Appendix for Online Publication

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

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

A A Simple Infinite Horizon Model

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

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

$$c_t = y_t + r_t \cdot a_t \tag{1}$$

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

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

We use a first-order Taylor approximation of the form $f(x) = f(x^*) + (x - x^*)f'(x^*)$. The left-hand side in (2) is then approximated by:

$$\log(c_t) = \log(c^*) + (c_t - c^*)\frac{1}{c^*}, \tag{3}$$

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

$$\log(y_t + r_t \cdot a_t) = \log(y^* + r^* \cdot a^*) + [(y_t + r_t \cdot a_t) - (y^* + r^* \cdot a^*)]\frac{1}{y^* + r^* \cdot a^*}. \tag{4}$$

Now, use $y^* + r^* \cdot a^* = c^*$ to simplify (4):

$$\begin{aligned}
\log(y_t + r_t \cdot a_t) &= \log(c^*) + [(y_t + r_t \cdot a_t) - (y^* + r^* \cdot a^*)]\frac{1}{c^*} \\
&= \log(c^*) + \frac{y_t - y^*}{c^*} + \frac{(r_t - r^*)a^*}{c^*} \\
&= \log(c^*) + \frac{y^*}{c^*}\frac{y_t - y^*}{y^*} + \frac{y^*}{c^*}\frac{a^*}{y^*}(r_t - r^*) \\
&= \log(c^*) + \theta\frac{y_t - y^*}{y^*} + \theta\frac{a^*}{y^*}(r_t - r^*). \qquad (5)
\end{aligned}$$

Substitute (3) and (5) into (2) to obtain:

$$\frac{(c_t - c^*)}{c^*} = \theta \frac{y_t - y^*}{y^*} + \theta \frac{a^*}{y^*}(r_t - r^*). \tag{6}$$

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

$$\Delta\log(c_t) = \theta\Delta\log(y_t) + \theta\frac{a^*}{y^*}\Delta r_t. \tag{7}$$

B A Quantitative Partial Equilibrium Model

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

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

subject to the constraint:

$$P_1(c_1 + h) + A_1 = P_1 w + D_1 + (1 + i_1) A_0, \tag{8}$$

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

$$P_t c_t + A_{t+1} = P_t w + (1 + i_t) A_t - i_t^D D_t - \gamma D_1 \tag{9}$$

and, finally, the constraint in the last period:

$$P_T c_T = P_T w + (1 + i_T) A_T - (1 + i_T) D_T + \alpha P_T h. \tag{10}$$

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

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

$$1 + i_t = (1 + r) \cdot \frac{P_t}{P_{t-1}}, \tag{11}$$

where r is the real interest rate.

B.1 ARMs

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

B.2 FRMs

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

B.3 Solutions to the model

B.3.1 Ex ante solutions

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

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

B.3.2 Ex post solutions

We will also shock the nominal interest rate i_i unexpectedly.

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

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

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

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

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

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

A noteworthy feature of the cash-flow channel is that it is operational regardless of the relationship between the nominal interest rate and inflation. For hand-to-mouth households with ARMs and no financial assets ($A_t = 0$), a change in the nominal interest rate affects real mortgage payments and real consumption instantaneously. The consumption function follows from the budget constraint (9):

$$c_t = w - i_t^D \frac{D_t}{P_t} - \gamma \frac{D_1}{P_t}. \tag{12}$$

For such a household, a shock to i_t (and hence i_t^D) is equivalent to a shock to r_t if the price level is constant. However, whether the price level is affected, or not, matters little quantitatively. The short-term effect on consumption is essentially the same even in the extreme case when the nominal interest rate and inflation move together so that the Fisher equation, (11), continues to hold. We label this case as "$\Delta\pi = \Delta i$".

For optimising households with ARMs, the relationship between the nominal rate and inflation matters more. If there is no effect on inflation (i.e., the shock has identical effects on i_t, i_t^D and r), optimising households' response is determined by intertemporal substitution to smooth out the wealth effect. This implies that for a positive shock the household borrows in the financial asset to smooth consumption. If the Fisher equation holds so the inflation increases, there are opposing short-term and long-term wealth effects. A short-term increase in the nominal interest rate leads to a short-term increase in real mortgage payments which is off-set by a long-term decrease in real mortgage payments. The wealth effects cancel so the optimising households off-set the effects on consumption by borrowing even more in the financial asset.[1]

B.3.4 Relationship to previous literature

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

In our analysis, we consider different scenarios for the persistence of the shock and whether inflation and interest rates move in tandem (i.e., whether the Fisher equation holds also after the shock). If the price level is unaffected by the shock, then the shock is equivalent to a shock to the real interest rate. A household with an FRM is partly insured against this shock, until the interest-rate fixation period ends. Auclert (2019) labels the differences between ARM and FRM holders as differences in unhedged interest rate exposure (URE). If the price level does move with the shock, there is an additional effect from households' nominal debt. Auclert (2019) labels this additional effect as differences in net nominal positions (NNPs).[2] If there is a positive relationship between

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

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

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

B.4 Calibration and solution of baseline specification

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

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

B.4.1 Persistent shocks to the interest rate

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

B.5 Illustration of the solutions

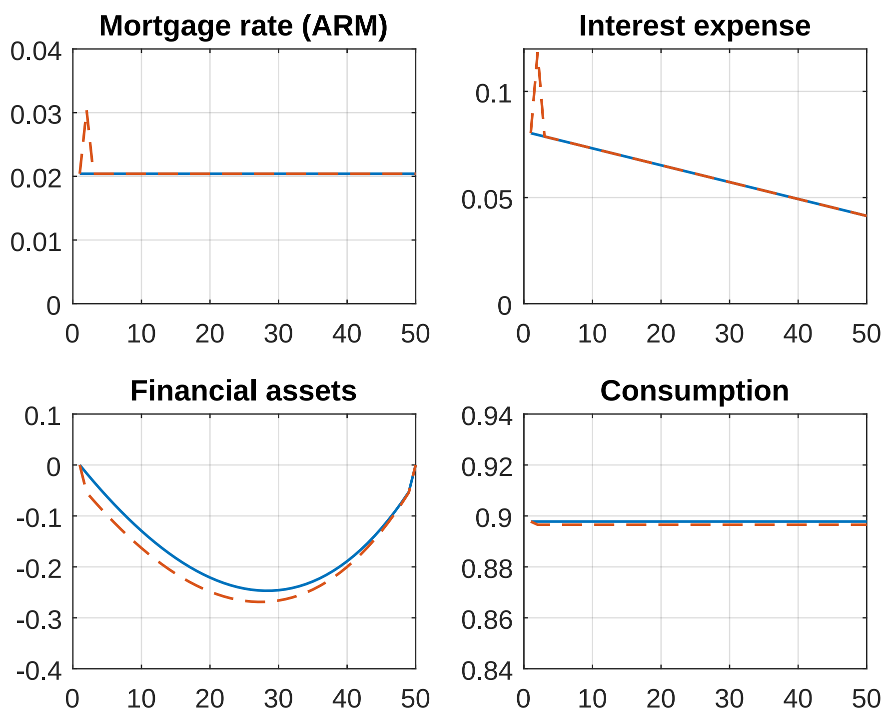
We first illustrate the model dynamics graphically in Figures A.1 to A.8. In these examples, the house value in time period 1 ($P_1 h$) is 4 and initial financial wealth (A_0) is 0. The interest rate is shocked (unexpectedly) in $t = 2$ by one percentage point. We consider both the case when the shock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

B.5.1 ARMs and temporary interest rate shocks

Figure A.1 shows the paths for an optimising household with an ARM. The blue solid line indicates the paths if there is no change to the short-term interest rate (and hence no change to the mortgage rate either), and the red dashed line indicates the path if the household unexpected faces a temporarily higher short-term interest rate in $t = 2$. Whereas the shock to the mortgage interest expense is substantial (upper right panel), the consumption response is miniscule (bottom right panel) because of the household's ability to smooth consumption by additional borrowing (bottom left panel).[3]

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

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



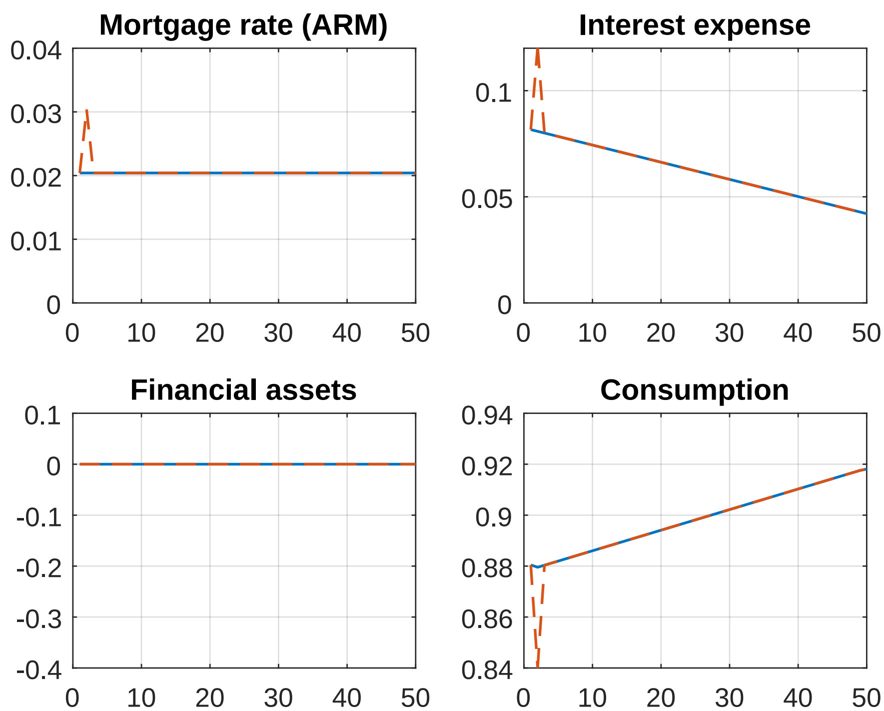
Note: All values are real. Real labour income is normalised to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the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

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

Figures A.3 and A.4 display the response when the shock to the interest rate is persistent. Figure A.3 indicates that an optimising household adjusts its financial assets less when the shock is persistent. Hence, the response to consumption is much greater compared with the case of a temporary shock (compare with Figure A.1). For an HtM household, the consumption response at impact is identical regardless of whether the shock is transitory or persistent (compare Figure A.4 with Figure A.2).

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

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



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

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

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

We now consider households' responses if they have FRMs (they do not respond to transitory shocks). Figure A.5 shows the response of an optimising household with an FRM. Upon a persistent shock to the interest rate, the household saves more. This is because it faces a higher savings rate in the financial asset, but another motive is to smooth out the future increase in the mortgage expense. Hence, consumption decreases immediately. The response is a bit more than half of the magnitude for a household with an ARM.

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

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

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

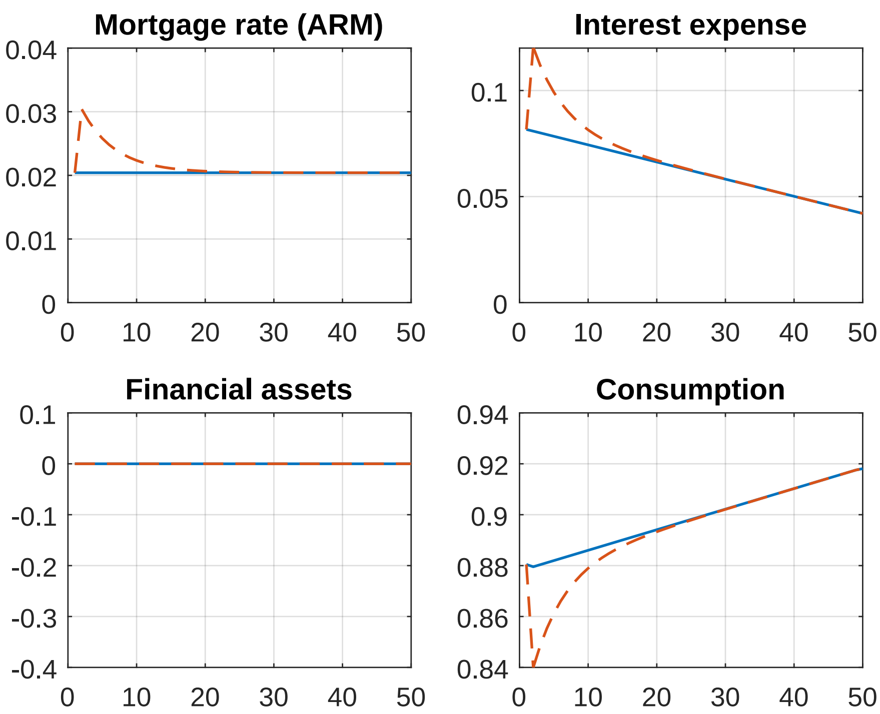
B.5.4 Persistent shocks to the interest rate and the inflation rate

We now consider the case in which, upon a persistent shock to the interest rate, the inflation rate moves in tandem through the Fisher equation (11). For both households with ARMs and those with FRMs, this implies that the negative effect of an increase in the interest rate to some extent is offset by a positive wealth effect, as its debt is worth less in real terms.

Figure A.7 displays the paths for an optimising household with an ARM. Relative to the case when the inflation rate does not move in tandem with the interest rate (as in Figure A.3), households respond much less. Essentially, the consumption response is similar to the response to a transitory shock since households are compensated through inflation.

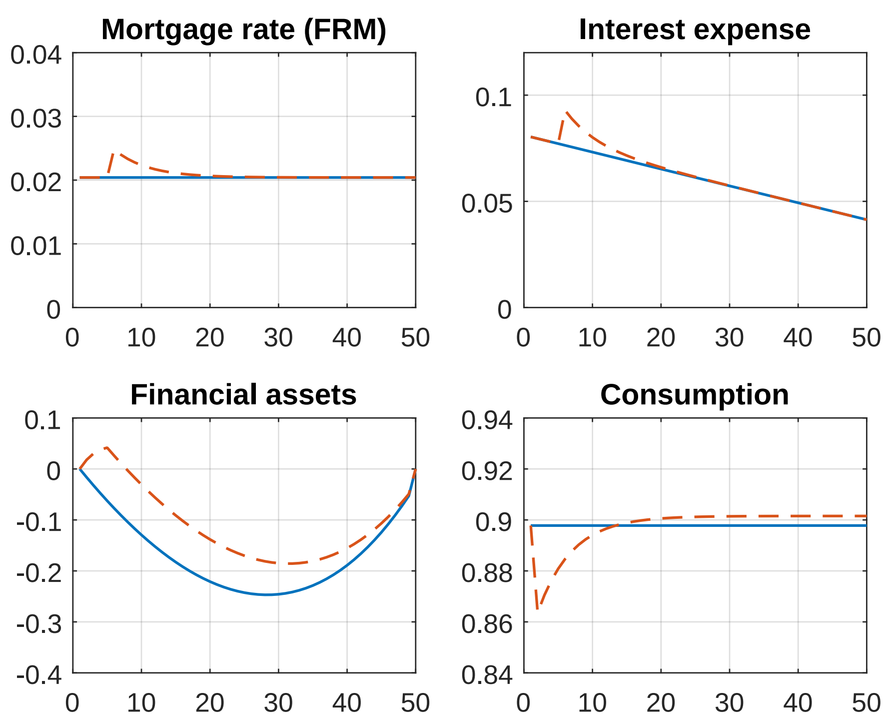
The same mechanism is present for households with FRMs. Figure A.8 shows the response of such a household. Consumption responds slightly positively due to the wealth effect, in contrast to the response in the absence of any inflation (Figure A.5).

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



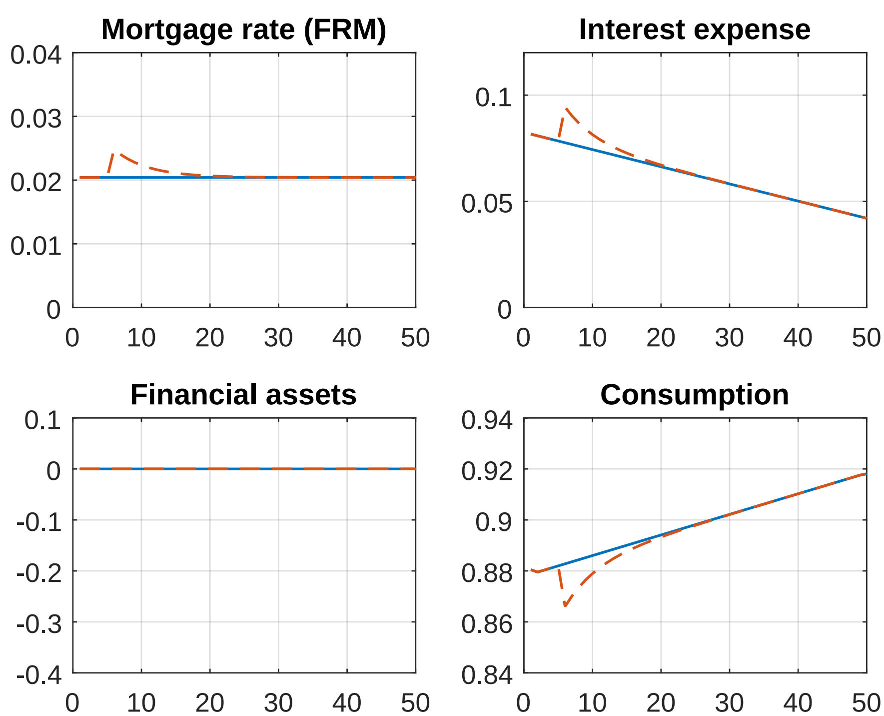
Note: All values are real. Real labour income is normalised to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the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

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



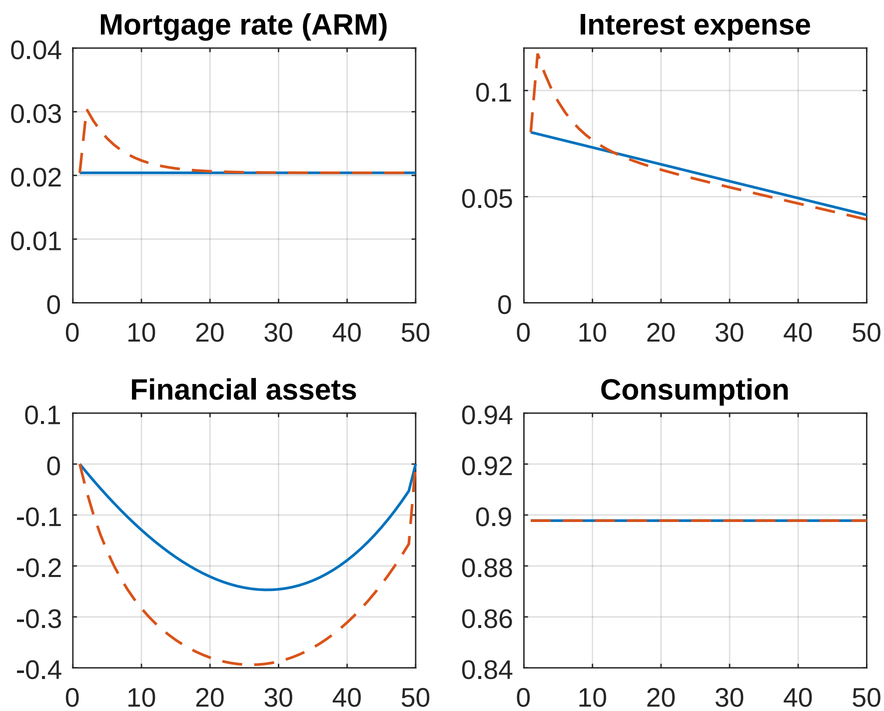
Note: All values are real. Real labour income is normalised to 1. The value of the house in $t = 1$ is 4. The price level is constant at 1. The short-term interest rate increases unexpectedly in t=2 by one percentage point. The blue solid line indicates the ex ante solution, and the red dashed line the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

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



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

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



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

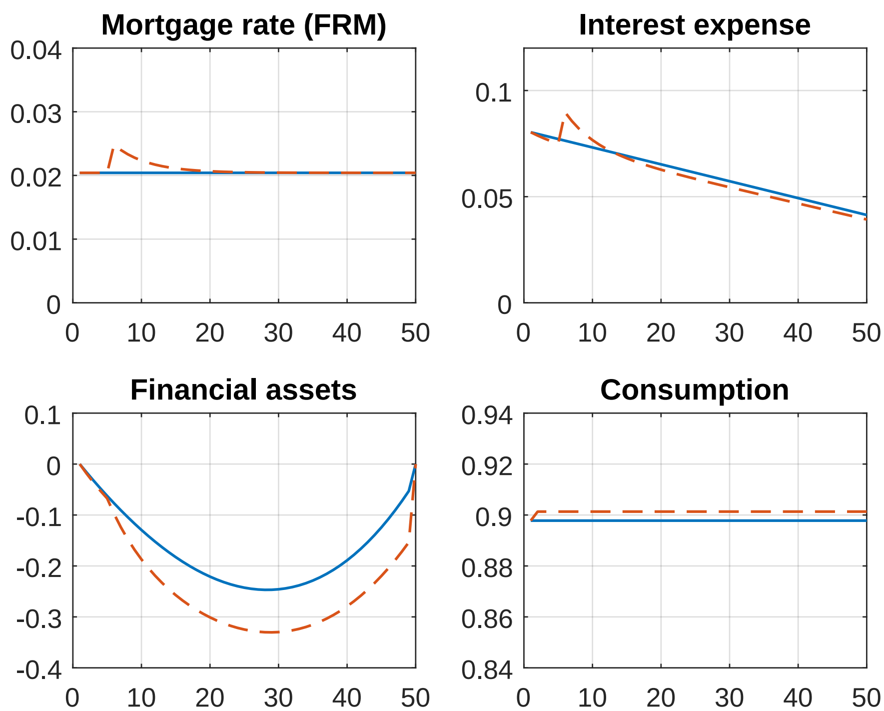
B.6 Quantitative analysis

We now simulate households in the partial equilibrium economy and estimate the response to changes in the interest rate for different configurations. We populate the economy with households of different age (i.e., τ is between 2 and 49 when the shock hits). We also consider cross-sectional variation in house values. House values, $P_1 h$, is uniformly distributed on the interval $[0, 8]$.

B.6.1 Motivation for the regression specification

Figure A.9 displays the consumption response to a persistent shock to the interest rate of four household types with different house values. The house values are 2, 4, and 6 and imply that the DTI ratios early in life are approximately 2, 4, and 6, respectively. The figure illustrates that a feature of HtM households' response is that it is proportional to their DTI ratios (right pan-

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



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

els), whereas optimising households respond almost uniformly (left panels).[4] This motivates the following regression specification:

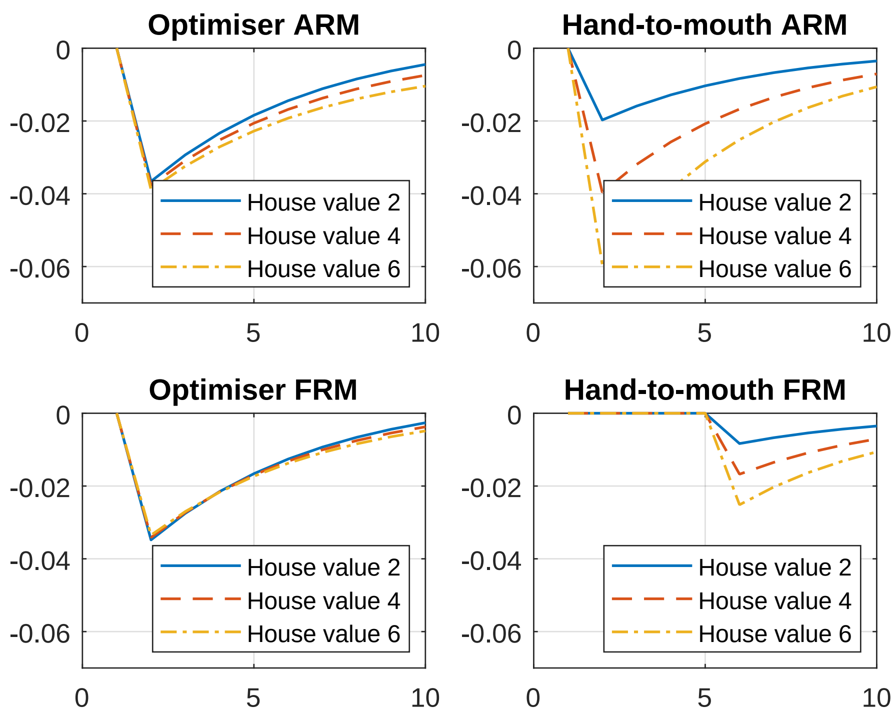
$$\Delta \log c_{i,\tau} = \alpha_i + \beta \mathrm{DTI}_{i,\tau-1} \times \Delta i_\tau + \gamma \mathbf{X_{i,\tau-1}} + \varepsilon_{i,\tau}, \tag{13}$$

where $\Delta \log c_{i,\tau}$ is log consumption growth, α_i are household fixed effects that capture time-invariance cross-sectional heterogeneity. In our simulated data, the change in the nominal interest rate is Δi_τ and it is 0.01 for all households, and $\mathbf{X_{i,\tau-1}}$ is a third-order polynomial in age (i.e., τ). The covariate $\mathrm{DTI}_{i,\tau-1} \times \Delta i_\tau$ captures responses of households that are hand-to-mouth. Figure A.9 shows that responses of such households increase linearly with debt. It is also consistent with the log-linearization leading to equation (7).

In our analysis on real data, we add year fixed effects (δ_t) that capture macroeconomic effects – including interest rate changes and aggregate shocks. Under the assumption of homogenous

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

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



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

preferences, the year fixed effects capture the response of optimising households, as long as the remaining life span is long relative to the persistence of the shock to the interest rate. To adjust for wealth effects due to life span, we include household age in $X_{i,\tau-1}$.[5]

B.6.2 Regression estimates

Tables A.1 and A.2 show estimated consumption responses in different configurations of the model economy based on panel data from simulations.[6] Table A.1 reports small responses for op-

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

[6]In the simulations, households' initial house values are uniformly distributed between 0 and 8 on an equidistant grid with nine grid points (i.e., nine house values). The age distribution is uniform, between 0 and 50 years. To exclude households that purchase or sell real estate, we include households aged 3 to 49 in these regressions. We also reduce the size of the data set by only including the time period in a household's life when the interest rate shock occurs. We

timising households with ARMs (columns (1)–(3)), whereas the combination of ARMs and HtM behaviour implies responses of approximately -1 (column (4)). For optimising households with FRMs, the response is moderate, at -0.118 (column (5)), and it is negligible among HtM households with FRMs (column (6)).

Table A.1: Regressions on simulated data

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{DTI}_i \times \Delta i$	-0.081	-1.282	-0.337	-1.282	-0.119	0.033
	(0.004)	(0.008)	(0.010)	(0.008)	(0.003)	(0.000)
Constant	-0.000	0.002	-0.029	0.002	-0.032	-0.000
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.000)
Observations	423	423	423	423	423	423
R-squared	0.690	0.993	0.812	0.993	0.988	0.974
Persistent shock	No	No	Yes	Yes	Yes	Yes
Fisher effect ("$\Delta\pi = \Delta i$")	No	No	No	No	No	No
Share ARM	1.0	1.0	1.0	1.0	0.0	0.0
Share HtM	0.0	1.0	0.0	1.0	0.0	1.0

Notes: There are nine values for households' initial house values, distributed equidistantly between 0 and 8. The age distribution is uniform, between 3 and 49 years. Only the time the period of the interest rate shock is included (i.e., one observation per household). A fourth-order polynomial in age is included in all regressions. Robust standard errors.

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

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

therefore exclude the household fixed effect, α_i, in 13. The simplest configuration thus consists of 423 observations.

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

	(1)	(2)	(3)	(4)	(5)	(6)
$\text{DTI}_i \times \Delta i$	0.000	-1.224	0.205	0.073	-0.434	-0.210
	(0.000)	(0.007)	(0.009)	(0.001)	(0.027)	(0.029)
Constant	-0.000	0.001	-0.002	-0.001	-0.015	-0.001
	(0.000)	(0.001)	(0.001)	(0.000)	(0.005)	(0.005)
Observations	423	423	423	423	$1,692$	$1,692$
R-squared	0.011	0.993	0.741	0.988	0.210	0.057
Persistent shock	Yes	Yes	Yes	Yes	Yes	Yes
Fisher effect ("$\Delta\pi = \Delta i$")	Yes	Yes	Yes	Yes	No	Yes
Share ARM	1.0	1.0	0.0	0.0	0.5	0.5
Share HtM	0.0	1.0	0.0	1.0	0.5	0.5

Notes: There are nine values for households' initial house values, distributed equidistantly between 0 and 8. The age distribution is uniform, between 3 and 49 years. Only the time the period of the interest rate shock is included (i.e., one observation per household). A fourth-order polynomial in age is included in all regressions. Robust standard errors.

References

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Doepke, M. and Schneider, M. (2006). 'Inflation and the redistribution of nominal wealth', *Journal of Political Economy*, vol. 114(6), pp. 1069–1097.

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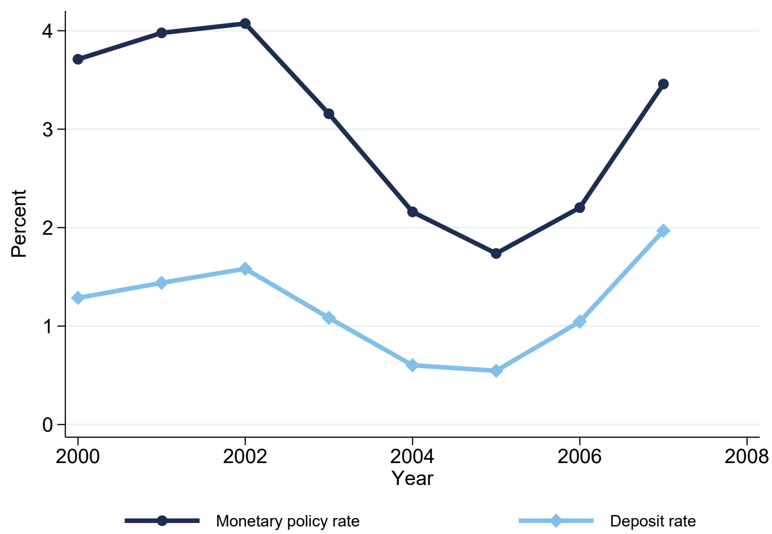
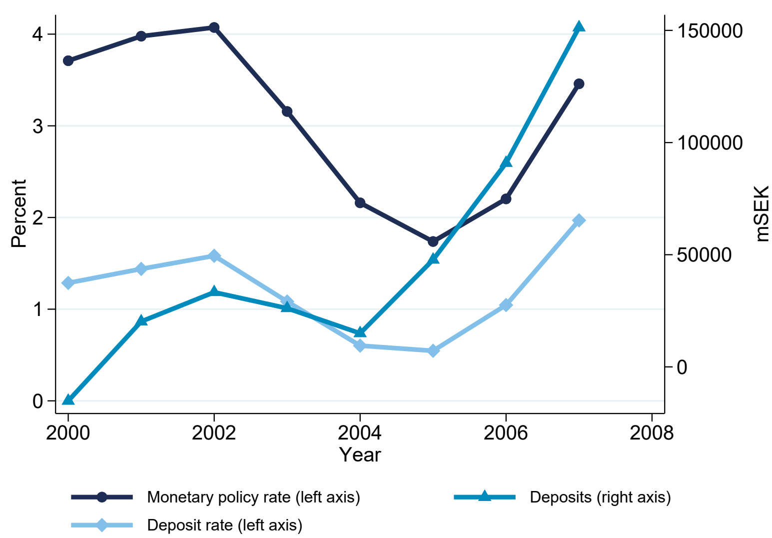
C Supplementary Figures

Figure A.10: The repo rate and deposits



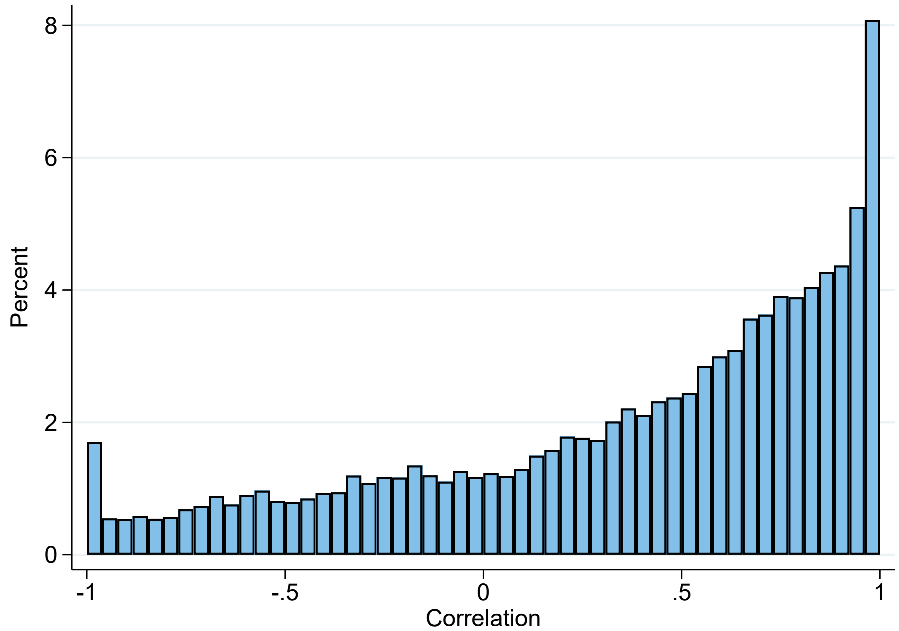
(a) Changes in the repo rate and spending growth (median)



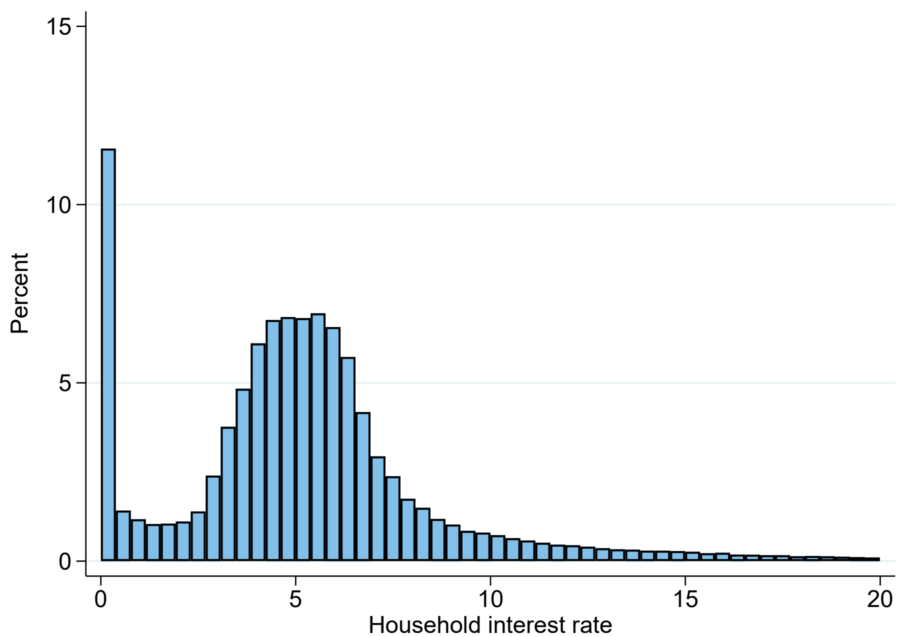
(b) Repo rate, deposit rates and demand deposits

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

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



(a) Correlation between household rates and monetary policy rate



(b) Household interest rates

Notes: Panel (a) displays the cross-sectional distribution of correlations between the repo rate (i.e., the monetary policy rate) and the household interest rate. Panel (b) displays the cross-sectional distribution of household interest rates.

D Supplementary Tables

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

	FRM	ARM	ARM – FRM
	(1)	(2)	(3)
Sociodemographics			
Disposable income	324	336	11.821***
	(140)	(147)	(1.588)
Disposable income a.e.	164	167	2.936***
	(56)	(59)	(0.620)
Age	50	50	0.090
	(13)	(13)	(0.153)
Household size	2.82	2.89	0.069***
	(1.48)	(1.49)	(0.017)
Consumption measure			
Consumption	301	314	12.787***
	(139)	(149)	(1.501)
Consumption a.e.	152	156	3.315***
	(58)	(61)	(0.582)
Balance sheet items			
Debt	500	556	55.576***
	(471)	(500)	(5.358)
Debt-to-income	1.46	1.57	0.115***
	(1.14)	(1.16)	(0.013)
Interest rate	5.38	5.04	-0.334***
	(2.40)	(1.89)	(0.020)
Interest share	7.37	7.47	0.001*
	(5.79)	(5.43)	(0.001)
Illiquid assets	1,120	1,220	99.430***
	(934)	(996)	(10.453)
Liquid assets	135	139	3.175
	(225)	(228)	(2.388)
Liquid assets-to-income	0.43	0.42	-0.003
	(0.74)	(0.71)	(0.008)
Loan-to-Value*	0.54	0.55	0.021***
	(0.46)	(0.42)	(0.005)
Unique households	15,695	15,857	31,552

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

Table A.4: Sample restrictions

	Type of restriction	Observations	Unique households	Age	Illiquid assets	Liquid assets
0.	Full sample (household heads)	2,434,359	412,568			
1.	Match with consumption data	1,890,190	394,504			
2.	Drop year 2000	1,591,265	329,001	47	816	236
3.	Excl. unstable households over time (includes dropping 2001)	1,066,434	255,014	49	872	248
4.	Excl. households who change official address or transact real estate	836,992	231,955	51	901	259
5.	Excl. self-employed	798,691	223,913	51	852	255
6.	Excl. households who hold derivatives	787,968	222,105	51	838	247
7.	Excl. households who hold securities with missing ISINs, or mutual funds or stocks with missing prices or returns	603,380	183,909	50	661	166
8.	Excl. households with missing disposable income in t, $t-1$ or $t-2$	603,314	183,890	50	661	166
9.	Excl. households with missing interest rate (unless debt is zero in t and $t-1$)	-	-			
10.	Excl. households with missing change in number of adults	-	-			
11.	Excl. households with missing DTI in $t-2$	566,891	177,792	52	701	177
12.	Excl. households that change housing tenure status	536,927	169,915	52	717	179
13.	Excl. households where the number of adults changes	524,935	167,280	52	708	179
14.	Excl. households where the household head is younger than 18	509,011	160,949	54	726	184
15.	Excl. households with negative consumption in t or $t-1$	485,982	156,982	54	713	167
16.	Excl. households with missing consumption growth	-	-			
17.	Excl. households with negative disposable income in t, $t-1$ or $t-2$	484,557	156,470	54	714	167
18.	Excl. lowest 1 percentile of disposable income in t, $t-1$ and $t-2$	474,957	153,096	54	724	169
19.	Excl. if the interest is higher than 20 percent for indebted households	461,922	151,409	54	740	172
20.	Excl. if consumption growth is higher/lower than +/- 50 percent	370,493	137,533	53	681	145
21.	Excl. if DTI in $t-2$ is negative or higher than 10	370,222	137,398	53	679	145
22.	Excl. households that are not in the sample at least 3 years	266,701	64,322	55	636	127
23.	Excl. indebted homeowners with no correlation measure	265,675	64,158	55	635	126
24.	Excl. singleton groups (as a result from the previous restriction)	265,642	64,125	55	635	126

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

	(1)	(2)	(3)	(4)	(5)
		OLS: All Households			
$\Delta r \times$ DTI	-0.260***	-0.266***	-0.295***	-0.367***	-0.473***
	(0.058)	(0.058)	(0.055)	(0.056)	(0.053)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	0.88	0.88	0.88	0.88	0.88
Observations	265,642	265,642	265,642	265,642	265,675
Clusters (households)	64,125	64,125	64,125	64,125	64,158
		OLS: Homeowners			
$\Delta r \times$ DTI	-0.199***	-0.211***	-0.447***	-0.236***	-0.581***
	(0.075)	(0.075)	(0.073)	(0.074)	(0.072)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	1.27	1.27	1.27	1.27	1.27
Observations	153,964	153,964	153,964	153,964	153,997
Clusters (households)	37,514	37,514	37,514	37,514	37,547

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

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

	(1)	(2)	(3)	(4)	(5)
			OLS: All Households		
$\Delta r \times$ DTI	-0.622***	-0.631***	-0.837***	-0.741***	-1.076***
	(0.087)	(0.087)	(0.084)	(0.085)	(0.080)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	0.88	0.88	0.88	0.88	0.88
Observations	265,642	265,642	265,642	265,642	265,675
Clusters (households)	64,125	64,125	64,125	64,125	64,158
			OLS: Homeowners		
$\Delta r \times$ DTI	-0.594***	-0.616***	-1.177***	-0.624***	-1.370***
	(0.114)	(0.114)	(0.112)	(0.112)	(0.111)
Liquid assets-to-income	No	Yes	No	No	Yes
Consumption-to-income	No	No	Yes	No	Yes
Income growth	No	No	No	Yes	Yes
Mean DTI	1.27	1.27	1.27	1.27	1.27
Observations	153,964	153,964	153,964	153,964	153,997
Clusters (households)	37,514	37,514	37,514	37,514	37,547

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

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

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

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

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

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

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

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

Homeowners

	(1)	(2)	(3)	(4)
	OLS		IV	
Interest fixation$_1$ $\times$ Δr $\times$ DTI	-0.034	-0.045	-0.016	-0.020
	(0.191)	(0.191)	(0.250)	(0.250)
Interest fixation$_2$ $\times$ Δr $\times$ DTI	0.058	0.052	-0.429*	-0.428*
	(0.172)	(0.172)	(0.221)	(0.221)
Interest fixation$_3$ $\times$ Δr $\times$ DTI	-0.306*	-0.312*	-0.512**	-0.512**
	(0.173)	(0.173)	(0.215)	(0.214)
Interest fixation$_4$ $\times$ Δr $\times$ DTI	-0.440***	-0.446***	-0.372*	-0.376*
	(0.156)	(0.156)	(0.212)	(0.212)
Interest fixation$_5$ $\times$ Δr $\times$ DTI	-0.279	-0.295*	-0.395*	-0.406*
	(0.170)	(0.170)	(0.228)	(0.228)
Interest fixation$_1$ $\times$ Δr	0.615	0.565	-0.325	-0.331
	(0.373)	(0.373)	(0.494)	(0.494)
Interest fixation$_2$ $\times$ Δr	0.665*	0.615*	0.371	0.371
	(0.366)	(0.366)	(0.489)	(0.489)
Interest fixation$_3$ $\times$ Δr	0.516	0.465	-0.124	-0.124
	(0.372)	(0.372)	(0.487)	(0.488)
Interest fixation$_4$ $\times$ Δr	0.457	0.418	-0.764	-0.740
	(0.365)	(0.365)	(0.497)	(0.497)
Interest fixation$_5$ $\times$ Δr	0.192	0.169	-0.525	-0.494
	(0.358)	(0.358)	(0.489)	(0.490)
Liquid assets-to-income	No	Yes	No	Yes
Observations	153,964	153,964	153,964	153,964
Clusters (households)	37,514	37,514	37,514	37,514

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

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

	(1)	(2)	(3)	(4)
	OLS			
	All Households		Homeowners	
Corr $\times$ Δr $\times$ DTI	-0.478***	-0.468***	-0.499***	-0.490***
	(0.093)	(0.093)	(0.102)	(0.102)
Δr $\times$ DTI	-0.098	-0.109	0.002	-0.017
	(0.076)	(0.076)	(0.094)	(0.094)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	1.23	1.23	1.57	1.57
Observations	192,242	192,242	129,406	129,406
Clusters (households)	46,801	46,801	31,552	31,552
	IV			
	All Households		Homeowners	
Corr $\times$ Δr $\times$ DTI	-0.413***	-0.404***	-0.485***	-0.473***
	(0.124)	(0.123)	(0.135)	(0.135)
Δr $\times$ DTI	-0.158	-0.167*	-0.107	-0.116
	(0.099)	(0.099)	(0.125)	(0.124)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	1.23	1.23	1.57	1.57
Observations	192,242	192,242	129,406	129,406
Clusters (households)	46,801	46,801	31,552	31,552

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

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

	(1)	(2)	(3)	(4)
Dependent variable:	Δ log $c_{i,t}$		$\Delta c_{i,t}$	
$\Delta r_i \times$ DTI	-0.184***	-0.183***	–	–
	(0.045)	(0.045)	–	–
Δinterest expenses$_i$	–	–	-0.217***	-0.216***
	–	–	(0.057)	(0.057)
Liquid assets-to-income	No	Yes	No	Yes
Mean DTI	1.41	1.41	1.41	1.41
Observations	167,109	167,109	167,109	167,109
Clusters (households)	45,968	45,968	45,968	45,968

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