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

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Abstract

We examine 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, which is broadly representative of Swedish households, we find substantial heterogeneity in consumption responses to changes in monetary policy. We find that consumption responds more strongly to changes in interest rates for households with high debt than for households with little or no debt. Moreover, households with ARMs appear to be more interest-rate sensitive than households with fixed-rate mortgages. Our results are consistent with hand-to-mouth behavior and an important transmission of monetary policy through the cash-flow channel.

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1 Introduction

A fundamental question in macroeconomics is how monetary policy affects the real economy. The primary transmission mechanism in standard macroeconomic models is the interest-rate channel. According to this mechanism, forward-looking households change the slope of their consumption profiles when interest rates change. The empirical support for this mechanism is, however, mixed.[1] Monetary policy indeed appears to have effects on the real economy that are both stronger and of a different character than predicted by the interest-rate channel. This suggests that monetary policy does not only operate through the interest-rate channel, but that there are also other important transmission mechanisms at work.[2]

One such mechanism is the *cash-flow channel*.[3] According to this mechanism, monetary policy has a direct effect on household spending through households' cash flows and disposable incomes. A tightening of monetary policy raises the interest-rate expenses for households with adjustable-rate mortgages and therefore has a negative impact on the disposable income of such households. 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 increase debt in response to temporarily lower disposable income, monetary policy will affect consumption also through the cash-flow channel.

In this paper, we investigate this cash-flow channel empirically using household data. A typical problem when trying to estimate the impact of monetary policy is that changes in monetary policy are endogenous to the economic development. Therefore, it is difficult to identify the causality from monetary policy to economic outcomes. This problem is mitigated with the household data that we use. All households are affected by the same monetary policy, but the impact varies from household to household if the cash-flow channel is important because households have a different exposure to interest-rate changes depending on the composition of their balance sheets and mortgage contracts. 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 adjustable-rate mortgages (ARMs) relative to households with fixed-rate mortgages (FRMs).

Our study builds on data on Swedish households between 2002 and 2007. For three reasons, Sweden is the perfect laboratory for examining the cash-flow channel. The first reason is that household debt is high and adjustable-rate mortgages are common in Sweden. Throughout our sample period, ARMs accounted for 30 to 40 percent of the aggregate value of outstanding mort-

[1] Attanasio & Weber (2010) and Jappelli & Pistaferri (2010) survey the empirical support for the consumption theories that underpin the interest-rate channel.

[2] Boivin *et al.* (2011) discuss different transmission mechanisms that have been suggested in the literature, and the (often weak) empirical support for these mechanisms.

[3] 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". However, Boivin *et al.* (2011) do not mention this channel in their survey.

gages. These ARMs often have an interest fixation period of only three months.[4] The second reason is that ARM is a standard product on the Swedish mortgage market. That is, it is not targeted to particular household groups. Therefore, it is unlikely that our results are contaminated by selection into different types of loan portfolios depending on household characteristics or spending behavior.[5] In support of this, we note that households that we identify as having ARMs in our sample are almost economically identical to households which we identify as having FRMs.[6] The final 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 that are representative for the population. 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.

Our main finding is that consumption responds more strongly to changes in interest rates for households with high debt than for households with little or no debt. If the monetary policy rate increases by one percentage point, a household with debt equal to one year's disposable income reduces its consumption by 0.15-0.26 percentage points relative to a similar household with no debt. The transmission of monetary policy to household consumption can be divided into two steps: first the transmission to interest rates faced by households, then the transmission from household rates to consumption. When focusing on the second step, we estimate responses in the range 0.28-0.39. That is, a household with debt equal to one year's disposable income reduces consumption by 0.28-0.39 percent relative to a similar household with no debt. The latter range of estimates can also be interpreted as the marginal propensity to consume (MPC) out of an interest-rate induced increase in cash flow. Our data set does not allow us to directly identify which households that have ARMs or FRMs. Instead we use the correlation between each household's interest rate and the monetary policy rate as a proxy for the contract type. Based on that approach, we find some evidence that households with ARMs respond more strongly to monetary policy than households with FRMs.

We argue that our findings are consistent with widespread hand-to-mouth behavior. The distribution of liquid assets in our sample provides further support for this interpretation. Only 22 percent of 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,

[4] 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. See also Figures 2 and 3 and Holmberg *et al.* (2015).

[5] A possible concern is otherwise that households may select into ARM or FRM based on household-specific characteristics that are correlated with macroeconomic developments (see, e.g.,. Campbell & Cocco (2003) and Campbell & Cocco (2015) for theoretical arguments, and Badarinza *et al.* (2018) for empirical evidence).

[6] Moreover, Holmberg *et al.* (2015) do not find that the probability that a Swedish household defaults on its mortgage correlates with the choice of interest-rate fixation.

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 affect consumption choices.

Our paper contributes, in particular, to the recent and still expanding empirical literature on the relation between household debt, mortgage markets, and the transmission of monetary policy. Most similar to our study are the papers by Cloyne *et al.* (2016) and La Cava *et al.* (2016). Cloyne *et al.* (2016) study the response of expenditure and income to monetary policy in the United Kingdom and the United States.[7] 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. They argue, however, 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. 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 rates.

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. 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 the consumption response is stronger for households with high debt (relative to house values) and low income. These findings thus indicate that cash flows matter for consumption decisions, and that the importance of cash-flow effects varies between different household groups. An important difference between their study and ours is that we use a comprehensive expense-based measure of consumption rather than car purchases.

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. Mian *et al.* (2013) explore regional differences in house price falls in the United States during the recent financial crisis and find a strong correlation between the fall in housing wealth and consumption. They also find that housing wealth had a larger impact on consumption in regions with poor and more levered households. Using detailed U.S. household data, Baker (2017) finds that the consumption elasticity of income as a result of credit constraints is significantly higher for households with high debt. Using Danish administrative data, Andersen *et al.* (2016) study if household leverage prior to the financial crisis amplified the reduction in

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

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.[8] Our findings are broadly in line with these papers, although our focus is slightly different. We thus provide further support for the importance of household debt and the mortgage market for the transmission of monetary policy.

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). Although we do not directly focus on this question, our findings highlight that the impact of monetary policy varies across households. Recent empirical papers that more directly study the distributional implications of monetary policy include Sterk & Tenreyro (2015) and Casiraghi *et al.* (2018).[9]

Lastly, our study is related to a series of papers studying household consumption responses to shocks to unearned income and fiscal stimulus programs. 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.[10] 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. These papers study consumption responses to changes in disposable income induced by fiscal policy. Our paper can be viewed as a monetary-policy analogue to that literature.

The remainder of this paper proceeds as follows. In the next section, we provide a theoretical motivation for our empirical framework. This is done by identifying how the consumption behavior behind the cash-flow channel differs from the standard consumer theory behind the interest-rate channel. Section 3 then provides details on the data set we use and our measure of consumption and presents some summary statistics. The empirical strategy is discussed in Section 4. We present our results in Section 5. Section 6 concludes the paper.

2 Theoretical Motivation

To motivate our empirical framework, we briefly consider models of consumer behavior. A natural starting point for studying consumption and savings decisions is the life cycle/permanent income model. Consumers then have concave preferences which induce a consumption smoothing motive. Another implication is that unconstrained households that are forward-looking and maximize expected utility only react 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,

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

[9] See Garriga *et al.* (2017) and Auclert (2017) for theoretical contributions.

[10] For studies on the consumption responses to other sources of shocks to disposable income, see, e.g., Stephens (2008), Kueng (2018), Hsieh (2003) and Agarwal & Qian (2014).

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 for household i from period $t-1$ to t, and where λ_t captures anticipated and unanticipated macroeconomic developments that are common to all households.[11]

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. An unanticipated persistent shock may, however, result in heterogeneous consumption responses if markets are not complete. For example, a surprisingly high return on savings would induce old, wealth-rich households with a short remaining planning horizon to raise the consumption more than younger or less wealthy households in a life-cycle setting. But for typical interest-rate shocks, most households have a sufficiently long remaining planning horizon for such heterogeneity to be of minor importance in these models.

According to these theories, a change in monetary policy will be captured by the term λ_t and will 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. Furthermore, Krusell & Smith (1998) show that if individuals have different subjective discount rates, rule-of-thumb behavior arises endogenously for a share of consumers (those with high discount rates).

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 for others. In particular, changes in disposable income will then feed directly into changes in consumption. To motivate an empirical specification that allows for such *cash-flow effects*, 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 the household’s ARM. Notice that for the typical mortgage holder, gross financial assets are 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 let d_t denote either gross or net debt and refer to $\frac{d_t}{y_t}$ as the debt-to-income ratio. The

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

intertemporal budget constraint reads $c_t - d_{t+1} = y_t + d_t(1 + r_t)$ where y_t is labor income and $d_t(1 + r_t)$ is debt service.[12]

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

$$c_t = y_t - r_t \cdot d_t. \tag{2}$$

In other words, if measured as a marginal propensity to consume, the response of a hand-to-mouth household to 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:

$$\Delta \log c_t \approx \theta \cdot \Delta \log y_t - \theta \cdot \frac{d}{y} \cdot \Delta r_t, \tag{3}$$

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 ratio.[13] 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, an HTM household with a debt-to-income ratio of 3 will reduce consumption (in percentage terms) by twice as much as an 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 whether the change was anticipated or not.

This simple framework suggests that the consumption response of HTM households differs from that of optimizing households in response to changes in interest rates. Optimizing households respond to new information about the future interest rate. HTM households, on the other hand, only respond when their cash flows change. If markets are complete, all optimizing households respond similarly to new information. HTM households respond differently depending on how their household-specific cash flows are affected. If markets are not complete, optimizing households may also display heterogeneous consumption responses to changes in their cash flows. However, this heterogeneity is typically of minor importance since these households are forward-looking and allocate the consumption response across their planning horizon.[14]

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

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

[14] Consider a (temporary) shock to the interest rate. An optimizing household in its final period responds as an HTM household with the same financial portfolio. The consumption of an optimizing household with T periods remaining is roughly $\frac{1}{T}$ times that of an HTM household.

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.[15] The tax registers therefore include information about 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.[16]

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 which is constructed from transactions in a given municipality in each year. Market values of apartments (shares in co-op associations) are also assessed by Statistics Sweden 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 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

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

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

[16] 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 & Fredriksson (n.d.).

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 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. Appendix B (Table 8) reports incremental changes to the sample as restrictions are imposed.

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).[17] This is a vital part of our exercise since the main outcome of interest is spending.

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

$$c_{i,t} = y_{i,t} + \Delta d_{i,t} - r^d_{i,t} d_{i,t-1} - \Delta a_{i,t} + r^a_{i,t} a_{i,t-1}. \tag{4}$$

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 (4) are observable in our data. Mapping equation (4) into the detailed structure of our data gives the identity:

$$c_{i,t} = y_{i,t} + \Delta d_{i,t} - r^d_{i,t} d_{i,t-1} - \Delta b_{i,t} - \Delta v_{i,t} - \Delta h_{i,t} - \Delta \psi_{i,t} - \omega_{i,t}, \tag{5}$$

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 (5) 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.[18]

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

[18] 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.

3.4 The Swedish mortgage market

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 of interest. Taken together, these aggregate statistics suggest that the cash-flow channel may be an important transmission mechanism. Another important aspect of Swedish mortgage contracts is that the borrower bears the cost of refinancing. If the borrower wishes to switch from an FRM to an ARM at a time when interest rates are low, the borrower must compensate the bank for the loss. Letting households bear these costs inhibits consumer mobility in the mortgage market. For us, this is helpful since we can only infer the mortgage type indirectly, as outlined below.

3.5 Household interest rates and correlation with the repo rate

In some of our empirical specifications, we try to identify differences in responses for households with adjustable- rather than fixed-rate mortgages. A problem in doing so is that we do not observe debt contract details in our data. In particular, we cannot directly see in our data if a household has chosen an adjustable- or fixed-rate mortgage, nor can we directly observe the interest rate that the household pays on its debt. Instead we calculate the household-specific interest rate from information on interest paid and the size of the household's debt. For each household we then calculate the correlation between its household-specific 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 that particular household, or to identify the household as having an adjustable- or fixed-rate mortgage.

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 (from t and $t-1$)

$$r^d_{i,t} = \frac{\text{interest payment}_{i,t}}{0.5 \cdot \text{debt}_{i,t} + 0.5 \cdot \text{debt}_{i,t-1}}. \tag{6}$$

Based on this definition, we construct value-weighted and equally weighted household interest rates in our sample. Figure 3 illustrates the fluctuation of these variables along with the fluctuation of the repo rate and an aggregate household interest rate reported by Statistics Sweden. The U-shaped pattern of all rates highlights the high prevalence of ARMs. The value weighted household interest rate almost perfectly tracks the repo rate with some lag. It also tracks the Statistics Sweden's reported rate well. The equally weighted measure also tracks the fluctuation well, but the level is too high, indicating that small credits carry a higher interest.

We then calculate the correlation between household-specific interest rates, $r^d_{i,t}$, and the repo rate, r_t, as:

$$corr_i = \text{correlation}\left(r_t, r^d_{i,t}\right). \tag{7}$$

We use this measure later on to proxy for whether a household holds an ARM or an FRM.[19] Appendix B (Figure 6) reports the cross-sectional distribution of household interest rates and correlations with the repo rate. The median correlation is 0.61, consistent with a high prevalence of ARMs.

3.6 Summary statistics

We report summary statistics for the main variables in our data set in Table 1. 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. Homeowners have more liquid assets than renters, 168 kSEK compared to 69 kSEK. However, most of their wealth is tied to illiquid assets. The average loan-to-value ratio is 0.45 and 78 percent of net worth are tied to illiquid assets.

Figure 4 provides a simple graphical illustration of why it is sensible to hypothesize that homeowners with a high DTI are more sensitive to interest-rate changes than are 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 debt-to-income ratio of less than 3, and homeowners with a debt-to-income ratio greater than 3. The group of homeowners with a high debt-to-income ratio comprises 13.2 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 distributed differently. The average homeowner has liquid assets worth approximately 8 months of disposable income. In contrast, the most highly indebted group has less than 4 months of disposable income. In other words, there is a strong negative correlation between illiquid and liquid assets and between debt and liquid assets. Combined with a high prevalence of ARMs, this increases the likelihood of hand-to-mouth behavior.

The bottom panels of Figure 4 display a cross-sectional variation in interest expenses relative to disposable income and consumption. Homeowners with a high DTI ratio (i.e., greater than 3) spend on average 0.15 years of their 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 large propensity to consume out of changes in transitory income and to not react strongly to news about future income changes. These empirical patterns support our hypothesis of the sensitivity of indebted households to changes in interest expenses. Our statistics are related to Kaplan *et al.* (2014) who argue that it is important to consider

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

the liquidity of households' assets and emphasize the significant population share of "wealthy-hand-to-mouth" households.

4 Empirical Framework

Our empirical strategy builds on the insights from the theory presented in Section 2. In particular, it is motivated by the interaction between hand-to-mouth behavior and the DTI ratio as given by equation (3). This cash-flow effect of monetary policy is likely to be detectable for households with a high DTI ratio as a large share of mortgages have adjustable rates and as high DTI households have little liquid assets. In order to test this hypothesis, our main regression specification is:

$$\Delta \log c_{i,t} = \beta_0 + \beta_1 DTI_{i,t-2} + \beta_2 \Delta r_t \times DTI_{i,t-2} + \beta_3 \Delta r_t \times \mathbf{X1}_{i,t} + \beta_4 \mathbf{X2}_{i,t} + \delta_t + \phi_i + \varepsilon_{i,t}, \quad (8)$$

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 $c_{i,t-1}$. The coefficient of main interest is β_2. It captures systematic variation in consumption growth due to differences in DTI in response to a change in the interest rate. In most of our specification, we use changes in the repo rate, denoted by Δr_t, but we also consider changes in the aggregate household interest rate, denoted by Δi_t.[20] If all households optimize, we would expect to estimate $\beta_2 = 0$. If all households instead obey equation (3), we would expect to estimate that β_2 equals the average income to consumption ratio (θ). In sum, the regression specification given by (8) is intended to capture the implications from Section 2.[21] The coefficients δ_t denote year fixed effects and capture common effects of aggregate shocks, including intertemporal responses to consumption of optimizing households. In some specifications we include household fixed effects, ϕ_i, to capture any time-invariant cross-sectional heterogeneity. In $\Delta r_t \times \mathbf{X1}_{i,t}$ we include an interaction between Δr_t and dummy variables for being young (below 40), old ($\geq$ 60) and having children to account for characteristics that may interact with interest rate sensitivity. We always include a set of control variables denoted by $\mathbf{X2}_{i,t}$ which consists of factors influencing preferences for consumption. In this vector, we include a fourth-order polynomial in age, number of children and the change in number of children.

We emphasize the implications of including 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 in

[20] Note that throughout our analysis, we prefer to use the change in an aggregate interest rate, Δr_t with no subindex i, i.e., we do not use a household-specific interest rate as defined by (6). We mainly use the repo rate but also consider an aggregate household interest rate provided by Statistics Sweden (for all loans to households). By omitting household-specific interest rates, we avoid 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.

[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. Therefore, we expect any strategic amortization adjustment to come from *less* constrained households, making the differential effect biased towards zero.

consumption growth. In other words, the coefficient β_2 captures responses less the aggregate effect. Our specification thus makes an inference about heterogeneous or relative responses to monetary policy rather than the aggregate effect per se.

A potential problem when including household fixed effects in the specification is that we have a short time dimension in our data set. This is not a major obstacle since much of the identification comes from the cross-sectional variation. However, we choose not to include $DTI_{i,t-2}$ as an explanatory variable in the fixed-effects regressions because there is a particular risk of bias in the estimates of β_1.[22]

5 Results

This section presents our main empirical findings.

5.1 Response to changes in the repo rate

Table 2 reports estimates based on the specification in equation (8), using changes in the repo rate. Column (1) reports a coefficient β_2 of -0.26 based on an OLS specification with year fixed effects. The interpretation is that the average household (with a DTI of 0.88) responds by 0.23 $(0.88 * 0.26)$ percentage points more than a household with no debt to a one-percentage point change in the repo rate.

Column (2) extends the specification so that it differentiates between renters and homeowners. The estimated β_2 then falls somewhat to 0.15. However, we estimate a stronger response to interest-rate changes for homeowners than for renters. Because homeowners on average have more debt than renters (DTI of 1.27 for homeowners and 0.33 for renters), it is possible that some of the effect of debt is instead captured by the ownership status. Column (3) reports estimates based on homeowners only. The heterogeneous response for homeowners with different DTI ratios is almost as large as in the greater population. Importantly, this means that the DTI ratio matters even within the group of homeowners. This is consistent with our discussion about the importance of the liquidity of assets.

Columns (4)-(6) report estimates from specifications that include household fixed effects. These estimates are very similar to those in columns (1)-(3), suggesting that unobserved time-invariant heterogeneity is not a major factor for our findings.[23]

[22] The problem with $DTI_{i,t-2}$ is that it is supposed to proxy for $DTI_{i,t-1}$. But with household fixed effects, we would only exploit the within variation in $DTI_{i,.}$. A high value of $DTI_{i,t-2}$ then means that $DTI_{i,t-2}$ is high relative to its value in the other time periods, and thus that it is likely that $DTI_{i,t-1}$ and $DTI_{i,t}$ are *low*. We would then obtain biased estimates of β_1. However, it is not likely that a similar bias would affect estimates of β_2, the parameter in which we are most interested.

[23] As noted in the previous section, we do not use $DTI_{i,t-2}$ as an explanatory variable in regressions where we include household fixed effects because of a risk of biased estimates when T is small. If we include $DTI_{i,t-2}$ in the regressions anyway, the estimates of β_2 increase in absolute value to between -0.29 and -0.35 (remaining highly significant), and the estimates of β_1 are between 0.04 and 0.05 and highly significant.

The results also some shed light on demographic differences in consumption responses to monetary policy. Conditional on a given DTI ratio, old households respond more strongly (more negatively) than younger and middle aged households. This finding is consistent with old households having shorter remaining planning horizons and therefore behaving more as hand-to-mouth households even if they are optimizing and forward-looking. However, the magnitude of our estimated response for the old households appears somewhat large for a strict interpretation along these lines. This finding differs from Wong (2018), who finds younger cohorts' consumption to be more sensitive to monetary policy, as responses are concentrated among households taking out new loans or refinancing, which, in turn, are mainly younger households. Since our empirical specification looks within DTI groups, these findings are not directly comparable. The prevalence of ARMs in Sweden may also contribute to the difference. We also find that households that have children appear to reduce their consumption less than households without children when the interest rate increases.[24]

We conclude that there are strong indications that the cash-flow channel is present in the data. That is, the elasticity of consumption responses to changes in the repo rate depends importantly on the household's debt-to-income ratio.

5.2 Response to changes in the aggregate household interest rate

Table 3 reports households' consumption responses to changes in the average interest rate faced by households instead of changes to the repo rate. By focusing on this interest rate, we ignore the first step in the transmission of monetary policy.[25] Thus, we can better identify the impact of cash flows on household consumption behavior. The downside is that we get one step further from identifying the impact of monetary policy on household behavior.

Columns (1)-(3) in Table 3 report estimates of β_2 between -0.28 and -0.39 based on OLS estimation. Compared to using the repo rate, the estimated coefficients are roughly fifty percent greater. That the estimated coefficients are greater than the coefficient reported in Table 2 is consistent with the interest rate here having a more direct impact on household cash flows. Columns (4)-(6) report panel estimates with household fixed effects. The results are still similar to those in Table 2 but β_2 is now estimated in the interval -0.59 to -0.62, thus indicating a substantially stronger response to the average household rate than to the repo rate.

Because the interest rate faced by households has a direct impact on household cash flows, the results here can be translated into a (relative) marginal propensity to consume (MPC) out of changes in cash flows. Average consumption is 241 kSEK and average debt is 284 kSEK implying an MPC in the interval 0.24 to 0.50.[26]

[24] Recall that all these estimates are in relative terms since we include year fixed effects. It is thus not clear from our estimates if households on average increase or reduce consumption when the interest rate is raised.

[25] However, the two interest rates follow each other closely as seen in Figure 3. A regression of the average household rate on the repo rate results in an estimated coefficient of 0.95 on the repo rate.

[26] A one percentage point higher interest rate then reduces household cash flows by $0.01 \times 284 = 2.84$ kSEK. The average reduction in consumption is in the interval $0.28 \times 241 = 0.7$ to $0.62 \times 241 = 1.4$ kSEK.

We conclude that using the average household interest rate rather than the repo rate reinforces our result that the cash-flow channel is strong. In the remaining analysis, we do, however, use the repo rate since it has a tight link to monetary policy.

5.3 The role of the net debt-to-income ratio

Depending on how households use their liquid assets to smooth consumption, the relevant metric on which to sort households is either the debt-to-income ratio or the debt-to-income ratio minus the liquid assets-to-income ratio. We name the latter metric households' net debt-to-income ratio and use it to replace the debt-to-income ratio in the baseline regression specification. Table 4 reports the estimates. Column (1) reports a coefficient β_2 of -0.07 which indicates substantially smaller differences in relative responses. It is indicative that households may compartmentalize debt and liquid assets and hence, do not use liquid assets to buffer changes in interest rate-expenses. In column (2), we find no evidence that the responses differ along the net debt-to-income ratio other than by average differences between renters and homeowners (which nevertheless are substantial). Column (3) is consistent with the findings in column (2). Estimates based on fixed effects (columns (4) to (6)) are consistent with the OLS estimates.

5.4 Proxies for type of mortgage contract

Although we do not observe the details of a household's mortgage contract, we can use our correlation measure defined by equation (7) as a proxy for the mortgage type. We either use a dummy variable for a correlation greater than the median (0.61) to proxy for an ARM contract, or directly interact the correlation measure with the repo rate. Appendix B (Table 9) reports differences between households with FRMs and ARMs based on our proxy. While there are statistically significant differences between the two groups, the differences are economically small. Households with ARMs earn a 3.6 percent higher disposable income than households with FRMs and their consumption differs by 4.3 percent. Households with ARMs and FRMs also have essentially equal liquid assets. One of the greater differences is their debt-to-income ratios, but at 11 percentage points, the difference is nevertheless economically small. This is consistent with the conventional Swedish view that ARMs is not an exotic mortgage product.

Table 5 presents estimates based on these proxies for the sample of households for which the correlation measure could be computed. Column (1) indicates a weaker relationship between the debt-to-income ratio and the response in consumption than in previous specifications. However, at the same time, it indicates a strong difference in the response between households with ARMs and FRMs. A household with an ARM responds by cutting consumption 0.53 percentage points more in response to a one percentage-point-increase in the repo rate. Evaluated at the mean, this corresponds to approximately SEK 1,600 more.[27] At a mean debt-to-income ratio of 1.57, this in

[27] This number comes from the significant response from column (1) for the interaction between having an ARM and the change in the interest rate, times average consumption for households with ARMs.

turn corresponds to an MPC of 0.32 for households with ARMs relative to households with FRMs. No further difference between ARMs with different debt-to-income ratios can be detected.

Using the continuous correlation measure itself in column (2) yields estimates consistent with column (1). There is a substantial difference in response for a household with a perfect correlation compared to household with an interest rate that is not correlated with the monetary policy rate. Furthermore, households with a high-debt-to-income and a high correlation respond more strongly than households with a high debt-to-income ratio and a low correlation.

Moving to fixed effect estimates in columns (3) to (4), it is evident that our proxies are too crude and time invariant to allow for precise inference. While the signs of estimates related to the ARM dummy variable remain correct, they are no longer statistically significant. That said, the correlation measure interacted with debt-to-income remains significant (column (4)). The main take-away is that consumption responses to monetary policy are much stronger among households with ARMs as compared to other households.

5.5 Non-linearities

Finally, we explore whether households with low income or little wealth are particularly sensitive to changes in interest rates. Such households could be more likely than others to be liquidity constrained and display hand-to-mouth behavior. The results are reported in Table 6. In column (1) we focus on households with low income, identified as adult-equivalent disposable income in the lowest quartile. They respond by an additional 0.37 percentage points for each percentage point change in the repo rate, but they do not appear to respond more strongly when they hold more debt.[28] In column (2) we focus on highly indebted households, identified as households with a debt-to-income ratio above 3. We do not find any evidence of non-linear behavior for that group. In column (3) we instead use the loan-to-value (LTV) ratio to identify highly indebted households. More precisely, we identify high LTV as the households having loans that exceed 85 percent of their house value. We find no evidence that households with an LTV ratio above 0.85 respond differently. Finally, there is also no evidence that households with a low assets-to-income ratio behave differently (column (4)).

6 Conclusion

This paper studies a transmission mechanism of monetary policy that operates through interest-rate changes on households' debt. We study this channel for monetary policy using an administrative panel data set for a large sample of Swedish households. The data set contains both detailed information about the balance sheet of households and their consumption. In Sweden during the years of our analysis (2002 to 2007), 30 to 40 percent of the aggregate value of mortgages were adjustable rates. Importantly, ARMs is a standard, non-exotic, form of mortgage contract in Sweden.

[28] The estimated coefficient on $Lowincome \times \Delta \times DTI_{t-2}$ is positive (rather than negative as expected) but only significant at the 10 percent level.

We find strong heterogeneity in the consumption responses to changes in monetary policy. In particular, households with more debt respond more strongly to changes in interest rates. We also find some evidence that households with adjustable-rate mortgages respond more strongly than households with fixed-rate mortgages. These findings are consistent with hand-to-mouth behavior, something that is further supported by the wealth distribution in our data set, where many households have little liquid wealth but adjustable-rate mortgages.

Our results highlight the importance of a cash-flow channel in the transmission of monetary policy. More precisely, our results indicate that monetary policy is more potent 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 then has a stronger effect on real economic activity than in other environments since households 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 their 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
	(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)
Education			
< 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)
Observations	265,675	111,678	153,997
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 (e.g., 192,569 in column (1)). For the loan-to-value ratio the mean for percentile 99 and below is reported.

Table 2: Consumption Responses to Changes in the Repo Rate

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{DTI}_{t-2} \times \Delta r_t$	-0.26***	-0.15***	-0.18***	-0.26***	-0.19***	-0.20***
	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.08)
DTI_{t-2}	0.00***	0.00***	0.01***			
	(0.00)	(0.00)	(0.00)			
Homeowner		-0.01***				
		(0.00)				
Homeowner$\times\Delta r_t$		-0.57***			-0.36***	
		(0.10)			(0.12)	
Young$\times\Delta r_t$	0.23*	0.15	0.04	-0.45**	-0.49***	-0.70***
	(0.13)	(0.13)	(0.19)	(0.18)	(0.18)	(0.26)
Old$\times\Delta r_t$	-1.14***	-1.06***	-0.97***	-1.10***	-1.05***	-0.94***
	(0.12)	(0.12)	(0.19)	(0.16)	(0.16)	(0.24)
Have children$\times\Delta r_t$	0.49***	0.56***	0.54***	0.50***	0.55***	0.53**
	(0.12)	(0.12)	(0.18)	(0.14)	(0.15)	(0.21)
Mean DTI	0.88	0.88	1.27	0.88	0.88	1.27
Observations	265,675	265,675	153,997	265,675	265,675	153,997
Sample	All	All	Home own.	All	All	Home own.
Household FE	No	No	No	Yes	Yes	Yes
Unique households				64,158	64,158	37,547

Notes: All specifications include year fixed effects, a fourth polynomial in age, the number of children and the change in number of children. 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. Columns (1)–(3) report results from the OLS estimation, columns (4)–(6) use fixed effects. In columns (3) and (6), the estimation is restricted to homeowners. Young is a dummy defined as < 40 and old as ≥ 60. Have children is a dummy for having children. 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 3: Consumption Responses to Changes in the Aggregate Household Rate

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{DTI}_{t-2} \times \Delta i_t$	-0.39***	-0.28***	-0.30***	-0.62***	-0.61***	-0.59***
	(0.08)	(0.08)	(0.10)	(0.09)	(0.10)	(0.11)
DTI_{t-2}	0.00***	0.00***	0.00***			
	(0.00)	(0.00)	(0.00)			
Homeowner		-0.01***				
		(0.00)				
Homeowner$\times\Delta i_t$		-0.61***			-0.06	
		(0.16)			(0.18)	
Young$\times\Delta i_t$	0.42**	0.33*	0.07	-0.69***	-0.70***	-1.12***
	(0.19)	(0.19)	(0.28)	(0.26)	(0.26)	(0.38)
Old$\times\Delta i_t$	-1.31***	-1.25***	-1.22***	-1.25***	-1.24***	-1.22***
	(0.18)	(0.18)	(0.27)	(0.24)	(0.24)	(0.36)
Have children$\times\Delta i_t$	0.50***	0.55***	0.51**	0.69***	0.70***	0.70**
	(0.18)	(0.18)	(0.26)	(0.22)	(0.22)	(0.32)
Mean DTI	0.88	0.88	1.27	0.88	0.88	1.27
Observations	265,675	265,675	153,997	265,675	265,675	153,997
Sample	All	All	Home own.	All	All	Home own.
Household FE	No	No	No	Yes	Yes	Yes
Unique households				64,158	64,158	37,547

Notes: All specifications include year fixed effects, a fourth polynomial in age, the number of children and the change in number of children. DTI denotes the ratio of debt-to-income. Δi_t is the year-on-year change in the average household interest rate (Statistics Sweden). Columns (1)–(3) report results from the OLS estimation, columns (4)–(6) use fixed effects. In columns (3) and (6), the estimation is restricted to homeowners. Young is a dummy defined as < 40 and old as ≥ 60. Have children is a dummy for having children. 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: Net debt-to-income

	(1)	(2)	(3)	(4)	(5)	(6)
Net DTI$_{t-2} \times \Delta r_t$	-0.07**	-0.04	-0.04	-0.10***	-0.08**	-0.07
	(0.03)	(0.03)	(0.04)	(0.04)	(0.04)	(0.05)
Net DTI$_{t-2}$	0.00***	0.00***	0.00***			
	(0.00)	(0.00)	(0.00)			
Homeowner		-0.00***				
		(0.00)				
Homeowner$\times\Delta r_t$		-0.68***			-0.48***	
		(0.09)			(0.11)	
Young$\times\Delta r_t$	0.21	0.13	0.00	-0.46**	-0.50***	-0.72***
	(0.13)	(0.13)	(0.19)	(0.18)	(0.18)	(0.26)
Old$\times\Delta r_t$	-1.11***	-1.04***	-0.93***	-1.10***	-1.04***	-0.92***
	(0.12)	(0.12)	(0.19)	(0.16)	(0.16)	(0.24)
Have children$\times\Delta r_t$	0.38***	0.53***	0.47***	0.42***	0.52***	0.46**
	(0.12)	(0.12)	(0.18)	(0.14)	(0.15)	(0.21)
Mean DTI	0.88	0.88	1.27	0.88	0.88	1.27
Observations	265,675	265,675	153,997	265,675	265,675	153,997
Sample	All	All	Home own.	All	All	Home own.
Household FE	No	No	No	Yes	Yes	Yes
Unique households				64,158	64,158	37,547

Notes: All specifications include year fixed effects, a fourth polynomial in age, the number of children and the change in number of children. $netDTI$ denotes the ratio of debt-to-income minus the ratio of liquid assets-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. Columns (1)–(3) report results from the OLS estimation, columns (4)–(6) use fixed effects. In columns (3) and (6), the estimation is restricted to homeowners. Young is a dummy defined as < 40 and old as ≥ 60. Have children is a dummy for having children. 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: Consumption Responses: Proxies for ARM

	(1)	(2)	(3)	(4)
$\text{DTI}_{t-2} \times \Delta r_t$	-0.15*		-0.13	
	(0.09)		(0.11)	
DTI_{t-2}	0.01***	0.01***		
	(0.00)	(0.00)		
ARM$\times\text{DTI}_{t-2} \times \Delta r_t$	-0.13		-0.21	
	(0.13)		(0.15)	
ARM$\times\Delta r_t$	-0.53**		-0.35	
	(0.24)		(0.28)	
Corr$\times\text{DTI}_{t-2} \times \Delta r_t$		-0.35***		-0.44***
		(0.10)		(0.12)
Corr$\times\Delta r_t$		-0.34*		-0.20
		(0.19)		(0.23)
Young$\times\Delta r_t$	0.01	-0.01	-0.77***	-0.78***
	(0.19)	(0.19)	(0.27)	(0.27)
Old$\times\Delta r_t$	-0.85***	-0.84***	-0.98***	-0.97***
	(0.21)	(0.21)	(0.28)	(0.28)
Have children$\times\Delta r_t$	0.55***	0.54***	0.58***	0.58***
	(0.18)	(0.18)	(0.22)	(0.22)
Mean DTI	1.52	1.52	1.52	1.52
Observations	129,406	129,406	129,406	129,406
Household FE	No	No	Yes	Yes
Unique households			31,552	31,552

Notes: All specifications include year fixed effects, a fourth polynomial in age, the number of children and the change in number of children. 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. Corr is the correlation between the household interest rate and the repo rate. ARM is a dummy equal to one if the correlation is above the median (0.61). Young is a dummy defined as < 40 and old as ≥ 60. Have children is a dummy for having children. Standard errors in parenthesis are clustered at the household level.

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

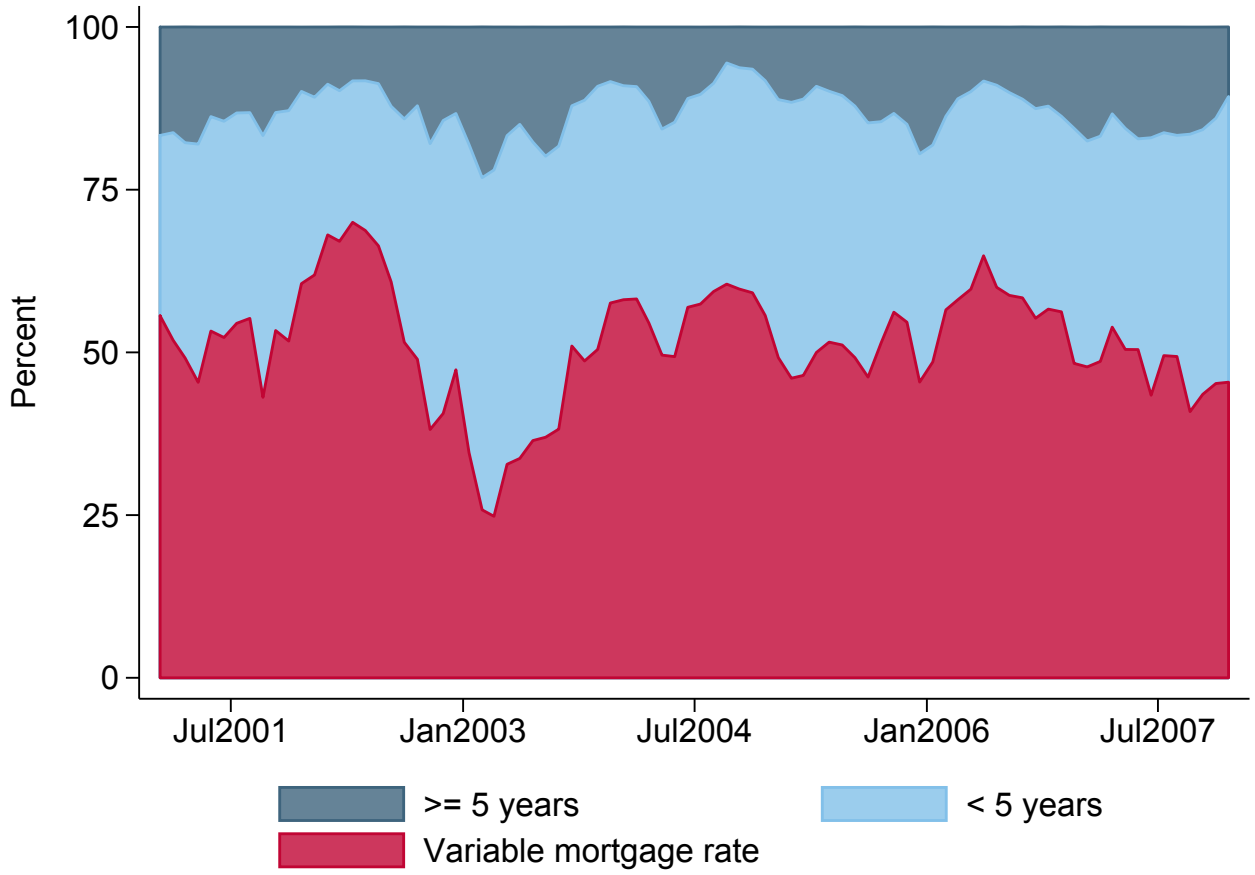
Table 6: Consumption Responses: Other factors

	(1)	(2)	(3)	(4)
$DTI_{t-2} \times \Delta r_t$	-0.32***	-0.32***	-0.19***	-0.26***
	(0.06)	(0.07)	(0.06)	(0.07)
DTI_{t-2}	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)
Young$\times\Delta r_t$	0.24*	0.22*	0.25*	0.20
	(0.13)	(0.13)	(0.13)	(0.13)
Old$\times\Delta r_t$	-1.09***	-1.15***	-1.13***	-1.10***
	(0.13)	(0.12)	(0.12)	(0.12)
Have children$\times\Delta r_t$	0.59***	0.55***	0.57***	0.55***
	(0.13)	(0.12)	(0.12)	(0.12)
Low income$\times\Delta r_t \times DTI_{t-2}$	0.19*			
	(0.11)			
Low income$\times\Delta r_t$	-0.37***			
	(0.12)			
High DTI$\times\Delta r_t \times DTI_{t-2}$		0.12		
		(0.25)		
High DTI$\times\Delta r_t$		-0.12		
		(1.00)		
High LTV$\times\Delta r_t \times DTI_{t-2}$			-0.12	
			(0.14)	
High LTV$\times\Delta r_t$			-0.25	
			(0.31)	
Low ATI$\times\Delta r_t \times DTI_{t-2}$				-0.00
				(0.09)
Low ATI$\times\Delta r_t$				0.22*
				(0.11)
Mean DTI	0.88	0.88	0.88	0.88
Sample	All	All	All	All
Household FE	No	No	No	No
Observations	265,675	265,675	265,675	265,675

Notes: All specifications include year fixed effects, a fourth polynomial in age, the number of children and the change in number of children. 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. Young is a dummy defined as < 40 and old as ≥ 60. Have children is a dummy for having children. The following variables are dummies. Low income is defined as belonging to the lowest disposable income quarter, adjusted for household size. High DTI, High LTV and Low ATI are defined using predetermined values (lagged by two years). High DTI is homeowners with a DTI above 3. High LTV is households with an LTV above 85 percent. Low ATI is households' assets-to-income that are lower than one month's disposable income. Standard errors in parenthesis are clustered at the household level.

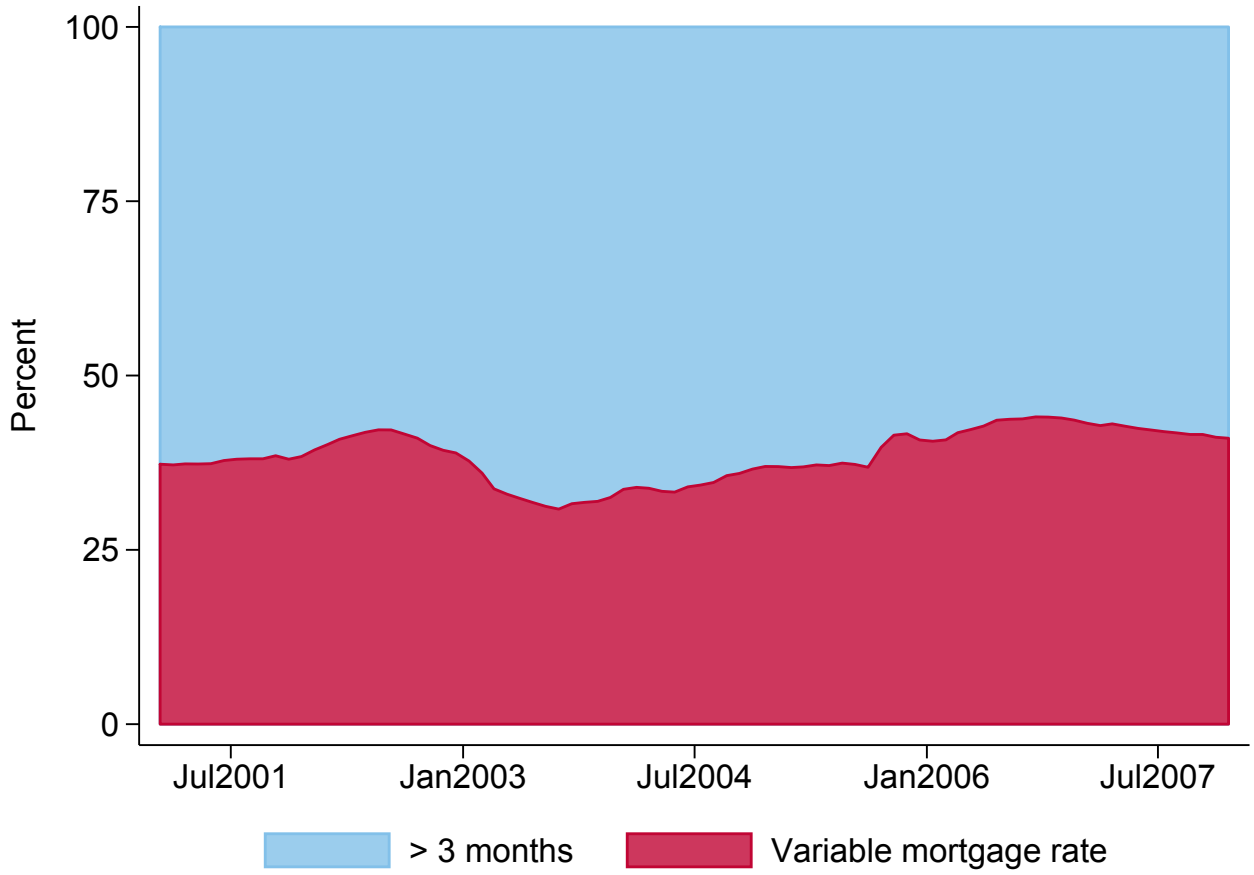
*, ** and *** denotes significance at the 10 percent, 5 percent and 1 percent level, respectively.

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



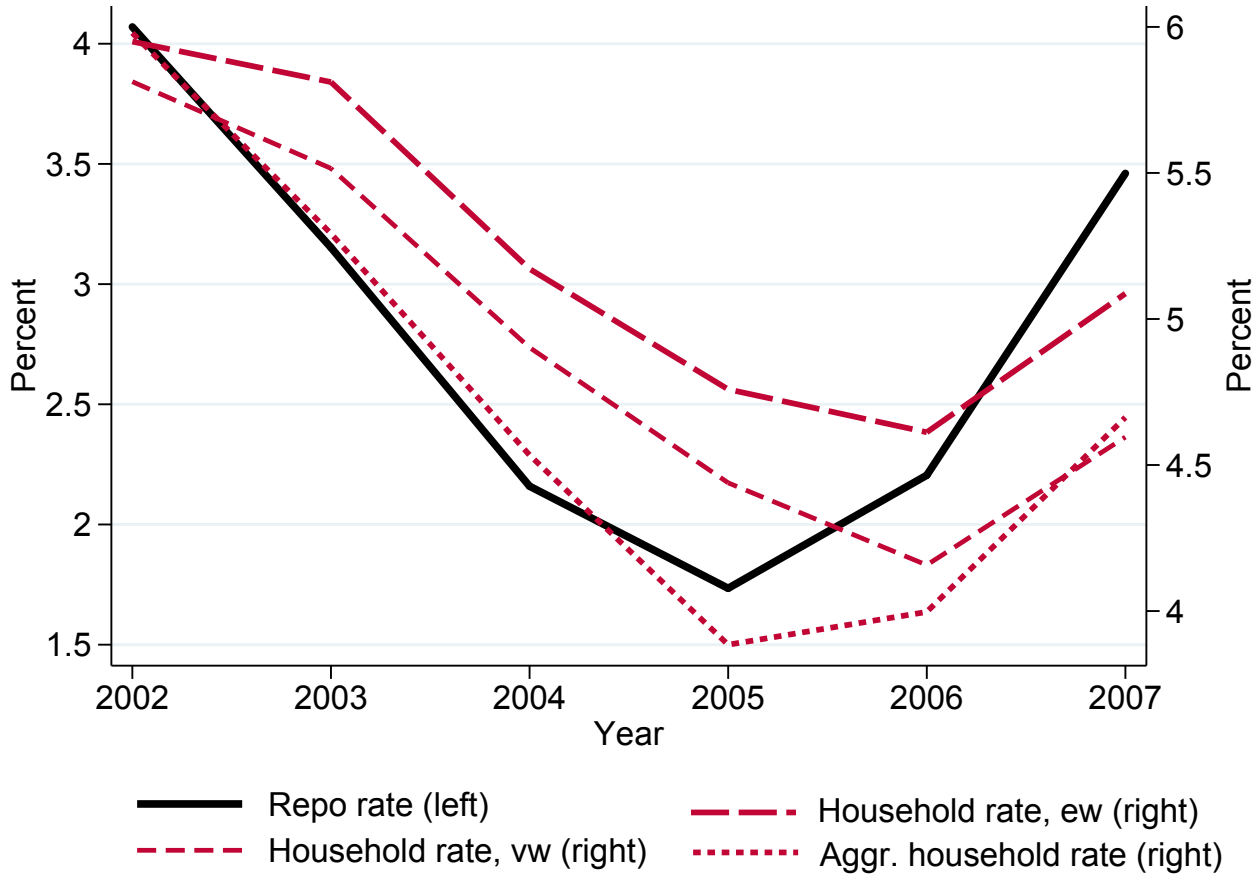
Note: Variable mortgage rate is defined as 3 months or shorter. The data source is Figure A18 in Riksbank (2012).

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



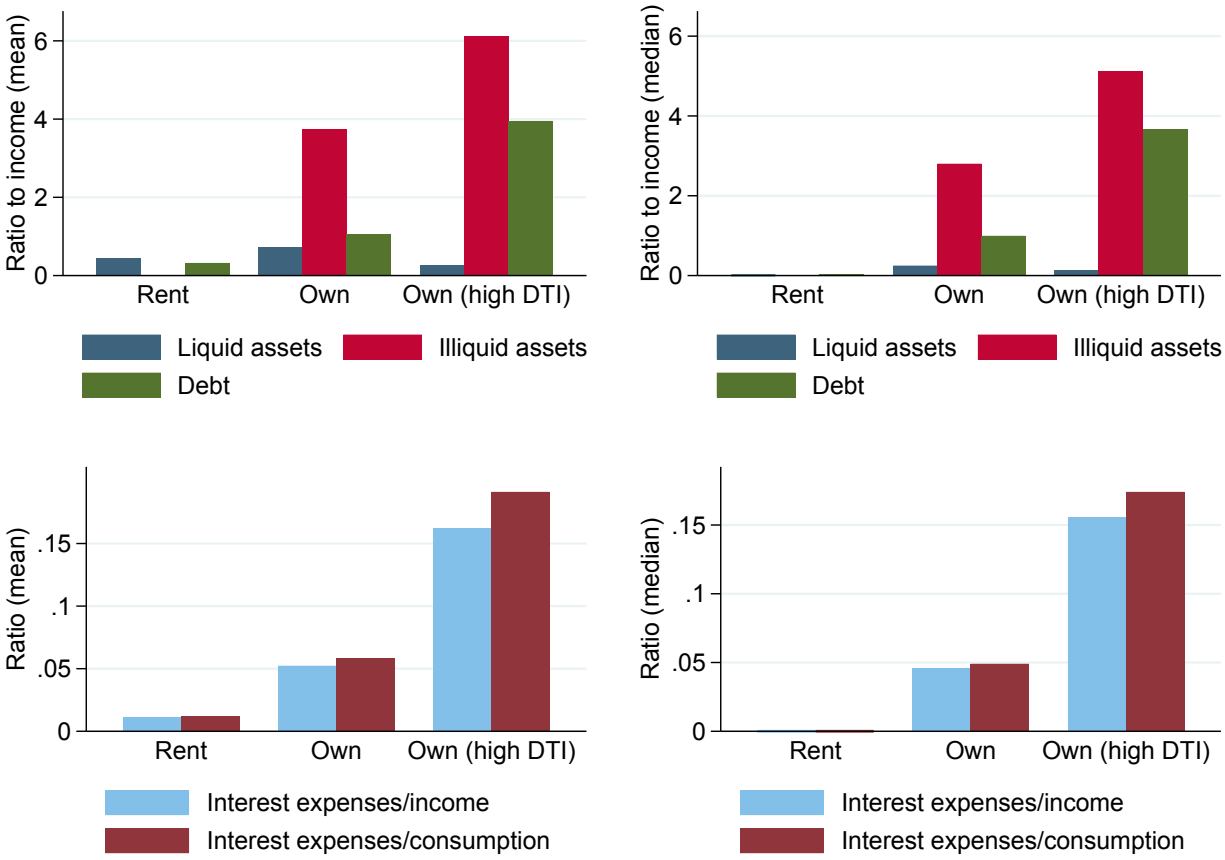
Note: Variable mortgage rate is defined as 3 months or shorter. The data source is Figure A30 in Riksbank (2015).

Figure 3: The repo rate and household interest rates



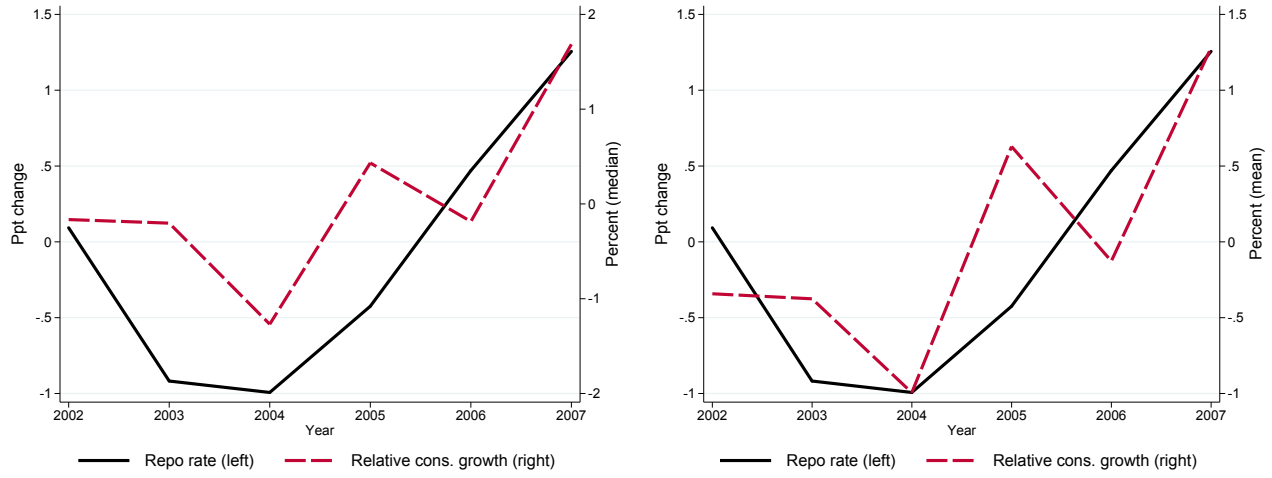
Note: The figure displays the repo rate, the average household interest rate (dashed lines) in our sample, both equally weighted (ev) and value weighted (vw), and an aggregate household interest rate from Statistics Sweden (dotted line).

Figure 4: Assets, debt, and interest expenses



Note: 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 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 5: The repo rate and relative consumption growth



Note: 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.

A Details on the Model

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

Let us again consider a_t, net financial assets. Starting from equation (2) we then want to approximate:

$$\log(c_t) = \log(y_t + r_t \cdot a_t). \tag{9}$$

We use a first-order Taylor approximation of the form $f(x) = f(x^*) + (x - x^*)f'(x^*)$. The left-hand side in (9) is then approximated by:

$$\log(c_t) = \log(c^*) + (c_t - c^*)\frac{1}{c^*}, \tag{10}$$

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

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

Now, use $y^* + r^* \cdot a^* = c^*$ to simplify (11):

$$\begin{aligned}
\log(y_t + r_t \cdot a_t) &= \log(c^*) + [(y_t + r_t \cdot a_t) - (y^* + r^* \cdot a^*)]\frac{1}{c^*} \\
&= \log(c^*) + \frac{y_t - y^*}{c^*} + \frac{(r_t - r^*)a^*}{c^*} \\
&= \log(c^*) + \frac{y^*}{c^*}\frac{y_t - y^*}{y^*} + \frac{y^*}{c^*}\frac{a^*}{y^*}(r_t - r^*) \\
&= \log(c^*) + \theta\frac{y_t - y^*}{y^*} + \theta\frac{a^*}{y^*}(r_t - r^*).
\end{aligned} \tag{12}$$

Substitute (10) and (12) into (9) to obtain:

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

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

$$\Delta\log(c_t) = \theta\Delta\log(y_t) + \theta\frac{a^*}{y^*}\Delta r_t. \tag{14}$$

A.2 Optimizing households – Alternative timing assumptions

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

$$\max \quad \mathrm{E}_0 \sum_{t=0}^{T^i-1} \beta^t u\left(c_t^i\right), \tag{15}$$

subject to the budget constraint:

$$\sum_{t=0}^{T^i-1} R_t^{-1}\left(c_t^i - y_t^i\right) = \left(1+r_0\right) a_0^i, \tag{16}$$

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 $u\left(c\right) = \dfrac{c^{1-\frac{1}{\sigma}}}{\left(1-\frac{1}{\sigma}\right)}$.

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

$$\frac{c_{t+1}^i}{c_t^i} = \left[\beta\left(1+r_{t+1}\right)\right]^{\sigma}, \tag{17}$$

and

$$c_0^i = \frac{Y^i + \left(1+r_0\right) a_0^i}{\sum_{t=0}^{T^i-1} R_t^{\sigma-1}\beta^{\sigma t}}, \tag{18}$$

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. However, there is 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 (17) and (18) for a given constant interest rate as the steady state. For these households, the response, measured as an elasticity, to a change in the interest rate is:

$$\Delta \log c_t \approx \sigma \cdot \Delta r_t. \tag{19}$$

Below we analyze scenarios when a household has chosen c_0 in steady state and then learns at 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 does therefore not want to reoptimize the slope of its consumption path. But the surprise in the return on savings between period 0 and 1 has consequences for the household's available resources at 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 (18), but that, at the beginning of period $t = 1$, it learns that the interest rate will be $\widetilde{r}_2$ instead of the anticipated r_2. The household will then reoptimize at the beginning of period $t = 1$, resulting in:

$$\Delta \log c_1^i \approx \alpha + \gamma^i\left(\widetilde{r}_2 - r_2\right), \tag{20}$$

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

$$\gamma^i \approx -\frac{T^i - 2}{T^i - 1}\left(\frac{T^i}{T^i + a^i/y^i} + \sigma - 1\right), \tag{21}$$

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 (20) is essentially equal to the negative of equation (19). The difference in signs appears because equation (19) 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 (18), but that the interest rate turns out to be $\hat{r}_1$ instead of the anticipated r_1. The household will then reoptimize at the beginning of period $t = 1$, resulting in:

$$\Delta \log c_1^i \approx \alpha + \delta^i \frac{a^i}{y^i}\left(\hat{r}_1 - r_1\right), \tag{22}$$

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

$$\delta^i \approx \frac{1}{T^i + a^i/y^i}, \tag{23}$$

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 uniformly distributed 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:

$$\Delta \log c_i = \beta_0 + \beta_1 DTI_i \times \Delta r + \varepsilon_i, \tag{24}$$

where subscript $t = 1$ has been omitted. Columns (1) to (3) of Table 7 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 (columns 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 columns 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 7: 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

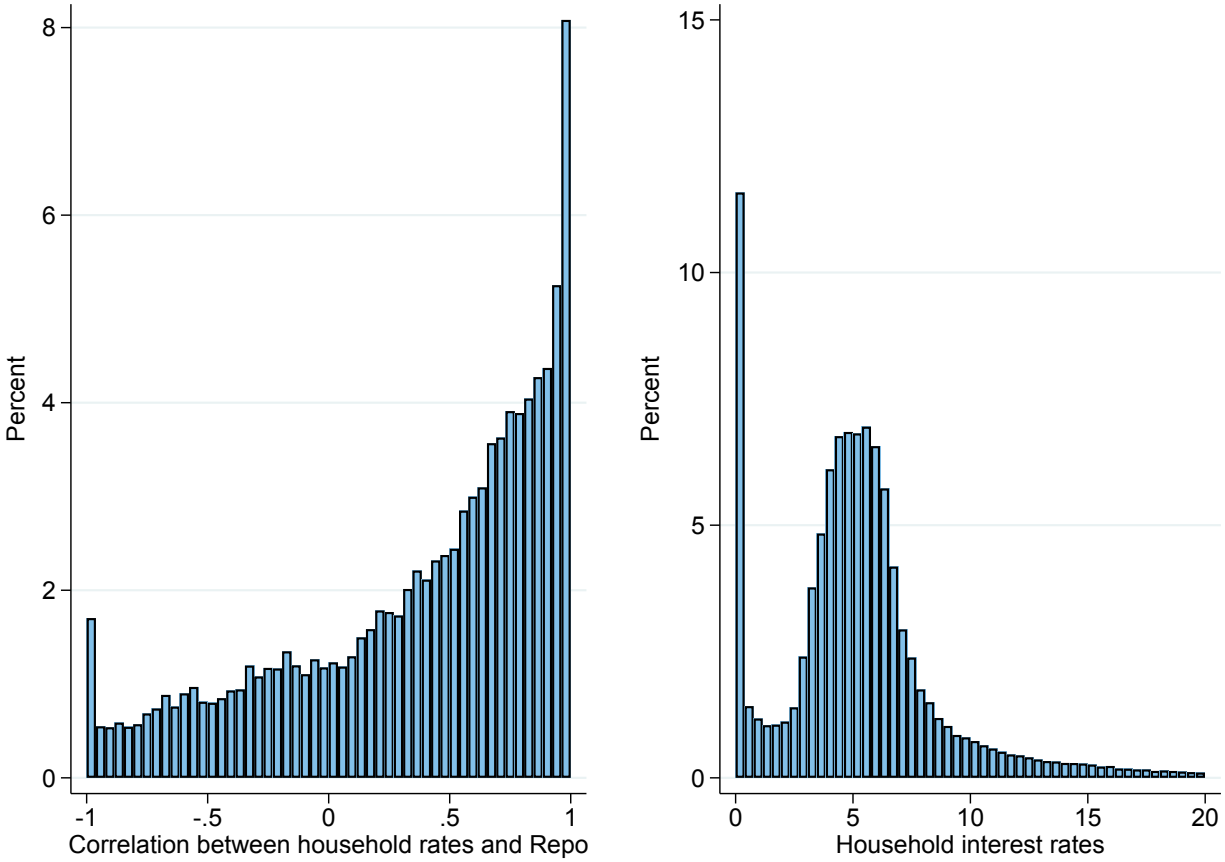
Notes: The sample is based on a parameterization where $y = 1$, $\beta = 0.98$, households whose heads are aged between 30 and 70 years (T uniformly distributed between 10 and 50), and debt-to-income uniformly distributed between 0 and 5 (DTI_i is the negative of $\frac{a_i}{y_i}$). The experiment involves a one-year increase in the interest rate from 0.02 to 0.03. Flexible current consumption denotes whether optimizers follow equation (22), in which case it is fixed, or equation (20), 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 above setting, 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 Details on the Data

Figure 6: 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 and the household interest rate. The right-hand panel displays the cross-sectional distribution of household interest rates.

Table 8: Sample restrictions

	Type of restriction	Observations	Unique households
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
3.	Excl. unstable households over time (includes dropping 2001)	1,066,434	255,014
4.	Excl. households who change official address or transact real estate	836,992	231,955
5.	Excl. self-employed	798,691	223,913
6.	Excl. households who hold derivatives	787,968	222,105
7.	Excl. households who hold securities with missing ISINs, or mutual funds or stocks with missing prices or returns	603,380	183,909
8.	Excl. households with missing disposable income in t, $t-1$ or $t-2$	603,314	183,890
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
12.	Excl. households that change housing tenure status	536,927	169,915
13.	Excl. households where the number of adults changes	524,935	167,280
14.	Excl. households where the household head is younger than 18	509,011	160,949
15.	Excl. households with negative consumption in t or $t-1$	485,982	156,982
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
18.	Excl. lowest 1 percentile of disposable income in t, $t-1$ and $t-2$	474,957	153,096
19.	Excl. if the interest is higher than 20 percent for indebted households	461,922	151,409
20.	Excl. if consumption growth is higher/lower than +/- 50 percent	370,493	137,533
21.	Excl. if DTI in $t-2$ is negative or higher than 10	370,222	137,398
22.	Excl. households that are not in the sample at least 3 years	266,701	64,322
23.	Excl. indebted homeowners with no correlation measure	265,675	64,158
24.	For the balanced sample: required in sample for 2002-2007	67,425	11,253

Table 9: 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)
Education			
< High school (share)	11.08	10.01	-
High school (share)	58.18	56.36	-
> High school (share)	30.74	33.63	-
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)
Correlation measure	0.09	0.83	-
	(0.43)	(0.11)	-
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)
Observations	64,704	64,702	129,406
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 below (above) the median among homeowners. 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. *) For the loan-to-value ratio the mean for percentile 99 and below is reported. See Table 1 for further details.