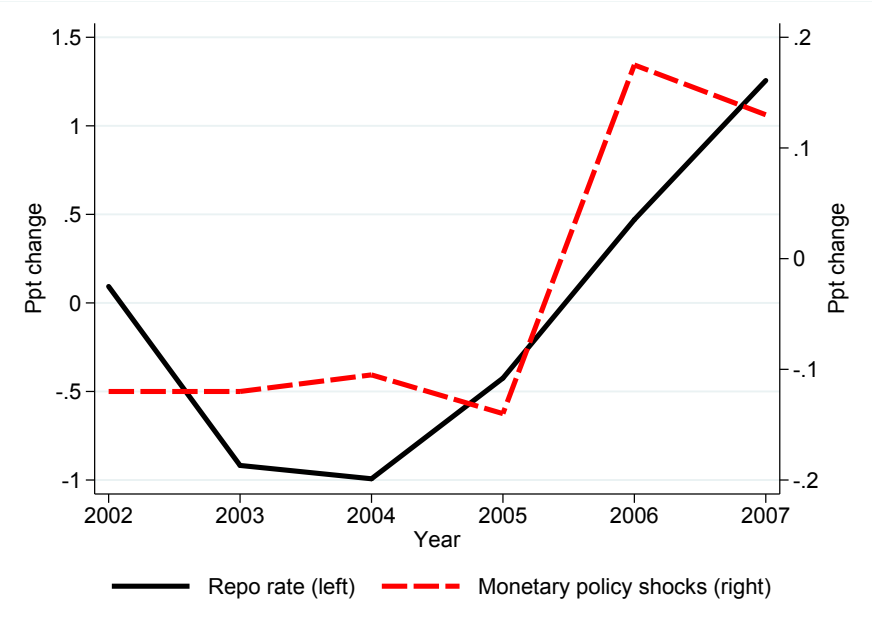
B Additional figures

Figure 7: Homeowners' assets, debt, and interest expenses (by quintiles of DTI)



Note: The figure displays home owners' assets, debt, and interest expenses normalized by disposable income across quintiles of the debt-to-income distribution. The left panels display means and the right panels display medians within each quintile.

Figure 8: Change in the repo rate and monetary policy shocks



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